



Child-parent immunization survey: How well are national immunization recommendations accepted by the target groups?

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ABSTRACT

Background: Pertussis disease rates are high in Switzerland, especially in infants and young infants. To protect newborns from this serious disease, EKIF, the Swiss National Immunization Technical Advisory Group, has recommended vaccination against pertussis during pregnancy (2nd or 3rd trimester) since 2013. Also, since 2009, EKIF has recommended vaccination against influenza during pregnancy.

We conducted this study to assess acceptance and implementation of these recently introduced recommendations.

Methods: We performed standardized interviews with parents of children born on or after 01.01.2013, hospitalized at the University of Basel Children's Hospital, Switzerland, between January and June 2017. If participation was declined, partial consent was sought for four questions regarding age, education level, attitudes towards vaccinations in general and availability of vaccination records.

Results: In 193 of 398 eligible children the mother participated. Five (3%) of 172 mothers had received both pertussis and influenza vaccines during pregnancy, 15 (9%) only against pertussis and 12 (7%) only against influenza. Very few mothers had received vaccination recommendation during pregnancy: 17 (10%) for both pertussis and influenza and 15 (9%) each for pertussis and influenza only. Main reasons for refusal of vaccination despite recommendation were that they were not deemed useful (59% for influenza and 37% for pertussis) and safety concerns for the child (18% for influenza and 26% for pertussis). **Conclusions:** Recommendation for and immunization rates against pertussis and influenza during pregnancy are low and need to be improved. As recommendations from health care personnel have been shown to have the most significant impact on immunization rates, we propose to focus on improving awareness and acceptance for immunization in pregnancy among health care personnel involved in the care of pregnant women.

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1. Background

Despite satisfactory vaccination coverage rates in Switzerland, the burden of pertussis is still high, especially in infants and young children. In fact, reported cases have been on the rise in the last decades making it the most common vaccine preventable disease in Switzerland, next to influenza [1–4]. The clinically most severely affected age groups are infants and young children, with potentially life-threatening complications such as pneumonia, respiratory failure and encephalopathy [5–7]. Adults, especially parents of young children, have been shown to be one of the main sources of transmission of *B. pertussis* to young infants [8–10].

In view of these findings, the Swiss National Immunization Technical Advisory Group (Eidgenössische Kommission für Impffragen, EKIF) has recently recommended several changes in the pertussis immunization schedule aimed at improving protection for young infants:

- First, in 2011, a booster dose was introduced for adults 25–29 years of age, to be administered in combination with diphtheria and tetanus toxoids (“Tdap”) [1]. Also, regardless of age, all individuals ≥ 16 years of age with regular contact to infants <6 months of age are advised to receive a dose of pertussis containing vaccine, unless they had received their last pertussis vaccine dose <10 years ago. This strategy, which aims to protect young infants from acquiring pertussis from their close contact persons, is known as “cocooning” [9,11,12].

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- Then, in 2013, EKIF recommended immunization against pertussis for pregnant women in the 2nd or 3rd trimester, unless they had received their last pertussis vaccine dose <5 years ago (Note: since 2017, pregnant women should receive a pertussis vaccine in every pregnancy). The goal of this recommendation is to provide passive protection for the child via transplacental transfer of specific anti-pertussis toxin antibodies from the mother [13–15].

Pregnant women also have an increased risk of complications due to influenza [16,17]. This has prompted EKIF to recommend immunization against influenza for pregnant women in Switzerland in late 2009 during the influenza pandemic [18].

No data are available on the practice of recommendations by health care professionals and the acceptance and implementation of these recently endorsed recommendations regarding pertussis and influenza immunizations in pregnant women. Therefore, we performed this observational study among parents of children in the concerned age groups, hospitalized at the University of Basel Children's Hospital (UKBB). Furthermore, we assessed the impact of individual counseling of parents by health care professionals regarding immunization gaps in general.

2. Methods

2.1. Study design and population

We designed a survey to interview parents of children who were hospitalized at the UKBB on general pediatric or surgical and orthopedic wards during the study period. For the parents to be eligible, their child had to be born on or after 01.01.2013 and at least 6 months of age at the time of hospitalization. Furthermore, current residence of the family, country of birth of the child and medical care of the mother during pregnancy had to be in Switzerland, which ensured that the study participants were concerned by the revised immunization recommendations regarding pertussis and influenza. Parents of children born before 33 weeks of gestation and/or with a birth weight of <1500 g (with a different immunization schedule) as well as parents of adopted children were excluded. Further exclusion criteria were lack of understanding German, French or English, prior study inclusion of a child's sibling, as well as repeated hospitalization of the child when the parent(s) had already participated in the study previously.

2.2. Recruitment and data collection

Study enrollment took place on a weekly basis according to the investigator's (MLE) availability between January and June 2017. Screening for eligibility based on birth date, country of residence and multiple hospitalizations during the study period was done using the UKBB's clinic information system. Then, a personal approach of the child's parents was attempted in order to assess the remaining exclusion criteria. In case of a successful approach, the study was briefly explained by the investigator and detailed information and consent form was distributed in written form to all eligible parents. Based on the expected hospital discharge date, a second approach was made either later on the same day or during the course of the following days in order to obtain written consent, perform the interview with the mother and/or the father and to obtain the vaccination records of the child and participating parent(s), if available. In those instances where study participants did not provide the vaccination records while in hospital, a reminder was sent per e-mail, by phone or text message several days after participation.

Parents were asked to give consent for the complete interview. If they declined, they were asked to give consent for a partial interview consisting of four questions regarding age, education level, attitudes towards vaccinations in general and availability of vaccination records. Parents who gave consent for the complete interview were offered vaccination counseling for free, based on their documented vaccinations.

Parental vaccination status was categorized as "up to date" if:

- ≥ 3 doses of diphtheria, tetanus and inactivated poliomyelitis (dT-IPV) vaccines
- ≥ 1 acellular pertussis component (p_a) vaccine <10 years (fathers) or <5 years before birth of child (mothers) or at any time after birth of child (mothers and fathers)
- ≥ 2 doses of measles-mumps-rubella (MMR) vaccine (unless born before 1964 in which case no MMR is recommended in Switzerland)
- >3 doses of hepatitis B vaccine (HBV) or 2 doses with full antigen content (formulation for adults) if immunized at 11–15 years of age were documented

2.3. Study interview

The standardized interview was divided into three sections, the first containing questions to be answered by the mother, the second containing questions to be answered by the father (Appendix 1). The final section contained questions concerning the child, which were posed to the first participating parent if both parents took part.

The first two sections included questions concerning the parent's last physician visits and last consultation of vaccination records by a physician, recommendations for vaccinations for the parent against pertussis after birth of the child, basic demographic information, and general attitudes towards vaccinations. Participating mothers were additionally interviewed concerning recommendations for and performance of vaccinations against pertussis and influenza during pregnancy.

Education level was categorized according to the International Standard Classification of Education (ISCE) [19].

Data from the interviews was electronically captured via secutrial (www.secutrial.com), a web-based data capture application.

2.4. Ethics

The study was approved by the Ethical Committee of Northwestern- and Central Switzerland, EKNZ, in November 2016 (Project-ID 2016-01894).

2.5. Statistics

Sample size was calculated so that the number of participants would allow to obtain a 95% confidence interval (95% CI) for the proportion of mothers who received immunization against pertussis and/or influenza during pregnancy that is not wider than 12% in 90% (power) of hypothetical study repetitions. Sample size was estimated using a simulation approach. Based on clinical experience, we assumed the proportion of mothers who received immunization against pertussis and/or influenza during pregnancy would be 20%. Therefore, 199 participants were initially planned to be recruited. Sample size re-estimation was carried out after 50% ($N = 100$) of interviewees had been recruited. With a calculated proportion for the primary outcome of 14% instead of 20% and with a CI not wider than 12%, sample size re-estimation resulted in 164.

For the primary research question a 95% CI was calculated by normal approximation. For all other calculated frequencies, no

inference was done. All analyses of secondary research questions are exclusively exploratory.

Data was analyzed using R language and environment (www.r-project.org).

3. Results

3.1. Study subjects and general findings

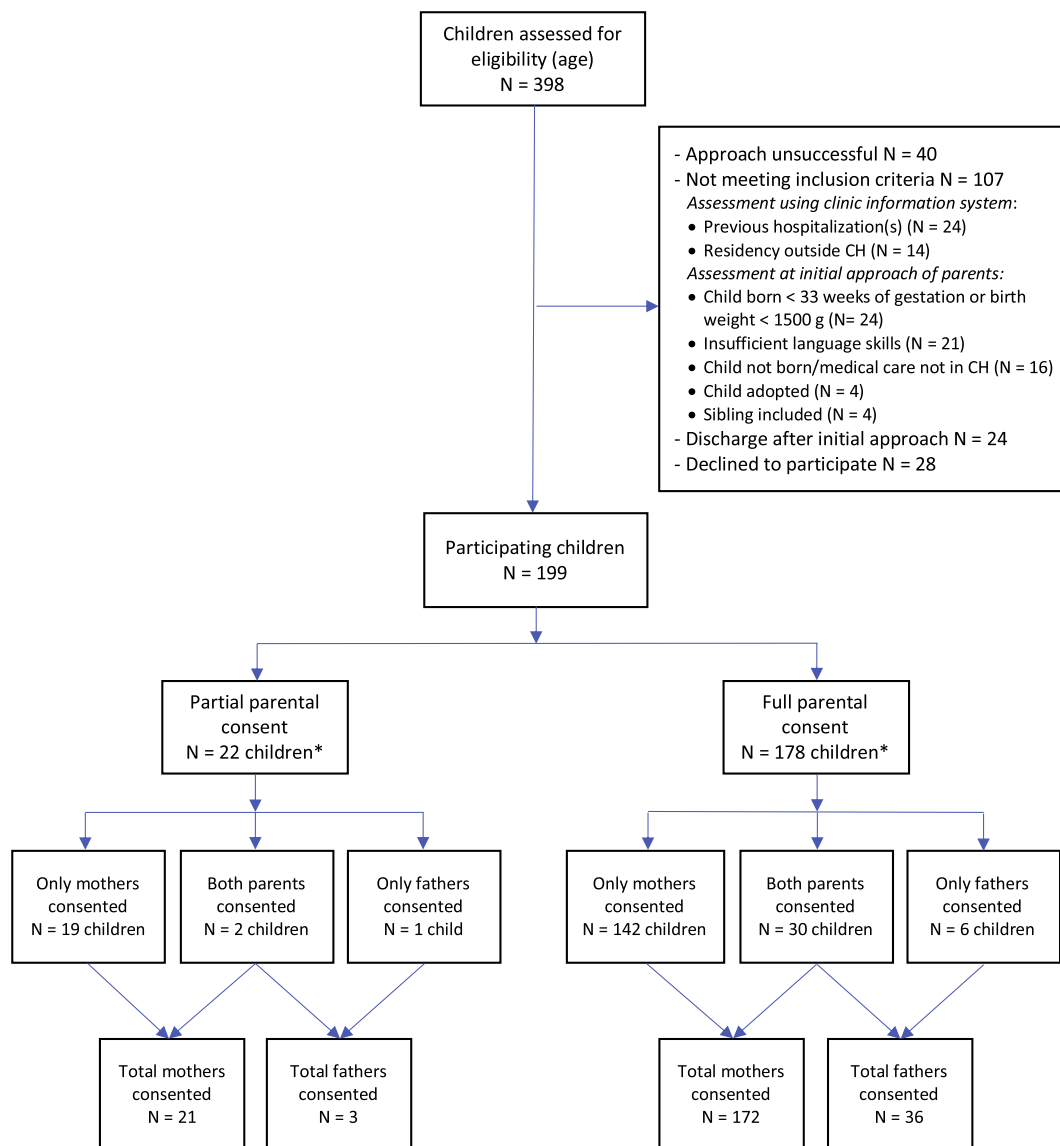
A total of 398 children who met the age criteria were screened for eligibility (Fig. 1). In 38 (10%) children, exclusion criteria were identified by use of the clinic information system. Further, repeated attempts to approach a parent failed in 40 (10%) children. Parents of the remaining 320 children were approached and informed about the study by the study investigator (MLE). During these first visits, further exclusion criteria were revealed in 69 (22%) of 320 children. Twenty-four (7%) children were discharged

before formal consent for participation could be obtained during the second approach by the study investigator. Finally, 227 children remained eligible. In 28 of them (12%) parents declined study participation whereas 199 (50%) of the original 398 children and 193 (48.5%) and 39 (9.8%) of their mothers and fathers, respectively, were enrolled. Here we report the findings regarding the mothers and their children.

In 172 (86.4%) children, the mother gave consent for a complete interview, in 21 (10.6%) children, the mother gave consent for a partial interview.

General characteristics of the study population including all participating mothers and the population including only mothers with consent for complete interview are shown in Table 1. The great majority of mothers had a positive or mostly positive attitude towards vaccinations: 163/172 = 94.7% in the group who gave full consent and 18/21 = 85.7% in the group who gave partial consent.

The following analyses are based on interviews with mothers who gave full consent for study participation.



* Note: in one child the father gave full consent while the mother gave partial consent

Fig. 1. Study Flow Chart.

Table 1
General characteristics of participating mothers and children.

Mothers	Partial and full consent	Full consent	
<i>Age (in years)</i>			
N Total	193	172	
Mean	33.7	33.7	
SD	5.0	5.1	
Median	33	33	
IQR	31–37	30–37	
Range	21–47	21–47	
<i>Educational level^a</i>			
N Total	193	172	
N (%;95%CI) Compulsory School (0–3)	21 (10.9; 7–16.4)	18 (10.5; 6.5–16.3)	
N (%;95%CI) Apprenticeship (4)	76 (39.4; 32.5–46.7)	68 (39.5; 32.3–47.3)	
N (%;95%CI) Higher Education (5–8)	96 (49.7; 42.5–57)	86 (50; 42.6–57.4)	
<i>Attitude towards vaccination</i>			
N Total	193	172	
N (%;95%CI) Negative	2 (1; 0.2–4.1)	2 (1.2; 0.2–4.6)	
N (%;95%CI) Mostly negative	10 (5.2; 2.7–9.6)	7 (4.1; 1.8–8.5)	
N (%;95%CI) Mostly positive	59 (30.6; 24.3–37.7)	51 (29.7; 23.1–37.2)	
N (%;95%CI) Positive	122 (63.2; 55.9–69.9)	112 (65.1; 57.4–72.1)	
<i>Vaccination record existent</i>			
N total	193	172	
N (%;95%CI) Record existent	151 (78.2; 71.6–83.7)	134 (77.9; 70.8–83.7)	
N (%;95%CI) Record available		73 (42.4; 35–50.2)	
<hr/>			
Children (by age groups)	Girls	Boys	Total
N total	78	100	178
N (%;95%CI) 6 – <12 months (group 1)	26 (33.3; 23.3–45)	29 (29.0; 20.6–39.1)	55 (30.9; 24.3–38.3)
N (%;95%CI) ≥ 12 – <24 months (group 2)	18 (23.1; 14.6–34.2)	32 (32.0; 23.2–42.2)	50 (28.1; 21.7–35.4)
N (%;95%CI) ≥ 24–48 months (group 3)	34 (43.6; 32.6–55.3)	39 (39.0; 29.6–49.3)	73 (41.0; 33.8–48.6)
<i>Vaccination records</i>			
N total	78	100	178
N (%;95%CI) with available record	47 (60.3; 48.5–71)	63 (63.0; 52.7–72.3)	110 (61.8; 54.2–68.9)
N (%;95%CI) 6 – <12 months (group 1)	15 (57.7; 37.2–76)	19 (65.5; 45.7–81.4)	34 (61.8; 47.7–74.3)
N (%;95%CI) ≥ 12 – <24 months (group 2)	13 (72.2; 46.4–89.3)	19 (59.4; 40.8–75.8)	32 (64.0; 49.1–76.7)
N (%;95%CI) ≥ 24–48 months (group 3)	19 (55.9; 38.1–72.4)	25 (64.1; 47.2–78.3)	44 (60.3; 48.1–71.3)

IQR = interquartile range; SD = standard deviation; CI = confidence interval.

^a According to International Standard Classification of Education Levels.

3.2. Immunizations during pregnancy

Of 172 mothers, 5 (2.9%; 95% CI: 1.1–7.0%) were in accordance with the recommendations for both influenza and pertussis immunizations, 12 mothers (7.0%; 95% CI: 3.8–12.2%) had received only influenza immunization and 15 (8.7%; 95% CI: 5.1–14.2%) were up to date only for pertussis immunization. Of the 20 mothers up to date with pertussis immunizations, 11 had received their immunizations during pregnancy and 9 had received them <5 years before pregnancy.

Recommendation rates and reasons for lack of immunization during pregnancy are shown in Table 2.

In total, 47 (27.3%) of 172 mothers received a recommendation for immunization against pertussis and/or influenza during pregnancy. However, only 13 (40.6%) of 32 women who received a recommendation to be immunized against pertussis and 15 (46.8%) of 32 women who received a recommendation to be immunized against influenza, actually accepted and received the vaccinations. The most frequent reason for maternal refusal of pertussis and influenza immunizations was that the immunization was not deemed useful. The second most frequent reason for both immunizations was safety concerns for the child. In the case of influenza immunization, also safety concerns for the mothers themselves were expressed.

Maternal age is likely to have no influence on acceptance of pertussis and/or influenza immunizations, non-compliance was evenly distributed across the six age groups with the highest non-compliance (100%, N = 2) in 46–50 year old individuals and

the lowest proportion (87.5%, N = 8) in those 20–25 years old. Regarding the year of birth of the child and immunizations in pregnancy, a trend towards an increase over time from 2013 to 2016 concerning compliance with pertussis immunization can be observed, with 3 mothers (4.3%) each having received pertussis immunization in 2013 and 2014, 5 mothers (10.2%) in 2015 and 7 mothers (13%) in 2016. Regarding maternal education level and acceptance of pregnancy immunization recommendations, compliance with influenza immunization was higher in mothers with higher education (N = 11/86, 12.8%) compared to mothers with basic education (N = 0/18, 0%) and mothers with medium level of education (N = 1/68, 1%). Compliance with pertussis immunization and for both immunizations combined showed no such association.

3.3. Immunizations in mothers after birth of their child

Overall, 64 (37.2%) mothers had received a recommendation for immunization against pertussis after birth of their child, with 32 (50%) of them following the recommendation. Main reasons for non-compliance with the recommendation were the notion that pertussis immunization was already up to date, that it was not considered useful, and that the recommendation had been forgotten.

Pertussis immunization was predominantly recommended by pediatricians (N = 22, 68.7%) while administration ensued to almost equal parts through pediatricians and general practitioners (N = 14, 43.8%, and N = 13, 40.6%). Pertussis immunization was recommended by gynecologists to 3 mothers (9.3%) and administered to 1 mother (3.1%).

Table 2Reasons for refusal of recommended immunizations[§] against pertussis and/or influenza during pregnancy.

Reasons for refusal [*]	Pertussis N (%) ^{**}	Influenza N (%) ^{**}
	19	17
Deemed not useful	7 (36.8)	10 (58.8)
Safety concerns for child	5 (26.3)	3 (17.6)
Forgotten/no time	3 (15.8)	2 (11.8)
Safety concerns for oneself	1 (5.3)	3 (17.6)
No reason	0 (0)	0 (0)
Other reasons: Pertussis up to date	3 (15.8)	not applicable
Other reasons (except pertussis up to date) ^{***}	4 (21.1)	6 (35.3)

^{*} multiple answers possible.^{**} % of individuals -> total is > 100% because of multiple possible answers.^{***} Other reasons regarding pertussis vaccination: "recommendation by gynecologist to vaccinate after birth of child (2); only useful if everybody vaccinates; friend had negative experience with pertussis immunization in the past". ^{***}Other reasons regarding influenza vaccination: "negative experience with influenza vaccination in the past (3); against vaccinations in general; protection against influenza is sufficient with hygienic sanctions; influenza season already passed".[§] Recommendations received and proportions accepted.

	Pertussis N (%)	Influenza N (%)	Pertussis + Influenza + Counseling N (%)	Pertussis + Influenza + Counseling N (%)	Recommendation not received N (%)	Unknown if recommendation received N (%)	Total N (%)
Recommendation received	15 (8.7)	15 (8.7)	12 (7)	5 (2.9)	119 (69.2)	6 (3.5)	172 (100)
Pertussis vaccination accepted	6 (40)	-	4 (33.3)	3 (60)	-	-	13 (7.5)
Influenza vaccination accepted	-	8 (53.3)	6 (50)	1 (20)	-	-	15 (8.7)

3.4. Assessment of maternal immunization status during medical consultations

All 172 mothers had 1 or more physician contacts in the last 5 years before study participation, mainly with general practitioners and gynecologists. Yet, only 94 (54.6%) of them reported that the last assessment of their immunization status by a physician was <5 years ago: <1 year ago in 24 mothers (14%) and ≥1 – <5 years ago in 70 mothers (40.7%). In only 18 (10.5%) mothers immunization records were assessed during their last medical consultation. In mothers, missed opportunities for immunization record assessments were similar between general practitioner (N = 68, 44.2%) and gynecologist (N = 66, 42.9%) visits.

3.5. Immunization scores

We developed individual immunization scores for mothers and children with the goal to quantify and compare completeness of immunization status (Appendix 2). Total immunization scores were highest with a mean of 6 (standard deviation, SD: 5.2) of a maximum possible score of 15 in the group of mothers with a positive attitude towards immunization. Concerning MMR immunization scores, the highest mean of 2.6 (SD: 2.3) of a maximum possible score of 5 was reached in the group of mothers with a positive attitude towards immunizations. A trend that an up-to-date immunization status of children correlated with a positive maternal attitude concerning vaccinations was noted: Children of mothers with mostly positive and positive attitude towards immunization reached high mean (SD) scores in all three age groups: 3 (0) and 2.8 (0.8) of a maximum of 3 in group 1, 5.7 (1.1) and 5.8 (0.7) of a maximum of 6 in group 2, and 9.6 (0.9) and 9.5 (1.9) of a maximum of 10 in group 3.

3.6. Immunization counseling for mothers during hospitalization of the child

We offered immunization counseling to all study participants and 58 (33.7%) of 172 mothers were interested. However, only 43 (25.0%) provided immunization records as the basis for

individual counseling. Of these, 13 (30.2%) were up to date with all generally recommended immunizations for adults, the remaining 30 mothers had 1 or more gaps and received recommendations for catch up or booster immunizations accordingly. Follow-up on the outcome of counseling 4–6 weeks later was successful in 19 (63.3%) of 30 mothers. Of these, 5 (26.4%) had received the recommended vaccination(s) in the meantime.

4. Discussion

In this study we assessed the compliance with recently implemented recommendations for immunizations against pertussis and influenza during pregnancy in the region of Basel in Switzerland. Our results showed a disappointingly low rate of immunizations in pregnancy in mothers who had given birth in recent years. There are two main reasons for this finding: (1) lack of recommendation by the women's gynecologists and (2) lack of compliance in many pregnant women who had received a recommendation for vaccinations during pregnancy.

Studies in other countries where pertussis immunization is recommended for pregnant women showed immunization rates to be in the range of 13–86% [20–24]. Similarly, rates for influenza immunization range from 20 to 66% [20,21,24,25]. The two main reasons for refusal stated by the women were that the immunizations were not deemed useful and safety concerns. Both reasons are not supported by available data. Immunization in pregnancy is unique in that it serves to protect the mother and the infant. Transferred maternal antibodies have been shown to be highly protective during the first months of the infant's life, i.e. during the time where risk of complications with influenza and pertussis is highest [26–28]. Multiple studies have shown influenza and pertussis immunizations to be safe and effective during pregnancy, a fact that needs to be communicated to expecting mothers [29–36]. A systematic review on influenza vaccine hesitancy in pregnant women showed that lack of confidence (which was defined to include high perceived risk of the vaccine), strong worry about safety of the vaccine, low perceived effectiveness of the vaccine, and misconceptions about the disease or vaccine played

the most important role in refusal of influenza immunization [37]. Evidently, more information is also needed for pregnant women concerning potential complications of influenza and pertussis for their children to be born and that this risk can be reduced significantly by safe and effective immunizations during pregnancy. The fact that the great majority of mothers state mostly positive or positive attitudes towards vaccinations in general is an ideal basis for the success of individual counseling or public information campaigns. Since vaccinations are covered by health insurances (at no extra costs for pregnant women) and can be received in every physician's office in Switzerland, access to vaccines should not be an issue for pregnant women.

Increased efforts need to be made to sensitize gynecologists and other health care professionals who care for pregnant women on the benefits of immunization during pregnancy. Reasons why recommendation rates are this low need to be evaluated, but such studies have not yet been performed in Switzerland. A study in Israel addressing exactly this question showed that health professionals' most important concerns were vaccine safety and efficacy during pregnancy [38]. It is essential to know if failure to recommend vaccination during pregnancy in Switzerland also stems primarily from concerns regarding safety and efficacy, or possibly from unawareness concerning current EKIF recommendations, general vaccine hesitancy or priority/time management issues, where health care professionals are not prepared to allot time to an additional topic in an already busy appointment with the pregnant woman.

Health care personnel have been shown to have the largest influence on vaccine acceptance [39–42]. Therefore, tailored educational activities aiming at health care professionals involved in the care of pregnant women, including midwives, need to be developed.

Second, information campaigns to sensitize pregnant women about the benefits and safety of immunizations in pregnancy are urgently needed, because safety concerns for the child were a major reason for declining immunizations in pregnancy. Parental knowledge about pertussis has been shown to be insufficient [41,43,44]. In a study previously conducted by members of our group, only 37% of questioned parents were able to answer three questions on pertussis correctly [43]. In a Canadian study, only a mean of 10 out of 19 questions concerning pertussis were answered correctly [40]. Providing accurate information online in addition to printed brochures may serve the needs nowadays so that pregnant women have easy access to trustworthy and useful information.

With regards to pertussis, recommendation rates after birth of the child were higher than during pregnancy, i.e. 37% versus 18%, and acceptance of the respective recommendations rates were similar (50% versus 41%). The slightly higher acceptance rate after birth of the child might be due to the fact that immunization then does not occur during pregnancy. Safety concerns as a reason for refusal of pertussis immunization after birth of the child are less important than during pregnancy.

A study conducted in 2012/2013 by members of our group in the same region consisted of a cross-sectional survey amongst parents of newborns to assess their knowledge about pertussis and the recommendation and implementation of cocooning. Results showed recommendation rates of 20% and 37% in 2012 and 2013, respectively, in mothers and 14% and 32%, respectively, in fathers, with acceptance rates of 64% in mothers and 59% in fathers [43]. Unfortunately, when comparing these figures with this current study, apparently no progress regarding implementation of cocooning has been made during the last several years. An Australian and a Canadian study conducted in 2013 showed similarly unsatisfactory vaccination rates with regards to cocooning [45,46].

With almost half of pertussis immunizations being administered to parents by pediatricians, the option of receiving the vaccination on-site during a consultation with the child without the need to arrange a separate consultation for themselves with another doctor apparently is worthwhile being further explored as an important opportunity to improve immunization rates amongst parents. Ideally, appropriate immunization recommendations are given to parents during their stay on the maternity ward, with a follow-up on the occasion of the first well baby visit with the pediatrician.

However, parental immunization after the birth of the child is only the second best option compared to the benefits of immunization during pregnancy along with catch-up immunizations for the father.

Unfortunately, review of their patients' immunization status is of low priority for many primary care physicians and gynecologists, as demonstrated by the high proportion of missed opportunities during consultations stated in the interviews in our study. Specifically, no review of their immunization status had occurred for at least five years in 45.3% of participating mothers. This is of concern, given that immunization gaps are substantial: only 30% of mothers who had immunization records available in our study were up to date with their immunizations. This is supported by the fact that maternal immunization scores were low with a mean of 6 points (maximum 15 points) even among those with a positive attitude towards immunizations in general who claim to accept all immunization recommendations. A Swiss study conducted by Valeri et al. in 2014 further confirms significant immunization gaps in adults. Individuals were invited to bring their immunization records to pharmacies for a free evaluation of immunization status. Rates for up to date tetanus immunization with five or six doses were 56% and 44% and those for diphtheria were 45% and 34% [47].

Given that immunization records in Switzerland are primarily paper based, data collection of documented immunizations was cumbersome for the participants and the investigators in this study. It is not hard to imagine that this also poses a problem in routine and emergency consultations where patients rarely have their vaccination records available. Only 77% of all mothers who took part in the full interview stated to have vaccination records. Documentations could then only be made available by 42% of them, which may indicate that they were missing. Of concern is the fact that these are mothers of young children for whom an up-to-date immunization status is particularly important. This problem could be avoided to the largest extent by introducing electronic immunization records with the possibility of remote accessing and updating according data whenever necessary by a physician or the patients themselves. In Switzerland, electronic documentation of vaccination records on a voluntary basis has been available since 2012 via www.meineimpfungen.ch or the associated application "MyViavac". Individuals can either document their vaccinations themselves or let existing written records get documented by professionals with advice on missing vaccinations as well as the option to receive reminders for updates. So far, electronic documentation has been poorly used with merely 150'000 registrations (<2% of the population) since its launch. However, a 20% increase in new registrations has been observed during 2017. Currently, campaigns supported by the Swiss Federal Office of Public Health with the goal to increase awareness in medical personnel are being ensued in an effort to promote the use of electronic vaccination records [48].

Our study has strengths and limitations. A strength is the personal interview that was conducted by the same investigator with every participant. Since the present results originate from these interviews, recall bias cannot be excluded and in fact, various mothers mentioned not being completely certain if a

recommendation had been made or if an immunization had been administered or not. Of note, comparisons with available immunization records revealed several instances where mothers had claimed to be immunized but in fact were not and vice versa. This observation also reveals a lack of interest and competence in health issues among mothers in our region. This is further supported by the fact that only about one third of all mothers showed interest in immunization counseling. Arguably one can state that a setting in the hospital is challenging for this type of intervention with mothers preoccupied with their sick child. On the other hand, none of the children were in a critical state of health as the intensive care unit was not included in our study. Strategies for a more suitable access to mothers need to be explored, for example during routine pediatrician or family doctor visits.

Due to the fact that enrollment took place on a weekly basis, subject to the investigator's availability, and that not all eligible parents could be approached at all or revisited after distribution of the study information, selection bias cannot be excluded, however we assume this to be negligibly small. Restriction to one region of Switzerland is a limitation of the study, posing a possible bias.

A major limitation is the limited sample size for secondary endpoints. Therefore, assessment of trends was difficult. However, sample size calculation for our defined primary endpoint, i.e. the proportion of mothers who received immunization against pertussis and/or influenza, was achieved.

Recommendation for pertussis immunization may not have been made because the gynecologist knew from existing documentation from a preceding pregnancy that a patient's pertussis immunization status was currently up to date (pertussis immunization having ensued during or after a preceding pregnancy). However, we expect the number of these cases to be negligibly small. The observed results for influenza need to be interpreted with caution as in those cases where pregnancy did not occur during an influenza season, immunization against influenza was not to be recommended. We did not differentiate our findings according to seasonality of the pregnancy.

In conclusion, recommendation and rates for immunizations against pertussis and influenza during pregnancy (and cocooning) are insufficient and this must urgently be improved. This should be feasible because vaccines are free of charge for pregnant women in Switzerland. In our opinion, primarily health care personnel involved in the care of pregnant women should be sensitized and educated on the topic to increase recommendation rates. As a further step, trustworthy information on the benefits of immunization needs to be provided to pregnant women.

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Conflicts of interest

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Appendix A. Supplementary material

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