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RESEARCH PAPER

Prenatal vaccination education intervention improves both the mothers' knowledge and children's vaccination coverage: Evidence from randomized controlled trial from eastern China

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ABSTRACT

Objectives: To verify the effectiveness of prenatal vaccination education intervention on improving mother's vaccination knowledge and child's vaccination status in Zhejiang province, eastern China.

Methods: Pregnant women with ≥ 12 gestational weeks were recruited and randomly assigned into the intervention group and the control group. The intervention group were given a vaccination education session while the control group were not. Two round surveys were performed before and 3 months after the intervention. The vaccination status of child was extracted at 12 months of age from immunization information system. The differences of the vaccination knowledge, the coverage, the completeness and the timeliness of vaccination between 2 groups were evaluated. The effectiveness of vaccination education intervention was assessed, under the control of the other demographic variables.

Results: Among the 1252 participants, 851 subjects replied to the post-survey. Significant improvements of vaccination knowledge between the pre- and the post- survey in the intervention group were observed (Mean ± S.D:1.8 ± 1.1 vs. 3.7 ± 1.2 for vaccines score and 2.7 ± 1.5 vs. 4.8 ± 1.0 for vaccine policy score, respectively). The coverage of fully vaccination was significantly higher in the intervention group (90.0% vs. 82.9%, $P<0.01$). The timeliness of fully vaccination was significantly higher in the intervention group (51.9% vs. 33.0%, $P<0.01$). In the intervention group, pregnant women were more likely to be with high score of knowledge (OR = 5.2, 95%*CI*: 2.6–8.8), and children were more likely to complete the full series of vaccination (OR = 3.4, 95%*CI*: 2.1–4.8), and children were more likely to complete the full series of vaccination in a timely manner (OR = 2.3, 95%*CI*: 1.6–3.5).

Conclusions: Vaccination education in the pregnant women can effectively improve the knowledge regarding immunization and increase the coverage, the completeness and the timeliness of childhood vaccination. Strong partnership needs to be established between the obstetricians and the vaccination staff to improve the performance of NIP.

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Education intervention; prenatal; randomized controlled trial; vaccination; vaccination coverage

Introduction

China started national immunization program (NIP) in 1978 with 4 vaccines. This program continues with 10 vaccines since 2008. According to the schedule of China's NIP, "A fully vaccinated child" needs to take one dose of bacillus calmette-guerin live attenuated vaccine (BCG), 3 doses of hepatitis B inactivated vaccine (HepB), 4 doses of oral polio live attenuated vaccine (OPV), 4 doses of diphtheria-tetanus-pertussis combined vaccine (DTP), one dose of diphtheria-tetanus combined vaccine (DT), one dose of measles-rubella combined live attenuated vaccine (MR), one dose of measles-mumps-rubella combined live attenuated vaccine (MMR), one dose of hepatitis A live attenuated vaccine (HepA), 2 doses of Japanese encephalitis live attenuated vaccine (JEV), and 4 doses of meningococcal polysaccharide vaccine (MenV) before the 7th birthday.[1] All the NIP vaccines are provided to children freely and its relevant logistic supports (e.g. disposable syringes and needles, refrigerator, cold box, vaccine carriers and vaccine transportation cost) are supplied by the national health development planning commission. The main objective is to achieve and to maintain the 90% coverage for each NIP vaccine at the district level according to the regulations of immunization of China.[2] All of the vaccinations are provided through the fixed immunization clinics at least once per month, and no vaccinations are provided at home. Centers for disease control and prevention (CDCs) at 4 administrative area levels (national, provincial, city and district) are responsible for planning, monitoring and evaluating of NIP.

NIP vaccine availability and coverage have been improved considerably in China, however, it is important to note that this overall coverage may hide gaps in the completeness or timeliness of vaccination. Actually, we have found the completeness and timeliness of NIP vaccines are associated with some demographic factors from recipients such as mother' age, immigration status, birth place, maternal education level, and maternal occupation status. However, the completeness and timeliness of vaccination are also affected by the factors from the provider's aspect, such as no unified vaccination education

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Table 1. Demographics between response and lost participants in the post-survey for both intervention group and control group.

Variables		Intervention				Control			
		Response	Lost	χ^2	*P*	Response	Lost	χ^2	*P*
Age (year)	<20	38	19	0.11	0.94	39	18	0.54	0.76
	20–30	254	129			268	115		
	31-	126	60			126	60		
Gestational week	12–21	116	61	1.15	0.77	122	54	2.57	0.46
	22–28	91	46			89	48		
	29–36	148	76			156	69		
	37–42	63	25			66	22		
Immigration status	Migrant	226	110	0.05	0.82	231	106	0.51	0.48
	Resident	192	98			202	87		
Education level	Junior high school or less	39	21	0.15	0.93	41	18	0.49	0.78
	Senior high school or technical school	125	64			132	57		
	College or above	254	123			260	118		
Occupation	No job	39	18	4.15	0.25	38	18	5.44	0.14
	Farmer/worker/ businessman	280	132			283	132		
	Civil servants	80	40			80	39		
	Medical staff	19	18			32	4		
Social-economic development level	High	138	67	0.13	0.94	139	67	0.19	0.91
	Middle	140	68			149	59		
	Low	140	73			145	67		

system has been established and vaccination information is not well distributed among parents who are responsible for deciding to receive vaccinations.[1] Providing unified and precise information on the importance, benefits of vaccination may increase the coverage of NIP vaccines.

Timing, content and procedure of vaccination education for parents are the most important issue. Vaccination education had been provided systematically and routinely during infant period in the US, but the lack of time for attending these education sessions was considered as the most common barrier among mothers.[3] On the other hand, mothers indicated that their knowledge on immunization was inadequate.[4] Previous studies indicated that early intervention programs such as prenatal vaccination education could improve mother's knowledge, attitude and practice (KAP) regarding immunization.[5, 6] Beside, a face to face education session may ensure a better understanding and reception of information on practice that have a positive impact on childhood immunization.[7] In contrast, there are very few data available indicating the effectiveness of vaccination education intervention during the prenatal period in China.

As such, a randomized controlled trial on assessing the effectiveness of vaccination education intervention during the prenatal period was conducted in Zhejiang province and the main objective of this study was to verify the effectiveness of vaccination education intervention, specifically on the improvements of mother's knowledge of vaccination, as well as the improvements of the coverage and the completeness and the timeliness of NIP vaccination of their infants.

Results

Participants

Totally, 1252 pregnant women agreed to participate in this study (Table S1) and they were randomly assigned into the intervention group (626) and the control group (626). A total of 851 post-survey questionnaires were returned with the drop-out rate of 32.0%. There were 418 participants from the intervention group returned the post-survey questionnaires with the drop-out rate of 33.2% and 433 participants from the control group with the drop-out rate of 30.8%, respectively. No statistically significant difference of the demographics between the response and the lost participants in the post-survey was observed, for both the intervention and the control groups (Table 1). The final number of participants in our analysis was 851 and no statistically significant difference of the demographics between the intervention and the control groups was observed (Table 2).

Information channels

In the baseline survey, the most common channel of vaccination information was family, colleagues or friends (11.3%) in currently, while the participants would be more rely on doctors' advice from the health personnel of the immunization clinics or other physicians in demand (28.0%) (Table 3).

Knowledge

Significant improvements of vaccination knowledge between the pre- and the post- surveys in the intervention group were observed, while the changes of the vaccine score and the vaccination policy score between the pre- and the post- surveys in the control group were not significant (Table 4).

In the post-survey, we found a significant difference regarding knowing all NIP vaccines between the intervention and the control groups (16.7% vs. 6.7%). Significant difference of knowing free vaccination policy for NIP vaccines was observed between the intervention and the control groups (84.2% vs. 66.5%). The proportions of participants who knew the location and time of immunization registry or the location for

Table 2. Demographic characteristics of study participants returned the post-survey questionnaires (N = 851).

Variables		Intervention (N = 418)		Control (N = 433)		χ^2	*P*
		n	%	n	%		
Age (year)	<20	38	9.1	39	9.0	0.12	0.94
	20–30	254	60.8	268	61.9		
	31-	126	30.1	126	29.1		
Gestational week	12–21	116	27.8	122	28.2	0.19	0.98
	22–28	91	21.8	89	20.6		
	29–36	148	35.4	156	36.0		
	37–42	63	15.1	66	15.2		
Immigration status	Migrant	226	54.1	231	53.3	0.04	0.83
	Resident	192	45.9	202	46.7		
Education level	Junior high school or less	39	9.3	41	9.5	0.05	0.99
	Senior high school or technical school	125	29.9	132	30.5		
	College or above	254	60.8	260	60.0		
Occupation	No job	39	9.3	38	8.8	3.08	0.38
	Farmer/worker/ businessman	280	67.0	283	65.4		
	Civil servants	80	19.1	80	18.5		
	Medical staff	19	4.5	32	7.4		
Social-economic development level	High	138	33.0	139	32.1	0.11	0.95
	Middle	140	33.5	149	34.4		
	Low	140	33.5	145	33.5		

vaccination or the vaccination school-entry requirement policy were higher in the intervention group (Table 5).

Vaccination coverage

The coverage of fully vaccination scheduled ≤ 12 months of age was significantly higher in the intervention group than that in the control group (90.0% vs. 82.9%). For the intervention group, the coverage rates of $HepB_3$, OPV_3, DTP_3, MR and JEV were 98.1%, 98.1%, 96.9%, 99.0%, 95.9%, respectively (Table 6).

The timeliness of fully vaccination scheduled ≤ 12 months of age was significantly higher in the intervention group than that in the control group (51.9% vs. 33.0%). For the intervention group, the timely coverage rates of BCG, $HepB_1$, OPV_1, DTP_1, MR, JEV were 82.1%, 89.0%, 73.9%, 72.0%, 92.1%, 65.1%, respectively (Table 7).

The effectiveness of vaccination education intervention

After controlling the other demographics, we found the pregnant women given vaccination education were more likely to get higher score of knowledge, with an OR of 5.2 (95%CI: 2.6–8.8). Children were more likely to complete the full series of vaccination in the intervention group, with an OR of 3.4 (95%CI: 2.1–4.8). Besides, children were more likely to complete the full series of vaccination in a timely manner in the intervention group, with an OR of 2.3 (95%CI: 1.6–3.5) (Table 8).

Table 3. Actual and desired channels of vaccination information for pregnant women in baseline survey (N = 1252).

Information channels	Actual channels (N = 1252)		Desired channels (N = 1252)	
	n	%	n	%
Doctor advice*	26	4.2	351	28.0
TV program, news paper	18	2.9	178	14.2
Books, magazines	16	2.6	129	10.3
Network media	20	3.2	198	15.8
WeChat, weibo	63	10.1	65	5.2
Family, colleagues or friends	71	11.3	125	10.0
Health lecture	27	4.3	206	16.5

*meant advice suggested by health personnel of the immunization clinics or other physicians in this study.

Discussion

This is the first randomized controlled trial to verify the effectiveness of prenatal parental vaccination education on improving the maternal knowledge on immunization and the vaccination coverage of their infants in China. Furthermore, the role of vaccination education during the prenatal period to facilitate the completeness and the timeliness of vaccination for infants has not been formally evaluated through a randomized controlled trial in China. As such, we believe that our findings will help establish or improve the vaccination education practices in China.

Significant improvement of the vaccination knowledge among participants in the intervention group was one of the most clearly identified outcomes of this study. Our findings verified that providing the general information on the vaccines and the NIP policy during the prenatal period could convey the concepts in a manner that would allow the pregnant women easily understand and accept them, and would induce a positive influence on maternal vaccination knowledge. Several previous studies also supported the effectiveness of early intervention in the prenatal care settings. For example, Zuniga et al. found that the prenatal educational sessions could improve the knowledge regarding various aspects of vaccination[5] and Navar et al. found that incorporating vaccination education into routine prenatal care could improve the parental knowledge on immunization and the timeliness of vaccination.[8] Additionally, previous study had demonstrated that the decision to seek childhood

Table 4. Vaccines score and vaccination policy score between pre- and post- survey for 2 groups.

		Intervention (Mean ± S.D)			Control (Mean ± S.D)		
Variables	Range	Pre-	Post-	*P*	Pre-	Post-	*P*
Vaccines score	0–5	1.8 ± 1.1	3.7 ± 1.2	<0.001	1.8 ± 1.0	1.9 ± 1.2	0.35
Vaccination policy score	0–6	2.7 ± 1.5	4.8 ± 1.0	<0.001	2.7 ± 1.3	2.6 ± 1.0	0.57

Table 5. Vaccination knowledge of study participants after intervention between 2 groups.

	Intervention (N = 418)		Control (N = 433)			
Variables	Positive response	%	Positive response	%	χ^2	*P*
Know all NIP vaccines	70	16.7	29	6.7	20.89	<0.01
Know free vaccination for NIP vaccines	352	84.2	288	66.5	35.72	<0.01
Know the location for immunization registry	346	82.8	296	68.4	23.85	<0.01
Know the time for immunization registry	340	81.3	272	62.8	36.13	<0.01
Know the location for vaccination	336	80.4	300	69.3	13.88	<0.01
Know vaccination school-entry requirement policy	359	85.9	328	75.8	14.04	<0.01

vaccination service was made during pregnancy.[9] Although there are few studies on the comparison of the effectiveness between the pre- and the post-natal education interventions, we still consider the prenatal vaccination education have more advantages. First, every pregnant woman needs to receive 12–16 antenatal care visits in Zhejiang province which makes the vaccination education practice feasible; Second, the coverage of antenatal care is over 90% in China,[10] which ensures the prenatal vaccination education can cover the majority of pregnant women; Third, the prenatal care setting offers an opportunity to educate the prospective parents before the initiation of immunization series of their infants. We suggest that vaccination education should be start during the pregnant period to assist the parental decision-making toward vaccination.

In this study, the pregnant women tended to believe their doctors or physicians' advice as they might considered that the doctor was an authoritative source of information and a doctor's explanation was a good opportunity to correct misinformation and misunderstanding, eliminating suspicion about the effectiveness of vaccination.[11] Moreover, doctors could make more informed decisions and more precise recommendations, including the importance of the completeness and the timeliness of vaccination, on a case-by-case basis for pregnant women when necessary. For childhood immunization being discussed in the pregnant period, strong partnerships need to be established with the obstetricians or the midwives to make collaborative efforts to improve mother's immunization knowledge and to increase the childhood vaccination coverage.

Although vaccination coverage achieved the NIP's goal of 90% for each vaccine in this study, we still found that only 83% of the children received all vaccine doses scheduled ≤ 12 months of age and only 33% received all of the 12 doses in a timely manner if their mothers did not receive any prenatal vaccination education. We inferred that the establishment of herd immunity might be weak or delayed and more children might be under the risk of acquiring VPDs than that indicated by the coverage estimates that did not consider the completeness and the timeliness. These findings were consistent with the reports from both the developed and the developing areas,[12-15] where substantial vaccination incompleteness or delays were observed despite the reasonably high estimates of coverage, calling for the completeness and the timeliness of vaccination to be considered as the alternative indicators of the performance of NIP. Furthermore, we found that the completeness and the timeliness of all 12 doses scheduled ≤ 12 months of age were higher in the intervention group than the control group even if the other demographics were controlled. Our findings were in line with the studies on vaccination education intervention from other countries, hence, we assumed that the educational interventions would be successful in

Table 6. Vaccination coverage of participants' children between intervention and control group.

	Intervention (N = 418)		Control (N = 433)			
Vaccines	n	%	n	%	χ^2	*P*
BCG	389	93.1	407	94.0	0.31	0.58
$HepB_3$	410	98.1	398	91.9	16.87	<0.01
OPV_3	410	98.1	394	91.0	20.51	<0.01
DTP_3	405	96.9	398	91.9	9.88	<0.01
MR	414	99.0	411	94.9	12.21	<0.01
JEV	401	95.9	390	90.1	11.16	<0.01
Fully immunized *	376	90.0	359	82.9	8.96	<0.01

*Children who received 1 dose of BCG, 3 doses of HepB, 3 doses of OPV, 3 doses of DTP, 1 dose of MR, and 1 dose of JEV.

Table 7. Timeliness of vaccination of participants' children between intervention and control group.

	Intervention (N = 418)		Control (N = 433)			
Vaccines	Timely vaccinated	%	Timely vaccinated	%	χ^2	*P*
BCG	343	82.1	364	84.1	0.61	0.44
$HepB_1$	372	89.0	381	88.0	0.21	0.65
OPV_1	309	73.9	286	66.1	6.27	0.01
DTP_1	301	72.0	260	60.0	13.55	<0.01
MR	385	92.1	325	75.1	44.71	<0.01
JEV	272	65.1	229	52.9	13.04	<0.01
Timeliness*	217	51.9	143	33.0	31.09	<0.01

*Children who timely received 1 dose of BCG, 3 doses of HepB, 3 doses of OPV, 3 doses of DTP, 1 dose of MR, and 1 dose of JEV.

increasing the parental awareness and demands regarding immunization. Usman et al[16] indicated an increase of 31% in DPT_3 completion was observed among infants whose mothers received primary health care center based health education on their first vaccination visit and they considered the education intervention was a strong factor associated with the completion of the vaccination schedule. Richards et al[17] found that the maternal knowledge of vaccines was important for predicting vaccine timeliness. Similarly, our previous survey had found that the maternal attitudes and knowledge, including the perception of vaccine necessity and the knowledge of the immunization schedule, were predictors of the timeliness of measles vaccination.[18] There was no significant differences of the coverage of BCG and the timeliness for both BCG and $HepB_1$ between the intervention and the control groups. A possible explanation is that the administration of BCG and $HepB_1$ is required for every registered maternity hospital in China in 24 hours after delivery, and the proportion of delivery at maternity hospitals is almost 100% in Zhejiang province. As a result, we infer that the vaccination education intervention is relatively less important for receiving these 2 doses in a timely manner. The threshold of timely vaccination is a major issue and it may not be easily compared among different countries due to the different immunization schedules. However, we chose the threshold of one month for most vaccine doses (one day for $HepB_1$) as it was appropriate for our study setting, where immunization clinics opened at least once per month.

There were still several limitations. First, the drop-out rate of participants was relatively high (29.1%) and the possible reason was that the mothers who were not interested in or less active in childhood immunization might not participate in the post-survey. This possible bias might affect the validity of the results. In fact, no statistically significant differences of the demographics were observed between the response and the lost participants for both the intervention and the control groups in the post-survey. It meant that the loss to follow-up bias would not be a major issue in this study and it was still well powered to detect differences between the 2 groups as the actual sample size was larger than the expected one (394 subjects in each group). Second, the follow-up period of infants was only 12 months after delivery. A longer observation period might highlight the differences in the completeness and the timeliness of the other NIP vaccine doses. Third, participants could receive vaccination information from other source (e.g., Internet, television, other health personnel) during the 3 months interval between the pre- and the post-surveys and it could induce bias and interfere the resluts.

Table 8. The influence of vaccination education intervention on knowledge improvement, completeness and timeliness of vaccination.

		OR(95% CI)		
Variables		Determinants for scores of knowledge on vaccination	Determinants for fully vaccination*	Determinants for timeliness of vaccination#
Vaccination education	No	—	—	—
	Yes	5.2(2.6–8.8)	3.4(2.1–4.8)	2.3(1.6–3.5)
Age (year)	<20	—	—	—
	20–30	1.2 (0.6–2.1)	1.1 (0.7–1.7)	1.6 (1.1–2.7)
	31-	1.7(1.3–3.5)	1.5(1.2–1.9)	2.1(1.6–3.9)
Immigration status	Migrant	—	—	—
	Resident	2.1(1.4–3.5)	2.8 (1.7–4.1)	1.3(1.0–2.7)
Education level	Junior high school or less	–	—	—
	Senior high school or technical school	1.7 (1.2–2.6)	1.4 (1.0–1.8)	0.8 (0.6–1.5)
	College or above	3.6(1.9–5.6)	1.9(1.4–4.3)	2.1(1.2–3.0)
Occupation	No job	—	—	—
	Farmer/worker/businessman	0.9(0.6–2.4)	0.9(0.4–1.2)	0.9(0.6–1.7)
	Civil servants	1.4(0.8–2.1)	1.5(1.1–2.9)	1.3(1.0–1.9)
	Medical staff	2.0(1.5–2.8)	1.9(1.4–3.0)	2.4(1.7–4.2)

*Children who received 1 dose of BCG, 3 doses of HepB, 3 doses of OPV, 3 doses of DTP, 1 dose of MR, and 1 dose of JEV.
#Children who timely received 1 dose of BCG, 3 doses of HepB, 3 doses of OPV, 3 doses of DTP, 1 dose of MR, and 1 dose of JEV.

Conclusion

Vaccination education in the pregnant women can effectively improve the knowledge regarding immunization and increase the coverage, the completeness and the timeliness of childhood vaccination. Strong partnership needs to be established between the obstetricians and the vaccination staff to improve the performance of NIP.

Methods

Study setting

Zhejiang province is a developed province located in eastern China with a total area of 104141 KM^2 and a population of 70 million. This study was conducted in 6 districts (total of 90 districts in Zhejiang Province), which were categorized into 3 socioeconomic strata (high, middle, and low) by gross domestic product (GDP) per capital level, according to the data from Zhejiang provincial bureau of statistics in 2013. Yinzhou and Dinghai belonged to the high strata for GDP per capital $\geq$ 12000 USD; Dongyang and Changxing were of middle strata for GDP per capital between 10000 to 12000 USD; Liandu and Kecheng were of low strata for GDP per capital 8000 to 10000 USD. The total population of Yinzhou, Dinghai, Dongyang, Changxing, Liandu and Kecheng was 840108, 383859, 830664, 628175, 460358 and 436856, respectively.

Study subjects

In each district, 4 obstetric hospitals with annual number of deliveries $\geq$ 500 were selected and in total 24 hospitals were chosen as the intervention sites. Pregnant women with ls were chosen as er of deliveries $\geq$evelopment areas for GDP per capital betwinations in the participating obstetric hospitals from 1 Jan 2014 to 31 Mar 2014 were recruited. In this study, migrant was defined as the person who lived in a district other than their hometown (even if from the same province) but had no local registration of the current living place.

Sample size

The formula used to estimate the sample size was as follows:

$$n = \frac{\left(z_\alpha \sqrt{2pq} + z_\beta \sqrt{p_0 q_0 + p_1 q_1}\right)^2}{(p_1 - p_0)^2}$$

According to the previous report conducted in Japan,[6] the lowest difference between the intervention and the control groups was the proportion of fully vaccination for vaccines scheduled $\leq$ 12 months. The proportions of fully vaccination were 80% in the control group and 90% in the intervention group, respectively. Besides, a p-value of 0.05, a level of power of 0.9 and an expected drop-out rate of 30% were also used for the sample size estimation. We used these parameters to estimate the sample size to ensure a larger minimum sample size. Thus, a minimum sample size of 394 subjects in each group would be sufficient to detect the differences of the variable on the vaccination knowledge and the coverage between the intervention and the control groups. Considering the feasibility of this study, the final sample size was 600 eligible pregnant women for each group or 25 in each group for every selected hospital.

Enrollment process

The enrollment period was from 1 Jan to 31 Mar, 2014. For each hospital, the enrollment would be ended if 50 eligible pregnant women were recruited. The medical staff at each selected hospital approached all pregnant women to determine the eligibility. All eligible pregnant women would receive a cover letter describing the study objectives and were asked if they were interesting in participating the study. Women who expressed interest needed to sign a written informed consent for their participation before involving them in the research.

Surveys and interventions

All participants were required to complete a baseline survey on site without reading any materials, using the self-administrated questionnaire. The questionnaire for baseline survey included 22 items to collect demographic information and to evaluate the knowledge on vaccination and vaccine preventable diseases, and also to determine the needs and resources of vaccination information. The questionnaire was developed by the study team and was pilot-tested among immunization specialists, nurses and physicians caring for pregnant women, then was revised to improve clarity.

Each participant was given an identification number and was randomly allocated into the intervention group or the control group through a computer generated randomization list. All participants were blinded to their group assignment at the recruitment and during the completion of the baseline survey. Given that it was an education intervention study, the blindness of study team and participants in the whole study period was impossible.

After the baseline survey, every participant in the intervention group was administrated a 15 minutes of one-on-one interactive vaccination education session, which was prepared by the researchers from Zhejiang provincial CDC. The session was delivered through physicians of selected hospitals who played the role of the educator. The education session included issues on the importance of vaccination, the schedule of vaccination, immunization policy in China, immunization doses, adverse reactions, and contradictions. The validity and understanding of the session were assessed by the vaccination staff, physicians, and pregnant women from each selected district and modifications were made to adapt the local situations. The participants in the control group did not receive any educational instructions. The post-intervention survey was mailed to all of the participants in both the intervention group and the control group using the same questionnaire as for the baseline survey, 3 months after the baseline survey with a 50 CNY (approximately 8 US $) gift. The vaccination status of child whose mother finished the post- survey was extracted at 12 months of age from Zhejiang provincial immunization information system (ZJIIS). The functions of ZJIIS were described previously elsewhere.[2]

Measurements

The primary outcome was the difference of the coverage of NIP vaccines scheduled ≤ 12 months of age between the intervention and the control groups, including 1 dose of BCG (at birth), 3 doses of HepB (0–1–6 months of age), 3 doses of OPV (2–3–4months of age), 3 doses of DTP (3–4–5 months of age), 1 dose of MR (8 months of age), and 1 dose of JEV (8 months of age). The vaccination coverage was defined as the proportion of children who had received the vaccine of interest, regardless of the age at which the vaccine was given.

Second, we compared the completeness and the timeliness of NIP vaccine doses scheduled ≤ 12 months of age between the intervention and the control groups. The completeness of vaccine that required more than one dose to complete the series (HepB, OPV, DTP), was defined as the coverage of the last dose as the outcome variables (OPV_3, DTP_3, and $HepB_3$).[1] The timeliness of vaccine that required more than one dose to complete the series, was defined as the coverage of the first dose as the outcome variables (OPV_1, DTP_1, and $HepB_1$). Thus, the timeliness of vaccination was defined as vaccination occurring within one month of the recommended age for BCG, OPV_1, DTP_1, MR, JEV, and within one day after the birth for $HepB_1$[1].

Third, the changes in maternal knowledge were assessed by comparing the results of the pre- and the post-surveys for both the intervention and the control groups. The knowledge on vaccine was measured based on the correct selection of the 10 NIP vaccines scheduled before the age of 6 and the knowledge on vaccination policy was measured by 6 relative questions. The number of respondent vaccine (one respondent vaccine gave 0.5 point) and the number of questions answered correctly (one correct answer gave 1 point) were aggregated to obtain the vaccines score and the vaccination policy score, respectively. Then, we aggregated the vaccines score and the vaccination policy score to obtain the total score of knowledge on vaccination, which ranged from 0 to 11 and was dichotomized as '≥ 7 points/< 7 points'.

Data analysis

Descriptive statistics were used to assess the disparities of demographic characteristics, knowledge on vaccines and vaccination policy between the intervention and the control groups for both the pre- and the post- surveys. χ^2 test was applied to evaluate the difference of the demographic characteristics between the response and the lost participants in the post-survey for both the intervention group and the control group. χ^2 test was also used to compare the vaccination coverage, the completeness and the timeliness of vaccination between the intervention group and the control group. One-sample Wilcoxon rank-sum test was conducted to compare the knowledge level on vaccination between the pre- and the post- surveys for the intervention group and the control group, separately. Logistic regression was used to verify the effects of the vaccination education intervention on the knowledge improvement, the completeness and the timeliness of vaccination, under the control of the other demographic variables. The multivariable analysis included variables that were significant at the 0.10 level in the univariate analysis. Statistical analysis were performed using SPSS version 13.0 (Chicago, IL). All tests were 2-tailed and the significance level was defined as 0.05.

Ethical considerations

This study was approved by the Ethical Review Board of Zhejiang Provincial Center for Disease Control and Prevention.

Disclosure of potential conflicts of interest

All authors have no conflict of interest.

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Author contributions

Yu Hu and Qian Li conceived and designed the experiments; Yu Hu and Yaping Chen performed the experiments; Yu Hu and Ying Wang analyzed the data; Quanwei Song and Ying Wang contributed reagents/materials/analysis tools; Yu Hu wrote the paper.

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