# Effect of a postpartum prescription for pertussis vaccine: a before-and-after study

M. Bucchiotty, S. El Morabit, Y. Hammou, R. Gallouj, N. Messaadi, S. Vanderstichele, M. Roumilhac, P. Dufour, Damien Subtil

▶ **To cite this version:**

M. Bucchiotty, S. El Morabit, Y. Hammou, R. Gallouj, N. Messaadi, et al.. Effect of a postpartum prescription for pertussis vaccine: a before-and-after study. Journal of Gynecology Obstetrics and Human Reproduction, 2021, Journal of Gynecology Obstetrics and Human Reproduction, 50 (4), pp.102050. 10.1016/j.jogoh.2020.102050 . hal-04502523

**HAL Id: hal-04502523**
**https://hal.univ-lille.fr/hal-04502523v1**

Submitted on 22 Jul 2024

**HAL** is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

Distributed under a Creative Commons Attribution - NonCommercial 4.0 International License

Version of Record: https://www.sciencedirect.com/science/article/pii/S2468784720304268
Manuscript_7801f8b8aecc828683e8c20acd69e4f1

# Effect of a postpartum prescription for pertussis vaccine: a before-and-after study

Marion Bucchiotty[a,*], Yamina Hammou[a], Rachida Gallouj[a], Nassir Messaadi[b], Sophie Vanderstichele[a], Marielle Roumilhac[a], Philippe Dufour[a], Damien Subtil[a,c,*].

[a] *Univ. Lille, CHU Lille, Hôpital Jeanne de Flandre, F-59000 Lille, France*

[b] *Univ. Lille, Département de Médecine Générale, F-59000 Lille, France*

[c] *Univ. Lille, EA 2694 Santé Publique, Epidémiologie et Qualité des Soins, F-59000 Lille France*

## [*]Corresponding author:

Marion Bucchiotty
Hôpital Jeanne de Flandre
Université Lille Nord de France
1 rue Eugène Avinée
59037 Lille Cedex, France
Tel: +33 3 20 44 66 26 - Fax: +33 3 20 44 63 11
*E-mail address*: marion_jb_10@hotmail.fr

## Abbreviation

dTpa-IPV : diphteria tetanus acellular pertussis poliomyelitis

## Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

© 2021 published by Elsevier. This manuscript is made available under the CC BY NC user license
https://creativecommons.org/licenses/by-nc/4.0/

# Effect of a postpartum prescription for pertussis vaccine: a before-and-after study

Marion Bucchiotty[a,*], Saliha El Morabit[a], Yamina Hammou[a], Rachida Gallouj[a], Nasser Messaadi[b], Sophie Vanderstichele[a], Marielle Roumilhac[a], Philippe Dufour[a], Damien Subtil[a,c].

[a] *Univ. Lille, CHU Lille, Hôpital Jeanne de Flandre, F-59000 Lille, France*

[b] *Univ. Lille, Département de Médecine Générale, F-59000 Lille, France*

[c] *Univ. Lille, EA 2694 Santé Publique, Épidémiologie et Qualité des Soins, F-59000 Lille France*

***Corresponding author :**

Marion BUCCHIOTTY

Hôpital Jeanne de Flandre

Université Lille Nord de France

1 rue Eugène Avinée

59037 Lille Cedex, France

Tel: +33 3 20 44 66 26 - Fax: +33 3 20 44 63 11

*E-mail address*: marion_jb_10@hotmail.fr

## Summary

**Background:** Among the strategies to encourage pregnant women to be vaccinated against pertussis in the postpartum period, that of giving them a prescription has been evaluated only sparsely.

**Objective:** To measure the effect of giving women who are not immunized against pertussis a prescription for the vaccine at discharge from the maternity unit.

**Material and methods:** Single-center before-and-after study (2011: before; 2015: after). All women received both oral and written information about vaccination against pertussis. During the after period, they were also specifically asked their immunization status during pregnancy. Those currently unimmunized received a written prescription for it at discharge.

**Results:** Among the women unimmunized at delivery, the percentage who were vaccinated postpartum climbed from 17 to 42% between 2011 and 2015 ($p<0.001$), while the percentage of their unimmunized partners who were vaccinated remained stable (27 and 29%, $p=0.74$). During this time, the percentage of women immunized against pertussis at the beginning of pregnancy rose from 32 to 52% ($p<0.001$). Finally, the percentage of all women protected against this disease postpartum climbed from 44 to 72% between these two periods ($p<0.001$).

**Conclusions:** In the postpartum period, giving a prescription for pertussis vaccine to women unimmunized is accompanied by a significant elevation in their vaccination rate. Nevertheless, this rate remains low and better strategies have to be implemented.



**Key words:** vaccination, pertussis, pregnancy, postpartum, prescription, cocooning strategy.

# INTRODUCTION

Pertussis, commonly known as “whooping cough”, is a highly contagious respiratory infection caused by a type of bacteria called Bordetella Pertussis.

It is still a major health issue to this day and affect people of all ages, but it is definitely more serious for young children and babies (1). The average annual infant mortality rate due to Pertussis is 2% (2–5). There are 40 million estimated cases which lead to 300 000 deaths each year (6).

Since the 1990s and despite mass vaccination, Pertussis infection rates have been rising in developed countries. It is probably due to the decrease of vaccinated persons. It can also be explained by the use of the acellular vaccine, which showed an early waning of vaccine-induced immunity (7–10). Pertussis spreads from person to person by coughing/sneezing or sharing enclosed space. In most cases, infants get infected by their parents or close family (11–13).

While many countries have chosen to vaccinate women during their pregnancy (14,15), some use the cocooning strategy instead. As a matter of fact, France has been doing it since 2004 (4). This program provides protection to infants too young to be vaccinated by targeting the family members or caregivers for vaccination. Its goal is to prevent and interrupt Pertussis transmission (16). However, mothers have to get vaccinated as soon as they give birth (17).

Nonetheless, this recommendation is difficult to carry out (13), and debates about incentive strategies for mothers who are recovering from childbirth are still going. Leboucher *et al.* reported that oral and written instructions, followed by a prescription and advice at discharge

from the maternity unit, was accompanied by a coverage rate of 69% at 8 weeks postpartum (18). However, Bonneau *et al*. found that this combination strategy resulted in a change of the immunization status for only 38% of women (19).

In 2012, our department chose to adopt this strategy which consists in giving a prescription for pertussis vaccine to unimmunized women at discharge after delivery. Therefore, we made the decision to perform a before-and-after comparative study to evaluate the effect of this postpartum prescription.

# MATERIAL AND METHODS

## A/ Study goal:

The objective of this study was to measure the trend between 2011 and 2015 in the rate of pertussis vaccination in postpartum women and their partners who had not been vaccinated within the previous 10 years.

The principal endpoint was parental vaccination among this unimmunized population at 8 weeks postpartum.

Two other secondary outcomes were also measured: the vaccination coverage rate observed during pregnancy, that is, the percentage of parents immunized at the beginning of pregnancy, and that measured postpartum, that is the total parental vaccination rate postpartum.

These three criteria were measured with a closed questionnaire during a telephone interview at 8 to 10 weeks after discharge. During this telephone interview, the women were asked to look at their own portable health or vaccination records. Women who did not have these records were asked to remember when they had last received this vaccine. Similarly, they were asked to describe their partner's vaccination status. Women and partners whose vaccine status was unknown were arbitrarily considered to be not currently immunized.

In 2011, evidence of the resulting low vaccination coverage led us to modify this strategy as of January 2012. After that change, in addition to the oral and written information that we had always provided, we asked women during their pregnancy to report their immunization status, by completing a self-administered questionnaire. Moreover, the form advised them to discuss their vaccinations with their general practitioner. After delivery, the women who had reported an uncertain or not up to date immunization status received a prescription for the quadrivalent vaccine at discharge (DTPa-IPV).

**B/ Type of study design:**

This is a before-and-after observational study. This study took place in one center, a French university hospital (level III).

**C/ Study population:**

Women were eligible if they had just given birth to one or more liveborn infants, regardless of gestational age at delivery. They were excluded, however, if they were younger than 18 years of age, if their telephone number was unknown, if they had been transferred *in utero* to our hospital just before their delivery, or if court action concerning the child was underway. They were also excluded if they refused to participate, if language difficulties prevented effective communication on this subject, if the telephone number in their records appeared to be wrong, or if we were unable to reach them by telephone after four attempts.

In this comparative study we selected two different populations at both time period.

All women provided oral consent at the beginning of the telephone interview. Women's medical and socioeconomic data were recorded from the obstetric files (telephone number, age, educational level, date of delivery, type of delivery, parity, breastfeeding at discharge, and date of discharge).

**D/ Periods studied:**

The previous strategy for pertussis vaccination in our maternity ward dated from 2005; we provided oral and written information about the need for up-to-date immunization from the beginning of pregnancy for the family – father, siblings, grandparents, and other persons in regular contact with the newborn – and very early in the immediate postpartum period for the mother.

The exploratory "before" period, intended to estimate vaccination coverage from a sample of around 100 women, was scheduled to take 14 days. The after period was chosen to be able to show an increase in vaccination coverage between the two periods. Demonstrating a 17% immunization rate postpartum in unimmunized women in 2011 allowed us to estimate that the inclusion of 200 women in 2015 would enable us to detect a possible doubling of this rate (α=5%, 1- ß=20%, bilateral risk). The inclusion period in 2015 was therefore twice as long as in 2011: 28 days.

In practice, the survey and data collection covered all women who gave birth between September 5 and 18, 2011, and from March 26 to April 22, 2015.

**E/ Statistical analysis:**

The computerized data were anonymized. Our study was reported under the simplified procedure to the National Data Protection Authority (CNIL) as number DEC 16-49.

The data were recorded and analyzed with Epi Info software (Version 3.1, Epidata Association, Denmark).

Comparisons of percentages used the Chi-2 test or Fisher's exact test when appropriate. Means were compared with Student's t test. The percentages were rounded to the closest whole number and are reported in parentheses. We report the means with their standard deviations. Differences were considered significant when $p<0.05$.

# RESULTS

During the 2011 study period, 147 women gave birth, and during the 2015 period, 364. After application of the exclusion criteria (women without a telephone number, late transfers, minors, and those whose child had been placed by a court), the percentage of eligible women was 91% (n=134/147) in 2011 and 95% (n=347/364) in 2015 ($p$=0.07).

After we counted the interviews that were impossible because of failure to reach the woman by telephone four times, or wrong telephone numbers, or communication (language) difficulties, interviews were possible for 65% (n=95/147) in 2011 and 76% (n=278/364) in 2015 ($p$=0.06). The percentage of participants rose significantly between 2011 and 2015 (64% (n=94/147) vs 74% (n=270/364), $p$=0.02).

The women during both study periods were comparable for their general characteristics (Table 1). Specifically, they did not differ by period for mean age, parity, educational level, vaginal delivery rate, or breastfeeding rate at discharge.

Table 2 presents their vaccination status by study period. Among the women unimmunized during pregnancy, the percentage vaccinated postpartum rose significantly between 2011 and 2015 (17% (n=11/64) vs 42% (n=54/130), $p$<0.001), regardless of parity. The percentage of women up to date for this immunization at the beginning of pregnancy also rose from 32% (n=30/94) in 2011 to 52% (n=140/270) in 2015 ($p$<0.001). This increase too was significant simultaneously in nulliparous and parous women. Overall, the percentage of women up to date for their pertussis vaccination in the postpartum period rose very significantly between 2011 and 2015 (from 44% (n=41/94) to 72% (n=194/270), $p$<0.001), with an amplitude almost identical in nulliparas and paras.

171 Finally, the vaccination status for partners initially unimmunized but vaccinated in the
172 postpartum period remained stable between the two periods (27% (n=18/68) vs 29%
173 (n=39/136), $p$=0.74). The percentage of partners immunized at the beginning of the pregnancy
174 did rise significantly – from 26 % (n=24/92) to 45% (n=109/245) between 2011 and 2015
175 ($p$<0.008), but only among paras. Finally, the total percentage of immunized partners
176 postpartum increased significantly between 2011 and 2015 (from 46% (n=42/92) to 60%
177 (n=148/245), $p$<0.001); again, this increase occurred only among partners of parous women.

178

# DISCUSSION

In our before-and-after study, giving women a prescription for pertussis vaccine at their discharge from the maternity unit allowed to observe in a significant elevation in the rate of vaccination postpartum.

This is a before-and-after study with all of the possible biases associated with this study design. The method of the survey itself can be criticized, since vaccine status was collected by telephone. We nonetheless limited this measurement bias by asking all women to have their vaccination records in front of them at the time of the interview. All surveys about this vaccine coverage are, like ours, self-reported (20–23).

The before-and-after nature of our study does not allow us to be certain that the increased vaccination rate observed between 2011 and 2015 is really due to giving a vaccine prescription to these unimmunized mothers. We observed a significant increase from 32 to 52% of women already immunized during pregnancy – regardless of parity – indicates that adherence to pertussis immunization guidelines by healthcare professionals improved notably between 2011 and 2015. This effect was also observed in partners, whose coverage during pregnancy rose from 26 to 45% during the same period, although the increase was significant only among partners of parous women. It is nonetheless probable that this better involvement of healthcare professionals in pertussis vaccination between 2011 and 2015 does not fully explain the increase in the postpartum vaccination rate that we observed in the unimmunized women. That is, the stability of postpartum vaccination of partners – who did not receive a prescription –between 2011 and 2015 while the rates of the mothers rose from 17 to 42% during the same period suggests strongly of a positive effect due to the prescription itself.

The vaccination coverage rates measured in our study during the postpartum period are in line with those measured in France in similar conditions (18,20,21). At the Angers University Hospital maternity ward, Leboucher *et al.* reported in 2009 that after they provided women with oral and written information and a prescription for the vaccine, the coverage rate reached 69% in mothers and 62% in their partners (18). A study at the maternity ward at Quimper Hospital, published in 2011, found that the provision of oral and written information and a vaccine prescription was associated with coverage rates of 65% in mothers and 59% in their partners (20). In our study, these rates in mothers and their partners were respectively 44 and 46% in 2011 and then 72 and 60% in 2015.

In 2015, despite the strategy of vaccine prescriptions, the postpartum vaccination rate of 42% observed among the women in our study unimmunized at delivery appears low, especially compared with the 61% rate observed with the same strategy in Quimper in 2011 (21). It is on the other hand, similar to the 38% measured at Tenon Hospital, a university hospital in Paris, in 2009 (19). We have no clear explanations for these low vaccination rates despite prescriptions from university hospital maternity units, but we can suggest two hypotheses. On the one hand, it is possible that the conditions in which the prescription is given are as important as the prescription itself. That is, we know that the healthcare professional's convictions play an essential role in vaccination adherence and we have observed that insufficient recommendations by the physicians and midwives who give the prescriptions can diminish women's desire to be vaccinated (24–26). On the other hand, the multiplicity of information delivered at discharge from maternity unit, the fear of vaccination during breastfeeding, and the lack of time inherent in the postpartum period are all factors that can negatively influence the likelihood of vaccination (18–21).

This vaccination rate, finally fairly low despite the prescription at discharge, has led some teams to offer the mother this vaccination during her postpartum hospitalization. This strategy has resulted in maternal coverage rates reaching 65% in North Carolina (US) (27) and even 75% in Texas (US) (28), but only 47% in Montreal (Canada) (23). Its superiority compared with the simple prescription of vaccine has not been proved. On the one hand, a before-and-after study in France has showed the superiority of vaccination in the maternity department, compared with prescription alone, with a modest but significant progression from 53 to 64% vaccination coverage of parents six weeks after discharge (21). On the other, this strategy faces the costs associated with purchasing the vaccine – approximately 20 € per dose – and with the supplementary time needed to perform the vaccination, which would have to be integrated into the cost of hospitalization. Rather than purchase by the hospital, a family member could purchase it at a pharmacy. Nonetheless, the complexity of this solution presents a risk of failure. The teams at Saint-Julien-en-Genevois and Caen observed refusal rates of 60 and 50%, respectively (21,22). Besides, this strategy of vaccination in the maternity unit does not prevent the prescription of the vaccine if the patient refuses immunization during hospitalization (21,22).

A vaccination strategy called cocooning for parents has appeared in the French guidelines since 2014 (16) and seems to result in coverage rates at six weeks postpartum of 64% for parents (21) and even 83% in mothers (22).

Lastly, these results cannot be discussed without mentioning those of another strategy: immunization of pregnant women with the pertussis vaccine at the beginning of the third trimester. This strategy is aimed at directly protecting infants against pertussis through their transplacental receipt of maternal antipertussis antibodies (4,14,15). This strategy is an alternative to the “cocoon” approach. Cocooning appears reduce the incidence of infantile

pertussis only when at least 65% of family members are immunized (29), a rate that the countries that have adopted this strategy, such as France, Switzerland, and Canada (23,30), do not appear to have reached. In our study, among the women vaccinated postpartum, 24% did not have this injection until were more than a month after they left the maternity unit. This delay limits still further the effectiveness of this strategy (data not shown) (31).

Moreover, the cost-effectiveness interest of the cocooning strategy – which must address several adults to protect one child – turns out to be poorer than vaccination of the pregnant woman only during pregnancy (4,32), now recommended in several countries, including the United States, United Kingdom, Argentina, New Zealand, Belgium, and Israel (4). The vaccination rate for pregnant women reached 82% in Massachusetts in 2013 (US) (33) and 62% in England in 2014 (34); vaccination effectiveness for pertussis may reach 91% in England (35,36).

In conclusion, the results of our study shed important light on the prescription of pertussis vaccine to unimmunized women in the postpartum period. Despite its observational character, our study strongly supports the positive role of this prescription. Nonetheless, it increased the vaccination rate only from 17 to 42% in this population and thus requires that we envision other strategies. Beyond vaccination at the maternity unit, which could give better results, pregnant women can help protect newborns by getting vaccinated during pregnancy, via transplacental transfer of maternal pertussis antibodies to the infant (37,38). This strategy appears the most cost-effective for preventing pertussis in infants. It has been recommended since 2014 by the World Health Organization (36,39) and should be studied as an alternative to the cocooning vaccination still in force in France. If pregnant women would accept a new vaccination during pregnancy, it should certainly improve the rate of protection of newborns during their first months of life (40).

## Declarations of interest: none

## Acknowledgements:

We are grateful to Jo Ann Cahn who helped us in translating this paper and reviewing different drafts.

.

# REFERENCES


1. Mattoo S, Cherry JD. Molecular pathogenesis, epidemiology, and clinical manifestations of respiratory infections due to Bordetella pertussis and other Bordetella subspecies. Clin Microbiol Rev. 2005;18(2):326-82.

2. Tan T, Trindade E, Skowronski D. Epidemiology of Pertussis: Pediatr Infect Dis J. 2005;24:S10-8.

3. World Health Organization. Pertussis vaccines: WHO position paper [Internet]. 2010 [cité 20 sept 2020]. Disponible sur: http://www.who.int/wer/2010/wer8540.pdf

4. Forsyth K, Plotkin S, Tan T, Wirsing von Konig CH. Strategies to Decrease Pertussis Transmission to Infants. PEDIATRICS. 2015;135(6):e1475-82.

5. Liu L, Oza S, Hogan D, Perin J, Rudan I, Lawn JE, et al. Global, regional, and national causes of child mortality in 2000–13, with projections to inform post-2015 priorities: an updated systematic analysis. The Lancet. 2015;385(9966):430-40.

6. Inserm. Coqueluche, La « toux des 100 jours » est revenue [Internet]. 2016 [cité 13 oct 2020]. Disponible sur: https://www.inserm.fr/information-en-sante/dossiers-information/coqueluche

7. Smallridge WE, Rolin OY, Jacobs NT, Harvill ET. Different effects of whole-cell and acellular vaccines on Bordetella transmission. J Infect Dis. 2014;209(12):1981-8.

8. Chiappini E, Stival A, Galli L, de Martino M. Pertussis re-emergence in the post-vaccination era. BMC Infect Dis. 2013;13:151.

9. Tan T, Dalby T, Forsyth K, Halperin SA, Heininger U, Hozbor D, et al. Pertussis Across the Globe: Recent Epidemiologic Trends From 2000 to 2013. Pediatr Infect Dis J. 2015;34(9):e222-232.

10. Burns DL, Meade BD, Messionnier NE. Pertussis resurgence: perspectives from the Working Group Meeting on pertussis on the causes, possible paths forward, and gaps in our knowledge. J Infect Dis. 2014;209 Suppl 1:S32-35.

11. Wendelboe AM, Njamkepo E, Bourillon A, Floret DD, Gaudelus J, Gerber M, et al. Transmission of Bordetella pertussis to young infants. Pediatr Infect Dis J. 2007;26(4):293-9.

12. Wiley KE, Zuo Y, Macartney KK, McIntyre PB. Sources of pertussis infection in young infants: a review of key evidence informing targeting of the cocoon strategy. Vaccine. 2013;31(4):618-25.

13. Cohen R, Gaudelus J, Denis F, Stahl J-P, Chevaillier O, Pujol P, et al. Pertussis vaccination coverage among French parents of infants after 10years of cocoon strategy. Med Mal Infect. 2016;46(4):188-93.

14. Centers for Disease Control and Prevention (CDC). Updated recommendations for use

of tetanus toxoid, reduced diphtheria toxoid, and acellular pertussis vaccine (Tdap) in pregnant women--Advisory Committee on Immunization Practices (ACIP), 2012. MMWR Morb Mortal Wkly Rep. 2013;62(7):131-5.

15. Public Health England. Vaccination against pertussis (whooping cough) for pregnant women [Internet]. 2014. Disponible sur: https://www.gov.uk/government/publications/vaccination-against-pertussis-whooping-cough-for-pregnant-women

16. Haut Conseil de la Santé Publique. Stratégie vaccinale contre la coqueluche chez l'adulte [Internet]. Disponible sur: https://www.hcsp.fr/Explore.cgi/AvisRapportsDomaine?clefr=410

17. Révision. Vaccination anticoquelucheuse [Internet]. Disponible sur: https://www.vaxinfopro.be/IMG/pdf/css_9110_vaccination_coqueluche.pdf

18. Leboucher B, Sentilhes L, Abbou F, Henry E, Grimprel E, Descamps P. Impact of postpartum information about pertussis booster to parents in a university maternity hospital. Vaccine. 2012;30(37):5472-81.

19. Bonneau C, Seror J, Seror E, Hervé F, Lardy L, Rouzier R. [Efficacy of systematic information and prescription of vaccine to implement the recommendations to prevent post-partum pertussis: A limited impact]. Gynecol Obstet Fertil. 2010;38(6):380-4.

20. Rousseau-Gouesnou N, Develay S, Moyo L, Staumont-Straczek H, Jacquot M, Vic P. [Parental information about pertussis vaccination in a maternity ward]. J Gynecol Obstet Biol Reprod (Paris). 2013;42(4):405-6.

21. Durand C, Flament E. [Pertussis vaccination for parents: proposal and evaluation of two professional practices in a maternity hospital]. Arch Pediatr Organe Off Soc Francaise Pediatr. 2011;18(4):362-9.

22. Decréquy A, de Vienne C, Bellot A, Guillois B, Dreyfus M, Brouard J. [Cocooning strategy: Effectiveness of a pertussis vaccination program for parents in the maternity unit of a university hospital]. Arch Pediatr Organe Off Soc Francaise Pediatr. 2016;23(8):787-91.

23. Frère J, De Wals P, Ovetchkine P, Coïc L, Audibert F, Tapiero B. Evaluation of several approaches to immunize parents of neonates against B. pertussis. Vaccine. 2013;31(51):6087-91.

24. Wiley KE, Massey PD, Cooper SC, Wood N, Quinn HE, Leask J. Pregnant women's intention to take up a post-partum pertussis vaccine, and their willingness to take up the vaccine while pregnant: a cross sectional survey. Vaccine. 2013;31(37):3972-8.

25. Johnson DR, Nichol KL, Lipczynski K. Barriers to adult immunization. Am J Med. 2008;121:S28-35.

26. Wong CY, Thomas NJ, Clarke M, Boros C, Tuckerman J, Marshall HS. Maternal

uptake of pertussis cocooning strategy and other pregnancy related recommended immunizations. Hum Vaccines Immunother. 2015;11(5):1165-72.

27. Steiner B, Swamy GK, Walter EB. Engaging expectant parents to receive Tdap vaccination. Am J Perinatol. 2014;31(5):407-12.

28. Healy CM, Rench MA, Baker CJ. Implementation of cocooning against pertussis in a high-risk population. Clin Infect Dis Off Publ Infect Dis Soc Am. 2011;52(2):157-62.

29. Coudeville L, van Rie A, Andre P. Adult pertussis vaccination strategies and their impact on pertussis in the United States: evaluation of routine and targeted (cocoon) strategies. Epidemiol Infect. 2008;136(5):604-20.

30. Urwyler P, Heininger U. Protecting newborns from pertussis - the challenge of complete cocooning. BMC Infect Dis. 2014;14:397.

31. Halperin BA, Morris A, Mackinnon-Cameron D, Mutch J, Langley JM, McNeil SA, et al. Kinetics of the antibody response to tetanus-diphtheria-acellular pertussis vaccine in women of childbearing age and postpartum women. Clin Infect Dis Off Publ Infect Dis Soc Am. 2011;53(9):885-92.

32. Terranella A, Asay GRB, Messonnier ML, Clark TA, Liang JL. Pregnancy dose Tdap and postpartum cocooning to prevent infant pertussis: a decision analysis. Pediatrics. 2013;131(6):e1748-1756.

33. Goldfarb IT, Little S, Brown J, Riley LE. Use of the combined tetanus-diphtheria and pertussis vaccine during pregnancy. Am J Obstet Gynecol. 2014;211(3):299.e1-5.

34. Public Health England. Pertussis Vaccination Programme for Pregnant Women : vaccine coverage estimates in England, September to December 2014 [Internet]. 2015. Disponible sur: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/408500/hpr0715_prtsss-vc.pdf

35. Amirthalingam G, Andrews N, Campbell H, Ribeiro S, Kara E, Donegan K, et al. Effectiveness of maternal pertussis vaccination in England: an observational study. Lancet Lond Engl. 2014;384(9953):1521-8.

36. Dabrera G, Amirthalingam G, Andrews N, Campbell H, Ribeiro S, Kara E, et al. A case-control study to estimate the effectiveness of maternal pertussis vaccination in protecting newborn infants in England and Wales, 2012-2013. Clin Infect Dis Off Publ Infect Dis Soc Am. 2015;60(3):333-7.

37. D'Heilly C, Switzer C, Macina D. Safety of Maternal Immunization Against Pertussis: A Systematic Review. Infect Dis Ther. 2019;8(4):543-68.

38. Sawyer MH, Long SS. Tdap in Every Pregnancy: Circling the Wagons Around the Newborn. PEDIATRICS. 2015;135(6):e1483-4.

39. World Health Organization. Meeting of the Strategic advisory group of experts on immunization, april 2014 – conclusions and recommendations [Internet]. 2014. Disponible sur: https://apps.who.int/iris/bitstream/handle/10665/242217/WER8921_221-236.PDF?sequence=1&isAllowed=y

40. Bellido-Blasco J, Guiral-Rodrigo S, Míguez-Santiyán A, Salazar-Cifre A, González-Morán F. A case-control study to assess the effectiveness of pertussis vaccination during pregnancy on newborns, Valencian community, Spain, 1 March 2015 to 29 February 2016. Euro Surveill Bull Eur Sur Mal Transm Eur Commun Dis Bull. 1 juin 2017;22(22).

Figure 1: Flow chart

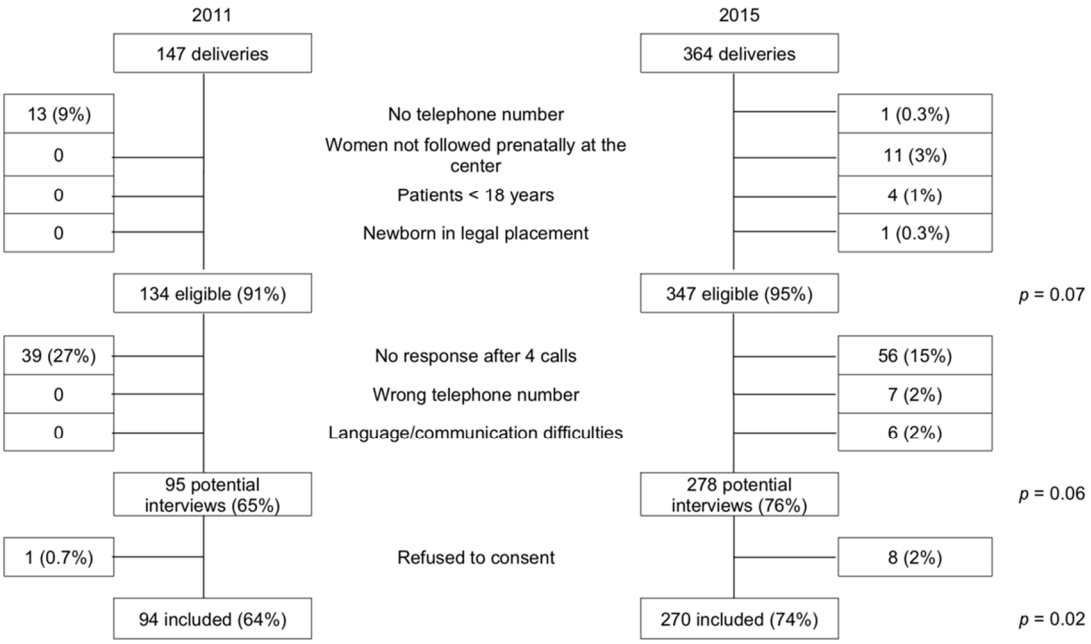


Table 1: Women's characteristics by study period

| | 2011<br>n=94 | 2015<br>n=270 | *p* |
|---|---|---|---|
| Age (years) | 30.0 ± 5.6 | 30.3 ± 5.0 | 0.65 |
| Nulliparous | 44 (47) | 110 (41) | 0.30 |
| Educational level ≥ baccalaureate exam | 76 (81) | 200 (74) | 0.44 |
| Vaginal delivery | 75 (80) | 224 (83) | 0.49 |
| Breastfeeding on D4 | 62 (66) | 200 (74) | 0.13 |

Table 2: Vaccination status of women by study period

| | 2011 | 2015 | *p* |
|---|---|---|---|
| Postpartum vaccination among unimmunized women | 11/64(17) | 54/130(42) | <0.001 |
| - Nulliparous | 7/31(23) | 31/59(53) | 0.006 |
| - Parous | 4/33(12) | 23/71(32) | 0.028 |
| Immunized women at the beginning of the pregnancy | 30/94 (32) | 140/270 (52) | <0.001 |
| - Nulliparous | 13/44 (30) | 51/110 (46) | =0.05 |
| - Parous | 17/50 (34) | 89/160 (56) | 0.008 |
| Total immunized women postpartum | 41/94(44) | 194/270(72) | <0.001 |
| - Nulliparous | 20/44(45) | 82/110(75) | <0.001 |
| - Parous | 21/50(42) | 112/160(70) | <0.001 |

401

Table 3: Vaccination status of partners by study period

| | 2011 | 2015 | *p* |
|---|---|---|---|
| Vaccination during or after pregnancy among unimmunized partners | 18/68(27) | 39/136(29) | 0.74 |
| - Nulliparous | 13/34(38) | 29/65(45) | 0.54 |
| - Parous | 5/34(15) | 10/71(14) | 0.93 |
| Immunized partners at the beginning of the pregnancy | 24/92(26) | 109/245(45) | 0.008 |
| - Nulliparous | 10/44(23) | 33/98(34) | 0.19 |
| - Parous | 14/48(29) | 76/147(52) | 0.007 |
| Total immunized partners postpartum | 42/92(46) | 148/245(60) | <0.001 |
| - Nulliparous | 23/44(52) | 62/98(63) | 0.22 |
| - Parous | 19/48(40) | 86/147(59) | 0.02 |

402

Table 1: Women's characteristics by study period

| | 2011<br>n=94 | 2015<br>n=270 | *p* |
|---|---|---|---|
| Age (years) | 30.0 ± 5.6 | 30.3 ± 5.0 | 0.65 |
| Nulliparous | 44 (47) | 110 (41) | 0.30 |
| Educational level ≥ baccalaureate exam | 76 (81) | 200 (74) | 0.44 |
| Vaginal delivery | 75 (80) | 224 (83) | 0.49 |
| Breastfeeding on D4 | 62 (66) | 200 (74) | 0.13 |

Table 2: Vaccination status of women by study period

| | 2011 | 2015 | *p* |
|---|---|---|---|
| Postpartum vaccination among unimmunized women | 11/64(17) | 54/130(42) | <0.001 |
| - Nulliparous | 7/31(23) | 31/59(53) | 0.006 |
| - Parous | 4/33(12) | 23/71(32) | 0.028 |
| Immunized women at the beginning of the pregnancy | 30/94 (32) | 140/270 (52) | <0.001 |
| - Nulliparous | 13/44 (30) | 51/110 (46) | =0.05 |
| - Parous | 17/50 (34) | 89/160 (56) | 0.008 |
| Total immunized women postpartum | 41/94(44) | 194/270(72) | <0.001 |
| - Nulliparous | 20/44(45) | 82/110(75) | <0.001 |
| - Parous | 21/50(42) | 112/160(70) | <0.001 |

Table 3: Vaccination status of partners by study period

| | 2011 | 2015 | *p* |
|---|---|---|---|
| Vaccination during or after pregnancy among unimmunized partners | 18/68(27) | 39/136(29) | 0.74 |
| - Nulliparous | 13/34(38) | 29/65(45) | 0.54 |
| - Parous | 5/34(15) | 10/71(14) | 0.93 |
| Immunized partners at the beginning of the pregnancy | 24/92(26) | 109/245(45) | 0.008 |
| - Nulliparous | 10/44(23) | 33/98(34) | 0.19 |
| - Parous | 14/48(29) | 76/147(52) | 0.007 |
| Total immunized partners postpartum | 42/92(46) | 148/245(60) | <0.001 |
| - Nulliparous | 23/44(52) | 62/98(63) | 0.22 |
| - Parous | 19/48(40) | 86/147(59) | 0.02 |