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Full length article

Interventional study to improve pertussis and influenza vaccination uptake in pregnant women

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ABSTRACT

Objectives: Pertussis and influenza are endemic infections and associated with relevant morbidity and mortality in newborns and young infants. The Swiss Federal Office of Public Health has recommended influenza vaccination since 2011 and pertussis vaccination in pregnancy (ViP) since 2013 and expanded to repetition in each pregnancy since 2017. ViP is safe and effective in preventing severe diseases, but implementation is a challenge. We hypothesized that the proportion of women receiving ViP is persistently low despite existing national recommendations.

Our primary objective was to compare the proportion of pertussis and influenza vaccine recommendations for and its acceptance by pregnant women before and after an information campaign tailored to obstetricians. Secondly, we aimed to identify reasons for missing or declining ViP.

Study design: We conducted a prospective, single-center, single-arm implementation study in the maternity ward at the University Women's Hospital Basel. We performed standardized interviews with women hospitalized for postpartum care before (October to December 2019, Phase 1, n = 262) and after an information campaign (October to December 2020, Phase 2, n = 233) and compared categorical variables using chi-squared or Fisher's exact test and continuous variables using Whitney Mann *U* test.

Results: We found no significant differences in the proportion of recommendation for pertussis ViP (80 % vs. 84 %, p = 0.25) and implementation (76 % vs. 78 %, p = 0.63) between Phase 1 and 2. Main reasons for missing or declining vaccinations were lack of recommendation (62.8 %) and safety concerns regarding the unborn child (17.7 %).

In contrast, the proportion of recommendation for influenza ViP (45 % vs. 63 %, p < 0.001) and implementation (29 % vs. 43 %, p < 0.001) increased significantly.

Conclusion: Proactive recommendations by obstetricians play a key role in the implementation of ViP but is still insufficient in our setting. We believe that future efforts should aim to explore possible hurdles that impede recommendations by obstetricians for ViP. The focus should be on the needs and experiences of obstetricians in private practice, but also other health care professionals involved in care of pregnant women. Local campaigns do not seem effective enough, therefore national campaigns with new strategies are desirable.

Introduction

Bordetella pertussis and influenza infections are endemic with intermittent epidemics worldwide. In particular, pertussis is associated with relevant morbidity and mortality in newborns and young infants [1,2]. The incidence of hospitalization due to pertussis in Switzerland

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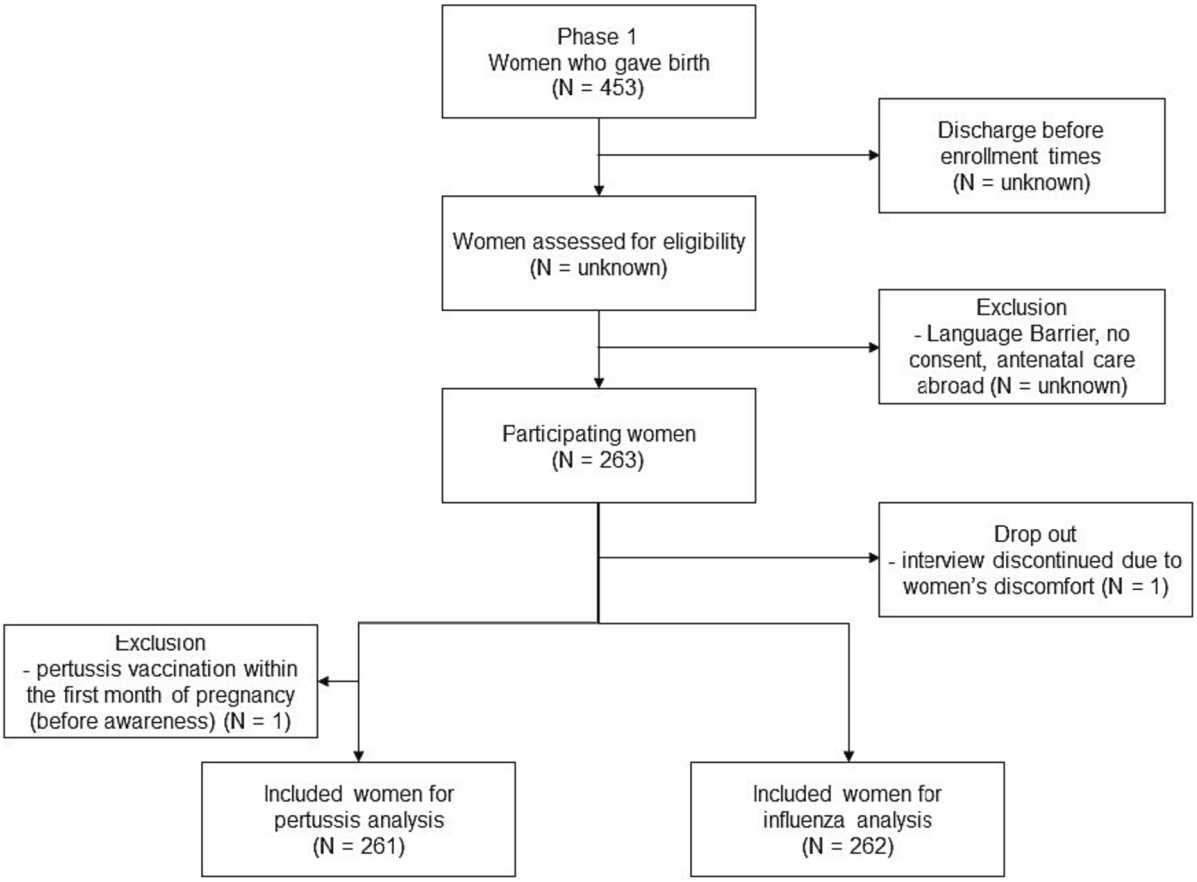

Fig. 1. Study flow chart from Phase 1 (October until December 2019).

was 56.1/100,000 in children under one year of age in 2015 [3]. About a half of the hospitalized children were younger than two months of age.

Pertussis and influenza are vaccine-preventable. Universal childhood immunization programs against pertussis have been in place globally since the 1950 s and 1960 s, whereas recommendations for booster doses later in childhood, adolescence and adulthood vary substantially by country [4]. Recently, vaccination in pregnancy (ViP) has been introduced in an increasing number of countries with the goal to protect the newborn child from pertussis [5]. In Switzerland, the National Immunization Technical Advisory Group (Eidgenössische Kommission für Impffragen, EKIF) has recommended a booster dose with acellular pertussis vaccine in combination with tetanus and diphtheria toxoids (Tdap) for pregnant women whose last dose had been administered more than five years ago in 2013 [6]. In 2017, this recommendation has been modified and since then, Tdap has been recommended in the second trimester (13th-26th week of gestation) of each pregnancy, irrespective of the interval of the last dose [7]. Each booster dose will temporarily increase the amount of maternal anti-pertussis toxin antibodies which are transported transplacentally to the fetus, thereby providing protection for the newborn for at least 3 months [8–10]. The vaccination is safe and effective in preventing severe pertussis disease in neonates and infants [11].

With regards to influenza, the risk of complications is increased for both pregnant women and young infants. Therefore, EKIF has recommended influenza vaccinations for pregnant women since 2009 [12]. Influenza vaccination decreases the risk of maternal infection and its complications among pregnant women and their infants [13–16].

A study by members of our group in the early phase after introduction of pertussis ViP revealed that only 9 % of mothers of children born in Basel between January 2013 and June 2017 had received Tdap during pregnancy. Furthermore, only 7 % of participating women had received an influenza vaccine during pregnancy and 3 % had received both influenza and pertussis vaccines [17].

Based on the above-mentioned data and our clinical experience, we hypothesized that the proportion of women receiving ViP was persistently low despite existing national recommendations.

The primary goal of this study was to compare the proportion of pertussis and influenza ViP recommendation and its implementation before and after an information campaign tailored to obstetricians. The secondary goal was to identify reasons for missing or declining vaccinations.

Methods

Design and study subjects

We conducted a prospective, single-center, single-arm implementation study in the maternity ward at the University Women's Hospital Basel (USB).

Eligible women were 18 years and older and were hospitalized for postpartum care within 28 days after delivery. The country of medical care during pregnancy had to be Switzerland, as different vaccination recommendations apply in other countries. Insufficient understanding of the study information due to language barriers or a lack of written consent were exclusion criteria.

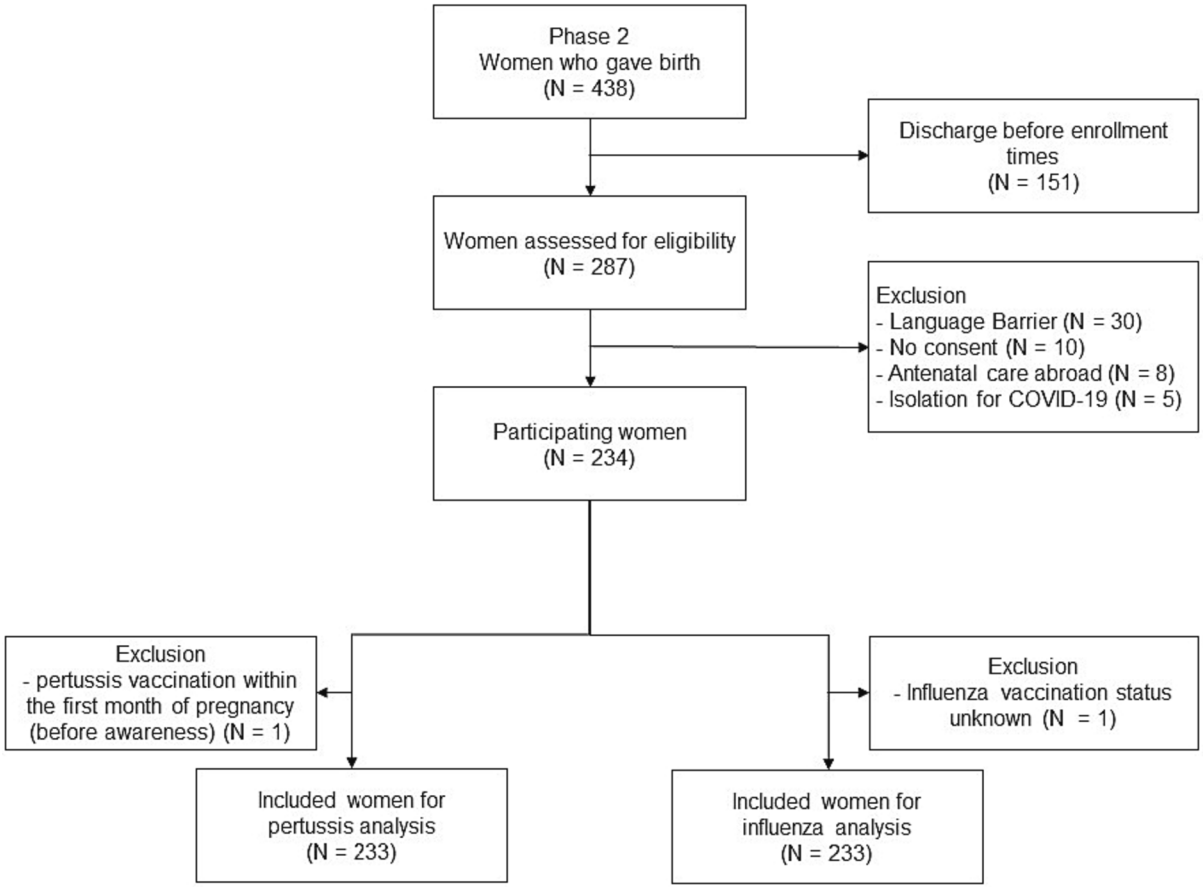

Fig. 2. Study flow chart from Phase 2 (October until December 2020).

Data collection

Beginning in October 2019, we continuously screened the clinic information system for eligibility of women based on age and country of antenatal care.

One author (MC) approached eligible women and conducted standardized structured in-person interviews on the maternity ward before (from mid-October to mid-December 2019, Phase 1) and after the information campaign (same time period in 2020, Phase 2). During Phase 1, no documentation on the number of eligible women approached took place whereas in Phase 2 this was documented (Figs. 1 and 2, respectively).

We divided the questionnaire into three sections. The first section included questions about antenatal care, vaccine recommendations by an obstetrician or other physician, and implementation of recommended vaccinations. The second section was directed at general attitudes towards vaccinations. The third section categorized the educational level according to the International Classification of Education (ISCE) [16]. In Phase 2, we added a fourth section to identify potential influence of the COVID-19 pandemic on vaccination behavior (Appendix A).

We collected relevant data from patient charts and documented whether women had antenatal care in the outpatient department or at the UBS inpatient clinic.

We also contacted the women's private gynecologist to evaluate their vaccination status, if written documentation about pertussis or influenza vaccination was lacking.

We recorded all data electronically in Labkey [18].

Primary outcomes:

1.) The proportion of women who received vaccination recommendations for a) pertussis and b) influenza during pregnancy in Phase 1 compared to Phase 2.

2.) The proportion of women who were actually vaccinated against a) pertussis and b) influenza during pregnancy in Phase 1 compared to Phase 2.

Secondary outcomes were:

- Obstetricians' recommendations and women's general attitudes towards vaccinations and their association with vaccination proportions.
- The association between demographic data (age, health insurance, residence, education, gravidity, parity, nationality) and vaccination proportions.
- The association between antenatal care at the USB or elsewhere and vaccination proportions.

Interventions

We conducted two information events (December 2019 and June 2020) between Phases 1 and 2 aimed at obstetricians who work in private practice in North-Western Switzerland or in the University Hospital Basel where we provided information about the current national ViP guidelines and background information for vaccination against pertussis and influenza.

We also sent a web-based survey to obstetricians reminding them of current national recommendations.

Table 1
Pertussis study part: General characteristics of participating women from Phase 1 compared to women from Phase 2.

Women of pertussis study part	Phase 1 (N = 261)	Phase 2 (N = 233)	P- value
Age in years	34.0 (30.0; 37.0)	33.0 (23.0; 41.2)	0.05
Duration of pregnancy (weeks)	39.6 (38.4; 40.6)	39.6 (38.6; 40.7)	0.78
Gravidity 1	95 (36.4)	95 (40.8)	0.32
Parity 1	144 (55.2)	134 (57.5)	0.60
Canton of residence			0.20
Basel-City	130 (49.8)	119 (51.1)	
Basel-Country	93 (35.6)	92 (39.5)	
others	38 (14.6)	22 (9.4)	
Canton private gynecologist			0.10
Basel-City	204 (78.2)	169 (72.5)	
Basel-Country	46 (17.6)	58 (24.9)	
others	11 (4.2)	6 (2.6)	
Nationality Swiss	125 (47.9)	127 (54.5)	0.14
Insurance Compulsory	230 (88.1)	200 (85.8)	0.45
Education			
Higher Education	173 (66.3)	152 (65.2)	0.85
Apprenticeship	61 (23.4)	59 (25.3)	
Compulsory School	27 (10.3)	22 (9.4)	
Outpatient department USB during pregnancy	200 (76.6)	177 (76.0)	0.86
Hospitalization during pregnancy	23 (8.8)	33 (14.2)	0.06
Attitude towards vaccination			0.55
Favorable	160 (61.3)	152 (65.4)	
mostly favorable	88 (33.7)	73 (31.3)	
unfavorable or mostly unfavorable	13 (5.0)	8 (3.4)	
Vaccination card sighted	192 (73.6)	154 (66.1)	0.07

Continuous data are presented as median and interquartile range. Categorical data are presented as numbers (%). USB = University Hospital Basel.

Table 2
Influenza study part: General characteristics of participating women from Phase 1 compared to women from Phase 2.

Women of influenza study part	Phase 1 (N = 262)	Phase 2 (N = 233)	P- value
Age in years	34.0 (22.0; 42.0)	33.0 (23.0; 41.2)	0.05
Duration of pregnancy (weeks)	39.6 (33.6; 41.7)	39.6 (31.6; 41.7)	0.71
Gravidity 1	95 (36.3)	96 (41.2)	0.26
Parity 1	144 (55.0)	135 (57.9)	0.50
Canton of residence			0.21
Basel-City	130 (49.6)	119 (51.1)	
Basel-Country	94 (35.9)	92 (39.5)	
others	38 (14.5)	22 (9.4)	
Canton private obstetician			0.10
Basel-City	205 (78.2)	169 (72.5)	
Basel-Country	46 (17.6)	58 (24.9)	
others	11 (4.2)	6 (2.6)	
Nationality Swiss	126 (48.1)	126 (54.1)	0.18
Insurance Compulsory	231 (88.2)	200 (85.8)	0.44
Education			0.89
Higher Education	174 (66.4)	153 (65.7)	
Apprenticeship	61 (23.4)	58 (24.9)	
Compulsory School	27 (10.3)	22 (9.4)	
Outpatient department USB during pregnancy	200 (76.3)	177 (76.0)	0.92
Hospitalization during pregnancy	23 (8.8)	32 (11.7)	0.08
Attitude towards vaccination			56
very favorable	161 (61.5)	152 (65.2)	
mostly favorable	88 (33.6)	73 (31.3)	
unfavorable or mostly unfavorable	13 (5.0)	8 (3.4)	
Vaccination card sighted	193 (73.7)	155 (66.5)	0.08

Continuous data are presented as median and interquartile range. Categorical data are presented as numbers (%). USB = University Hospital Basel.

Statistical analysis

Sample size was estimated using a simulation approach. Since we assumed a higher vaccination proportion for pertussis than for influenza vaccination based on clinical experience and clinical studies, we based the simulation on the data of the pertussis vaccination. Based on an estimated pertussis vaccination rate of 40 % during pregnancy, an expected increase of 13 % in the vaccination rate after the information campaign and aiming for a statistical power of 80 % and a significance level of 5 %, we anticipated to recruit at least 230 pregnant women in each study phase, i.e., $\geq$ 460 in total.

We compared categorical variables using chi-squared or Fisher's exact test and continuous variables using Whitney Mann *U* test. Statistical analysis was performed in R Studio [19].

Ethical approval

The Ethics Committee of North-West and Central Switzerland (EKNZ) approved this study (Project-ID 2019–01805).

Table 3
Recommendations for vaccination and implementation of vaccinations against pertussis and influenza in pregnant women comparing phases 1 and 2.

Women	Phase 1 (N = 262)	Phase 2 (N = 234)	OR (CI 95 %)	P-value
Pertussis vaccination:				
Recommendation received	209 (80.1)	196 (84.1)	1.32 (0.83; 2.11)	0.25
Vaccination implementation	199 (76.2)	182 (78.1)	1.11 (0.73; 1.70)	0.63
- excluded	1	1		
Influenza vaccination:				
Recommendation received	119 (45.4)	146 (62.7)	2.01 (1.41; 2.89)	<0.001
Vaccination implementation	76 (29.0)	100 (42.9)	1.84 (1.27;2.67)	0.001
- excluded	0	1		
Both vaccinations:				
Recommendation received	109 (41.8)	138 (59.7)	2.04 (1.43; 2.94)	<0.001
Vaccination implementation	68 (26.1)	98 (42.2)	2.07 (1.42; 3.04)	<0.001
- excluded	1	2		

Categorical data are presented as numbers (%).

Table 4
Pertussis study part: Secondary outcome parameters of women who received pertussis vaccination compared to women without pertussis vaccination.

Women of pertussis study part	Phase 1 (N = 261) Immunized (N = 199)	Not immunized (N = 62)	P - value	Phase 2 (N = 233) Immunized (N = 182)	Not immunized (N = 51)	P - value
Age in years	34 (31.0; 37.0)	33 (29.0; 37.0)	0.43	33.0 (30.0; 36.0)	32.0 (27.5; 35.0)	0.07
Duration of pregnancy (weeks)	39.6 (38.6; 40.4)	39.4 (38.4; 40.6)	0.71	39.6 (38.6; 40.6)	39.9 (38.8; 40.8)	0.67
Term delivery	185 (93.0)	57 (91.9)	1.00	163 (89.6)	42 (82.4)	0.25
Gravidity 1	75 (37.7)	20 (32.3)	0.44	68 (37.4)	27 (52.9)	0.05
Parity 1	109 (54.8)	35 (56.5)	0.81	104 (57.1)	30 (58.8)	0.83
Canton of residence			0.29			0.81
Basel-City	104 (52.2)	26 (41.9)		94 (51.6)	25 (49.0)	
Basel-Country	66 (33.2)	27 (43.5)		72 (39.6)	20 (39.2)	
others	29 (14.6)	9 (14.6)		16 (8.8)	6 (11.8)	
Canton private gynecologist			0.27			0.57
Basel-City	160 (80.4)	44 (71.0)		129 (70.9)	40 (78.4)	
Basel-Country	31 (15.6)	15 (24.2)		48 (26.4)	10 (19.6)	
others	8 (4.0)	3 (4.8)		5 (2.7)	1 (2.0)	
Nationality Swiss	94 (47.2)	31 (50.0)	0.70	101 (55.5)	26 (51.0)	0.57
Insurance Compulsory	174 (87.4)	56 (90.3)	0.54	156 (85.7)	44 (86.3)	0.92
Education			**0.008**			0.3
Higher Education	142 (71.4)	31 (50.0)		123 (67.6)	29 (56.9)	
Apprenticeship	39 (19.6)	22 (35.5)		44 (24.2)	15 (29.4)	
Compulsory School	18 (9.0)	9 (14.5)		15 (8.2)	7 (13.7)	
Outpatient department USB during pregnancy	160 (80.4)	40 (64.5)	**0.01**	148 (81.3)	29 (56.9)	**< 0.001**
Hospitalisation during pregnancy	19 (9.5)	4 (6.5)	0.62	27 (14.8)	6 (11.8)	0.74
Recommendation pertussis vaccination	196 (98.5)	13 (21.0)	**<0.001**	179 (98.4)	17 (33.3)	**< 0.001**
Attitude towards vaccination			**< 0.01**			**< 0.001**
very favorable	130 (65.3)	30 (48.4)		135 (74.2)	16 (31.4)	
Mostly favorable	65 (32.7)	23 (37.1)		46 (25.3)	27 (52.9)	
unfavorable or mostly unfavorable	4 (2.0)	9 (14.5)		1 (0.5)	8 (15.7)	

Continuous data are presented as median and interquartile range. Categorical data are presented as numbers (%). USB = University hospital Basel.

Results

Subjects

We enrolled 263 women during Phase 1 of the study and excluded one woman from the whole analysis and one woman for the pertussis analysis (Fig. 1). We enrolled 234 women in Phase 2 of the study and excluded one woman for the pertussis analysis and another for the influenza analysis (Fig. 2).

The baseline characteristics were comparable between the two phases for pertussis and influenza analysis (Tables 1 and 2).

Primary outcomes

209 (80.1 %) of the 261 women interviewed in Phase 1 received a recommendation for Tdap during pregnancy by their healthcare professional and 199 (95.2 %; 76.2 % of total) were subsequently immunized. The proportion of women who received a recommendation during Phase 2 increased non-significantly to 84.1 % (p = 0.25) of which 92.9 % (78.1 % of total; p = 0.63) were immunized. In contrast, the proportion of women who received a recommendation for influenza vaccination increased significantly from 45.4 % in Phase 1 to 62.7 % in Phase 2.

Similarly, the proportion of women immunized against influenza also increased significantly from 29.0 % in Phase 1 to 42.9 % in Phase 2. The proportion of women who accepted the influenza vaccination after recommendation increased from 63.6 % (76/119) to 68.5 % (100/146). The proportion of women vaccinated against both diseases during pregnancy increased significantly from Phase 1 to Phase 2 (26.1 % to 42.2 %; p < 0.001, OR 2.04) (Table 3).

Secondary outcomes

We assessed the secondary outcomes performing explorative

Table 5
Influenza study part: Comparison of secondary outcome parameters by influenza immunization during pregnancy.

Women of influenza study part	Phase 1 (N = 262) Immunized (N = 76)	Not immunized (N = 186)	P-value	Phase 2 (N = 233) Immunized (N = 100)	Not immunized (N = 133)	P-value
Age	34.0 (31.0; 36.25)	34 (30.0; 37.0)	0.89	33 (31.0; 36.0)	32.0 (28.0; 36.0)	**0.02**
Duration of pregnancy (weeks)	39.8 (38.7; 40.6)	39.4 (38.4; 40.4)	0.23	39.7 (38.6; 40.7)	39.6 (38.6; 40.7)	0.85
Gravidity 1	28 (36.8)	67 (36.0)	0.9	41 (41.0)	55 (41.4)	0.96
Parity 1	44 (57.9)	100 (53.8)	0.54	57 (57.0)	78 (58.6)	0.8
Canton Residence			**0.04**			0.49
Basel-City	45 (59.2)	85 (45.7)		54 (54.0)	65 (48.9)	
Basel-Country	26 (34.2)	68 (36.6)		39 (39.0)	53 (39.8)	
others	5 (6.6)	33 (17.7)		7 (7.0)	15 (11.3)	
Canton private gynecologist			0.15			0.94
Basel-City	65 (85.5)	140 (75.3)		72 (72.0)	97 (72.9)	
Basel-Country	8 (10.5)	38 (20.4)		25 (25.0)	33 (24.8)	
others	3 (4.0)	8 (4.3)		3 (3.0)	3 (2.3)	
Nationality						
Swiss	39 (51.3)	87 (46.8)	0.5	57 (57.0)	69 (51.9)	0.44
Insurance						
Compulsory	64 (84.2)	167 (89.8)	0.2	83 (83.0)	117 (88)	0.28
Education						
Higher Education	55 (72.4)	119 (64.0)	0.18	77 (77.0)	76 (57.1)	**0.003**
Apprenticeship	12 (15.8)	49 (26.3)		19 (19.0)	39 (29.3)	
Compulsory School	9 (11.8)	18 (9.7)		4 (4.0)	18 (13.5)	
Outpatient department USB during pregnancy						
yes	61 (80.3)	139 (74.7)	0.34	84 (84.0)	93 (69.9)	**0.01**
Hospitalisation during pregnancy						
yes	4 (5.3)	19 (10.2)	0.29	12 (12.0)	20 (15.0)	0.5
Attitude towards vaccination			**< 0.001**			**< 0.001**
Very favorable	61 (80.3)	100 (53.8)		85 (85.0)	67 (50.4)	
mostly favorable	13 (17.1)	75 (40.3)		15 (15.0)	58 (43.6)	
Unfavorable or mostly unfavorable	2 (2.6)	11 (5.9)		0 (0.0)	8 (6.0)	

Continuous variables are displayed as median (interquartile range); categorical variables are displayed as count (%). USB = University hospital Basel.

Table 6
Main reason for lack of pertussis vaccination in Phase 1 and Phase 2 stratified by recommendation not received and received. Categorical variables are displayed as count (%).

	Phase 1		**Phase 2**	
Women without pertussis vaccination	N = 62 (%)		N = 51 (%)	
	No recommendation received (N = 49)	Recommendation received (N = 13)	No recommendation received (N = 34)	Recommendation received (N = 17)
No Recommendation	41 (68.3)	0 (0.0)	30 (58.8)	0 (0.0)
Safety concern regarding child	4 (6.7)	3 (4.8)	2 (3.2)	11 (21.6)
Safety concern regarding mother herself	1 (1.6)	1 (1.6)	1 (1.9)	2 (3.9)
No time or forgotten	1 (1.6)	3 (4.8)	0 (0.0)	0 (0.0)
Not deemed useful	1 (1.6)	3 (4.8)	0 (0.0)	3 (5.9)
Others	1 (1.6)	1 (1.6)	1 (1.9)	1 (1.9)

Table 7
Pertussis study part: Timepoint of pertussis vaccination during pregnancy.

	Phase 1	**Phase 2**
Women with pertussis vaccination	N = 199	N = 182
Available data for timepoint of vaccination	192/199 (96.5)	167/182 (91.8)
Mean week of pregnancy at time of vaccination (IQR)	26.7 (25.43; 30.3)	26.4 (24.4; 29.9)
Range	16.9; 38.1	17.1; 37.3
Vaccination in the second trimester	106/192 (55.2)	92/167 (55.1)
Pertussis vaccination at least 2 weeks before delivery	187/192 (97.4)	163/167 (97.6)

Continuous variables are displayed as median (interquartile range and range). Categorical variables are displayed as count (%).

analyses (Tables 4 and 5). The recommendation for ViP by an obstetrician was the most significant factor for a subsequent vaccination ($p < 0.001$). Without recommendation by an obstetrician, only 1.6 % of participants received a vaccination against pertussis. These women had heard about ViP from other sources. Women who received either pertussis or influenza vaccination compared to women who did not had more positive attitudes towards vaccinations and a higher level of education (Table 4). Women who visited the outpatient department in the USB for antenatal care at least once during pregnancy were more likely to be vaccinated than those who did not. Women who live in Basel-City were more likely to be vaccinated against influenza than women from Basel-County or other cantons in Switzerland.

During phases 1 and 2, a total of 113 (22.9 %) of 494 women did not receive a pertussis vaccination. Seventy-three (64.6 %) of these women stated a lack of recommendation as the primary reason for not being vaccinated. The second most important reason for not being vaccinated was safety concerns regarding the fetus (Table 6).

In Phase 2, 38 of 100 (38.0 %) women vaccinated against influenza reported that their decision was influenced by the COVID-19 pandemic. They stated an increased awareness of infectious diseases, more detailed advice by obstetricians, and a motivation to reduce the burden on the healthcare system.

The great majority (95.8 %) of all women reported having a very favorable (63.4 %) or mostly favorable (32.5 %) attitude towards vaccinations. Only 21 women (4.2 %) reported having an either mostly or very unfavorable attitude towards vaccinations in general (Table 1).

Only 30 (7.4 %) of the 405 women who received a recommendation rejected the pertussis vaccination. In contrast, 98 (37.0 %) of 265 women were not vaccinated against influenza despite a recommendation. In Phase 2, 15 of 49 (30.5 %) of the women cited a shortage of influenza vaccine as the primary reason of not being vaccinated.

In 358 (94.0 %) of 381 pertussis vaccinated women the date and corresponding postmenstrual age was known. Of these, 198 (55.3 %) were vaccinated according to the EKIF recommendations in the second trimester (Table 7), whereas the remaining 160 were vaccinated in the third trimester.

Discussion

Main findings

We found that the proportion of pertussis vaccination recommendation and implementation did not change significantly between Phase 1 and 2. However, the proportion of pertussis vaccine recommendation and acceptance in general was unexpectedly high, making further improvement challenging. In contrast, the proportions of influenza recommendation and consequent ViP started from a lower level and increased significantly from Phase 1 to Phase 2.

We confirmed previous observations that health care professionals' advice is the main driver for vaccination acceptance [20] as in our current study implementation of ViP depended mainly on the recommendations provided by the obstetricians. In addition, factors such as a higher educational level, antenatal consultation at the tertiary clinic (USB) and positive attitude towards vaccination were also associated with a higher vaccination acceptance.

Interpretation of the findings and previous studies

Our results suggest that the local campaign for obstetricians was not powerful enough to improve the pertussis vaccine uptake in pregnant women. Rather, the increase in pertussis vaccination proportions compared to previous local data [17] is probably mainly due to the revised national vaccine recommendations published in 2017 [4]. Nevertheless, almost one in five women did not receive a pertussis ViP recommendation. Non-vaccinated women expressed a lack of recommendation as the main reason why they were not vaccinated. Moreover, almost half of the vaccinated women who received Tdap did not receive it at the recommended preferred time point, i.e. in the second trimester. This is problematic especially for preterm infants because their protection from pertussis will be suboptimal or even absent if their mothers received Tdap too close to delivery.

Multiple factors may contribute to missing recommendations and vaccination proportions: a) Switzerland does not have an official pregnancy pass with a designated item for the pertussis and influenza vaccinations; b) Obstetricians are confronted with a great number of medical, social, and psychological questions and an increasing list of preventive measures that need to be explained and discussed within a limited timeframe with pregnant women under their care. Lack of time during consultation is a well-known vaccination barrier [21].

Information campaigns in Greece and the Netherlands [22,23] were tailored to pregnant women instead of the obstetricians. Pregnant women received information on vaccinations in the outpatient clinic [22] or were asked to complete a survey [23]. Afterwards, recommended vaccinations were offered to them and more than 90 % accepted them. Studies confirm that counselling pregnant women by healthcare professionals has a strong influence on the acceptance of vaccinations [24–27].

We have reason to believe that the significant increase in influenza vaccination proportion between Phase 1 and 2 in our study was mainly due to the COVID-19 pandemic rather than our information campaign, for the following reasons: 1) Globally, influenza vaccination rates were higher during the COVID-19 pandemic than in previous years [28]. 2) An increased demand for influenza vaccines was also noted in Switzerland in autumn 2020 [29]. 3) The Federal Office of Public Health encouraged the influenza vaccination to dampen the impact of the pandemic on the health services in their publications [17]. 4) The media much discussed influenza vaccination in pregnant women when the vaccination against COVID-19 was not yet possible. Taken together, these factors might have led to an increased interest among obstetricians in protecting their patients as well as among pregnant women in protecting themselves from influenza. In contrast, pertussis did not receive any increased attention during the pandemic but rather the opposite was true as the disease temporarily almost disappeared due to lockdown and other measures to combat the COVID-19 pandemic [30].

Influenza vaccination was both less often recommended and less often accepted than the pertussis vaccination in our study. Only half of the women received a recommendation for influenza ViP and about 1/3 of those women rejected it. In contrast, less than 10 % of women rejected pertussis ViP. Some women wished to receive influenza ViP but the vaccine was not available due to delivery shortage in Phase 2 during the COVID-19 pandemic. Erroneously, many pregnant women did not perceive themselves or their unborn child as a group at specific risk for severe influenza and its complications [31] Other psychological factors such as doubts about the efficacy of the vaccine, safety concerns for mother and unborn child, lack of confidence, and insufficient knowledge presented as further barriers to vaccination acceptance [32]. Several studies also cite a knowledge gap, safety concerns and attitudes of healthcare professionals as a hesitancy to vaccination [21,31,33].

Higher education and a positive attitude towards vaccination were associated with a higher acceptance of ViP, which is in line with the current literature [23,34]. Moreover, women living in Basel-City had a higher influenza vaccination rate compared to those living in other cantons. The urban population might have better access to influenza vaccines and the attitude towards vaccination might differ between urban and rural populations. We assume that obstetricians in the university hospital setting were more alert of recommendations than in private practice. In accordance, pregnant women with at least one consultation for antenatal care at the USB were more likely to be receive ViP.

Unlike other authors [35] we did not observe a lower influenza vaccination proportion among multiparous women, compared to first time mothers. Obstetricians should educate women who have factors with a lower association for vaccine acceptance with special attention.

Strengths and limitations

The strength of our study is the interventional approach. To our knowledge, this is the first study to investigate the effect of information campaigns aimed at obstetricians regarding acceptance of ViP in women under their care.

Another interesting aspect of our study is the possibility to compare current findings with data from a previous study in Basel performed shortly after the introduction of ViP against pertussis in Switzerland [17]. We could demonstrate a positive long-term development and

improvement of vaccination uptake over time. This provides insight into how well the national vaccination recommendations are implemented.

Due to the COVID-19 pandemic, unfortunately some pre-planned information events could not be realized; we also believe that the pandemic had a positive influence on changes in the influenza ViP acceptance and the outcomes of our study might have been different in the absence of the COVID-19 pandemic. We assume that the effect of our interventional study on influenza ViP acceptance would have been less, whereas the impact on pertussis VIP acceptance was independent of the pandemic.

Our study also has some limitations. We were unable to rule out a selection bias since we have only recruited pregnant women giving birth at a university hospital. The attitudes towards vaccinations of these women may not be representative for the total population. In addition, the recruitment started in mid-October when the annual influenza vaccination roll-out had already started. This might partially explain a lower vaccination proportion for influenza vaccination.

The power analysis underestimated the proportion of pertussis vaccination but was adequate for the influenza vaccination.

Conclusion

The recommendation of obstetricians plays a key role in the implementation of ViP and still is insufficient in our setting. Of note, acceptance of pertussis ViP is higher than against influenza. We believe that future efforts should aim to explore possible hurdles that impede recommendations by obstetricians for ViP. The focus should be on the needs and experiences of obstetricians in private practice, but also other health care professionals involved in care of pregnant women, e.g. midwives. Future efforts should also take into account factors in pregnant women that are associated with a lower vaccination rate. Local campaigns do not seem effective enough, therefore national campaigns with new strategies are desirable. A standardization of the vaccination recommendation at the timepoint of a routine pregnancy check-up could be one solution for improved implementation.

CRediT authorship contribution statement

Martin Cremer: Data curation, Funding acquisition, Writing – original draft. **Siree Kaempfen:** Conceptualization, Data curation, Formal analysis, Methodology, Project administration, Supervision, Writing – review & editing. **Olav Lapaire:** Conceptualization, Writing – review & editing. **Irene Mathilde Hoesli:** Conceptualization, Resources, Validation. **Ulrich Heininger:** Conceptualization, Supervision, Writing – review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

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