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RESEARCH PAPER

Hepatitis B birth dose vaccination rates among children in Beijing: A comparison of local residents and first and second generation migrants

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ABSTRACT

Providing hepatitis B vaccine to all neonates within 24 hours of birth (Timely Birth Dose, TBD) is the key preventative measure to control perinatal hepatitis B virus infection. Previous Chinese studies of TBD only differentiated between migrant and non-migrant (local-born generation-LG) children. Our study is the first to stratify migrants in Beijing into first generation migrants (FGM) and second generation migrants (SGM). Based on a questionnaire survey of 2682 people in 3 Beijing villages, we identified 283 children aged 0–15 years, from 246 households, who were eligible for a TBD. Multinomial logistic regression and statistical analyses were used to examine factors explaining TBD rates for LG, FGM and SGM children. Surprisingly, the TBD for LG Beijing children was not significantly different from migrant children. But after stratifying migrant children into FGM and SGM, revealed significant TBD differences were revealed across LG, FGM and SGM according to domicile (p-value < 0.001, OR $= 3.24$), first vaccination covered by government policy (p-value < 0.05, OR $= 3.24$), mother's knowledge of hepatitis B (p-value < 0.05, OR $= 1.01$) and the government's HBV policy environment (p-value < 0.05, OR $= 2.338$). Birthplace (p-value $= 0.002$, OR $= 6.21$) and better policy environments (p-value $= 0.01$, OR $= 2.80$) were associated with higher TBD rate for LG and SGM children. Compared with FGM children, SGM had a significantly poorer TBD rate (Fisher exact test of chi-square $= 0.013$). We identified SGM as a special risk group; proposed Hukou reform to improve SGM TBD; and called for Beijing health authorities to match TBD rates in other provinces, especially by improving practices by health authorities and knowledge of parents.

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Introduction

World-wide, an estimated 2 billion people have been infected by the hepatitis B virus (HBV), more than 240 million suffer chronically from HBV and between 500–700 thousand HBV patients die annually.[1,2] In 2015, it was estimated that 90 million people are HBV infected in China through blood and other body fluid transmission, for example saliva, tears, semen, and vaginal secretions.[3] While one main mode of HBV transmission is sexual intercourse, [3] the most common HBV transmission route is from infected mothers to infants at the time of birth. [2] Mother to child transmission remains a leading cause of HBV infection in China, accounting for between 40–50% of total HBV infections.[4,5] Without receiving the HBV vaccine, between 70–90% of infants born to mothers positive for hepatitis B surface antigen (HBsAg) and HBeAg will acquire HBV perinatally.[5]

To prevent perinatal HBV, the World Health Organization (WHO) recommended that the hepatitis B vaccine should be administered to all newborns within 24 hours of birth, the so-called timely birth dose (TBD).[4,6,7] The HBV TBD recommendation formed part of WHO's objective to extend the benefits of immunization equitably to all people. That is, every eligible individual should be immunized with all appropriate vaccines—irrespective of geographic location, age, gender, disability, educational level, socioeconomic level, ethnic group or work condition.[8] Less than half the WHO members have a policy to provide HBV vaccine at birth, and only 27% of newborns globally received the HBV vaccine. [7] In contrast, a national survey of China's TBD rate revealed that the TBD rate increased from 60% in 2002 to 99% in 2013, although the TBD rate fell to 94% in 2014. [4,9] In spite of these national TBD rates, HBV TBD remains problematic in China, with differences between birth province and migration status. Based on a population study in northwest China, Ji *et al* (2014) found that the lack of hepatitis vaccination was one of the main risk factors for HBV infection in children aged 1 to 14 y. [10] The migration of children from one region to another has also been found to be associated with low TBD rates. [11] Unfortunately, there are no national data about HBV vaccination rates for migrant children. Analyzing the HBV vaccination status in Ningbo, a city in Zhejiang province, Sun (2007) found that the TBD rate of migrant children was far lower than local children[12] and lower TBD rates were

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found for migrant compared to local-born children in Guangdong province in 2010.[13]

Previous research on HBV in China has considered only 2 types of children: migrant children and local children. To get a clearer picture of TBD rates for migrant children, a finer stratification of migrant children is required. Jane *et al* (2012) separated people in Amsterdam into 3 groups: first generation migrants (FGM), second generation migrants (SGM) and the native Dutch population. They drew the conclusion that low-endemic areas, such as Amsterdam, should offer the HBV vaccine to FGM and SGM with low TBD from high-endemic countries as a matter of urgency. [14] We develop similar categories for migrant children living in Beijing. We chose Beijing as a representative city in China experiencing an explosive growth in the number of migrants. According to 2012 Beijing Statistics Year Book, there were more than 7.5 million internal migrants, including 668,000 children under 15 y old, in Beijing's total population of 21 million, or roughly 36% of Beijing's population. In 2015, the migrant population was 202% higher than that in the Beijing 2000 Population Census.[15,16]

In the Daxing District in Beijing, we conducted a 2012 cross-sectional survey of children aged under 15 y old, divided into Beijing-born local generation (LG) children; first generation migrant (FGM) children, who were born and (not) vaccinated in their home town; and second generation migrant (SGM) children born in Beijing, but without a Beijing Hukou and (not) vaccinated in Beijing. The paper's objectives are to explore the factors accounting for differences among FGM, SGM and LG children in their hepatitis B TBD status and, second, recommend policies to address HBV TBD issues among children in Beijing.

Results

As shown in Table 1, our sample comprised 283 children aged 0–15 y old from 246 households, where 73.85% were migrants from provinces other than Beijing. Half (46%) the children were female and roughly 3-quarters (71.02%) were aged under 8 y old, who were subject to the Government's 2005 second supplemental agreements to the Expanded Programme on Immunization (EPI) that made the HBV vaccine and vaccination available to all newborns at no cost. Between 2002 and 2005, government policy (the first supplemental agreements to Expanded Programme on Immunization) made the HBV vaccine freely available, but the parents were charged a vaccination fee, which was captured by the 8–10 age group (12.37%). Children over 10 y old (16.61%) did not receive free vaccine or the free vaccination (see Table 1).

Total timely birth dose rate of study population

As shown in Table 1, all of the participants had a first vaccination for HBV, but 19.08% were not vaccinated in the first 24 hours of birth. While migrant children had a higher TBD rate (82.21%) than local children (77.33%), this was not significant (see Tables 1 and 2). Our results are surprising compared to other studies that found migrant children had significantly lower TBD than local children.[10,11,13] However, we found significant differences between the TBD for Beijing LG (77.33%) and the 2 cohorts of migrants, FGM (87.31%) and SGM (72.97%) children. The average HBV knowledge score was highest for FGM mothers (6.25), and the mother's education level was highest for the LG group (64.0% with higher education). For all groups, the data also show that with increases in the mother's hepatitis B knowledge, the TBD rate also increased from 76.32% to 92.86% (see Table 2).

Table 2 shows that male children's TBD rate (79.29%) was lower than for female children (84.62%). The TBD HBV vaccination rate declined with increasing age for all groups (84.58% to 70.21% in different age groups, p-value = 0.036), which reflects the impact of government policies to provide free vaccines, then free vaccines and free vaccinations. Children who vaccinated in their registration places had a higher TBD rate (83.73%, p = 0.045) than those not registered in their place of residence (72.97%) (see Table 2). Hukou registration districts and place of residence mattered. FGM (87.31%) had a higher TBD rate than Beijing LG (77.33%), but SGMC (72.97%), who were born in Beijing and had a non-Beijing Hukou, had the lowest TBD.

Multinomial logistic regression analysis

Our multinomial logistic regression analysis used vaccinated first dose at birth within 24 hours as dependent variable and migrant status, mother's knowledge scores of hepatitis B, policy for first vaccination, birth place and first vaccination place as independent variables with covariant variable of different age groups. Table 3 illustrates the results that adjusted by age groups, "first vaccination place" (p-value < 0.001), "policy for first vaccination"(p-value < 0.02) and "mother's knowledge scores of hepatitis B" (p-value < 0.02) were significantly related to dependent variable for all participants (n = 283). Children vaccinated in registered permanent residence have 2.24 (OR = 3.24, CI = 1.50–7.01) higher probability of TBD than children vaccinated out of their registered permanent residence. Children who enjoyed the free vaccination policy were more likely to vaccinated on time (OR = 2.26, CI = 1.15–4.45) and mothers with better knowledge of hepatitis B tend to vaccinate their children more timely (OR = 1.1, CI = 1.02–1.19). Children born in better policy environments for vaccination were more likely to vaccinate within first 24 hours (OR = 2,26, CI = 1.15–4.45) of birth (see Table 3).

As noted earlier, and confirmed in Table 3, migrant status was not significant in our analysis, which contrasts with previous research. Table 4 presents multinomial logistic regression results for FGM and SGM, with LG the reference. SGM (OR=0.31, CI=0.14–0.67 were significantly less likely to receive TBD than FGM or LG children. This confirms the importance of stratifying migrant children into FGM and SGM children.

Comparison of timely birth rate among different types of migrant children

Whether a child had its birth dose in its permanent registration residence was significant (see Tables 3 and 4). Given the role of the Hukou, these results confirm our

Table 1. Description of Dependent variables and Independent variables, Beijing, 2012.(n = 283)*.

Variable	Variable Definition	Non-migrant	Migrant		Total of Migrant	Total
			FGM	SGM		
First Vaccination Place						
At the location of registration	1 if local,0 otherwise	75 (100%)	134 (100%)	0	134 (64.42%)	209 (73.85%)
Not at the location of registration	1 if not local, 0 otherwise	0	0	74 (100%)	74 (35.58%)	74 (26.15%)
Gender						
Male	1 if male, 0 otherwise	46 (61.33%)	68 (50.75%)	38 (52.05%)	106 (51.21%)	152 (53.9%)
Female	1 if female, 0 otherwise	29 (38.67%)	66 (49.25%)	35 (47.95%)	101 (48.79%)	130 (46.1%)
Missing				1		1
Knowledge of hepatitis B	Ranged from 0 to 19					
Average Level		5.55	6.25	6.05	6.18	6.01
Maximum		15	19	18	19	19
Minimum		0	0	0	0	0
Mother's education level						
Low education	1 if years of school< = 6 years, 0 otherwise	1 (1.33%)	20 (14.93%)	12 (16.22%)	32 (15.38%)	33 (11.66%)
Medium education	1 if 6 < years of school < = 9 years, 0 otherwise	26 (34.67%)	90 (67.16%)	44 (59.46%)	134 (64.42%)	160 (56.54%)
High education	1 if years of school > 9 years, 0 otherwise	48 (64.00%)	24 (17.91%)	28 (24.32%)	42 (20.19%)	90 (31.80%)
Age group						
0-7 y old	1 if aged 0–6, 0 otherwise	49 (66.33%)	94 (70.15%)	58 (78.38%)	152 (73.08)	201 (71.02%)
8–10 y old	1 if aged 7–9, 0 otherwise	7 (9.33%)	19 (14.18%)	9 (12.16%)	28 (13.46%)	35 (12.37%)
11–15 y old	1 if aged 9–15, 0 otherwise	19 (25.33%)	21(15.67%)	7 (9.46%)	28 (13.46%)	47 (16.61%)
Birth place						
home	1 if born at home,0 otherwise	0	5 (3.73%)	2 (2.70%)	7 (3.37%)	7 (2.47%)
village clinic	1 if born at village clinic,0 otherwise	15 (20%)	39 (29.10%)	15 (20.27%)	54 (25.96%)	69 (24.38%)
county clinic	1 if born at county clinic,0 otherwise	51 (68%)	80 (59.70%)	45 (60.81%)	125 (60.10%)	176 (62.19%)
other clinic	1 if born at other clinic,0 otherwise	9 (12%)	10 (7.46%)	12 (16.22%)	22 (10.58%)	31 (10.95%)
First vaccnation in 24 hours or not(DV)						
In time	1 if first dose vaccinated in 24 hours,0 otherwise	58 (77.33%)	117 (87.31%)	54 (72.97%)	171 (82.21%)	229 (80.92%)
more than 24 hours	1 if first dose vaccinated more than 24 hours,0 otherwise	17 (22.67%)	17 (12.69%)	20 (27.03%)	37 (17.79%)	54 (19.08%)
First vaccine covered by policy						
covered by policy	1 if first vaccine covered by policy, 0 otherwise	52 (69.33%)	94 (70.15%)	54 (72.97%)	148 (71.15%)	200 (70.67%)
not covered by policy	1 if first vaccine not covered by policy, 0 otherwise	23 (30.67%)	40 (29.85%)	20 (27.03%)	60 (28.85%)	83 (29.33%)

* **n(%)**

Table 2. Timely Birth Dose Rate Among Persons in DaXing District, Beijing City, in China, 2012.

Variable	TBD Rate(95%CI),%	FGMC TBD Rate(95%CI),%	SGMC TBD Rate(95%CI),%	LG TBD Rate(95%CI),%
All participants	80.92 (75.85–85.33)	87.31 (80.47–92.43)	72.97 (61.39–82.65)	77.33 (66.21–86.21)
Gender				
Female	84.62 (77.24,90.34)	87.87 (77.51–94.61)	80 (63.06–91.56)	82.76 (64.23–94.15)
Male	78.29 (70.88–84.56)	86.76 (76.36–93.77)	68.42 (51.34–82.49)	73.91 (58.87–85.73)
Age				
0–7 y old	84.58 (78.83–89.27)	87.23 (78.76–93.23)	81.03 (68.59–90.13)	83.67 (70.34–92.68)
8–10 y old	74.29 (56.74,-87.51)	94.74 (73.97–99.87)	94.73 (73.97–99.87)	57.14 (18.41–90.10)
11–15 y old	70.21 (55.11,82.66)	80.95 (58.09–94.55)	42.86 (9.90–81.59)	68.42 (43.45–87.42)
First Vaccination Place				
At the location of registration	83.73 (78.01–88.46)	87.31 (80.47–92.43)		77.33 (66.21–86.21)
Not at the location of registration	72.97 (61.39–82.65)		72.97 (61.39–82.65)	
Knowledge of hepatitis B				
0∼4	76.32 (67.44–83.78)	80.36 (67.57–89.77)	70.83 (48.91–87.38)	73.53 (55.64–87.12)
59	80.18 (71.54–87.14)	91.49 (79.62–97.63)	73.17 (57.06–85.78)	69.57 (47.08–86.79)
1014	90.91 (78.33–97.47)	90.91 (70.84–98.88)	80 (28.36–99.49)	94.12 (71.31–99.85)
1519	92.86 (66.13–99.82)	100 (66.37–100*)	75 (19.41(99.37)	100 (2.5–100*)
Mother's education level				
Low education	78.79 (61.09–91.02)	85 (62.11–96.79)	75 (42.81–94.51)	100 (0–97.5*)
Medium education	81.25 (74.33–86.98)	86.67 (77.87–92.92)	72.72 (57.21–85.04)	76.92 (56.35–91.03)
High education	81.11 (71.49–88.59)	91.67 (73.00–98.97)	72.22 (46.52–90.31)	79.17 (65.01–89.53)
Birth place				
home	85.71 (42.13)	100 (47.82–100*)	50 (1.26–98.74)	
village clinic	75.36 (63.51,-84.95)	87.18 (72.57–95.70)	73.33 (44.90–92.21)	46.67 (21.27–73.41)
county clinic	81.25 (74.69–86.73)	68.89 (53.35–81.83)	68.89 (53.35–81.83)	82.35 (69.13–91.60)
other clinic	90.32 (74.25–97.96)	80 (44.39–97.48)	91.67 (61.52–99.79)	100 (66.37–100*)
First vaccine covered by policy				
covered by policy	85 (80.01–89.99)	89.37 (83.01–95.71)	79.63 (68.53–90.73)	82.69 (72.05–93.33)
not covered by policy	71.08 (61.12–81.04)	82.5 (70.19–94.81)	55 (31.11–78.89)	65.22 (44.16–86.28)
Three types of children				
First Generation Migrant(FGM)	87.31 (80.47–92.43)			
Beijing-born Second Generation Migrant(SGM)	72.97 (61.39–82.65)			
Beijing-born Local Generation(LG)	77.33 (66.21–86.21)			
Migrant status				
Migrant	82.21 (76.32–87.16)			
Non-migrant	77.33 (66.21–86.21)			

*Note. one-sided, 97.5% confidence interval

contribution of dividing migrants into FGM and SGM children. Chi-square tests revealed significant difference in TBD among the 3 groups (Pearson chi-square = 0.27). We found significant differences in the TBD rate between FGM and SGM (Fisher exact test (one-tail) = 0.009) children and FGM and LG (Fisher exact test (one-tail) = 0.048) children. SGMC and LG were not significantly different in TBD rate (Fisher exact test (one-tail) = 0.335).

Within the FGM group we found that the TBD rate increased with the mother's increasing knowledge of hepatitis B (Pearson chi-square = 0.001). Within the LG group, the TBD rate was significantly different among birthplace (Pearson

Table 3. Multinomial logistic regression analysis (1).

First vaccnation in 24 hours or not(DV)	OR	P-value	OR Conf. Interval
Migration Situation	1.77	0.21	[0.72–4.32]
First Vaccination Place	3.24	0.00	[1.50–7.01]
First vaccine covered by policy	2.26	0.02	[1.15–4.45]
Mother's education level			
Low education	(Ref)		
Medium education	0.80	0.69	[0.27–2.35]
High education	0.79	0.71	[0.23–2.74]
Knowledge of hepatitis B	1.10	0.02	[1.02–1.19]
Birth place			
home	(Ref)		
village clinic	0.37	0.40	[0.04–3.74]
county clinic	0.49	0.55	[0.05–5.00]
other clinic	1.21	0.89	[0.09–15.92]
Age group			
11–15 y old	(Ref)		
8–10 y old	1.273	0.66	[0.43–3.73]
0–7 y old	2.338	0.05	[1.01–5.43]
Intercept	1.37	0.82	[0.09–20.10]

Table 4. Multinomial logistic regression analysis (2).

First vaccnation in 24 hours or not(DV)		OR	P-value	OR Conf. Interval
Children Group				
FGM		(Ref)		
LG		0.57	0.21	[0.23–1.38]
SGM		0.31	0.00	[0.14–0.67]
First vaccine covered by policy		2.26	0.02	[1.15–4.45]
Mother's education level				
Low education		(Ref)		
Medium education		0.80	0.69	[0.27–2.35]
High education		0.79	0.71	[0.23–2.74]
Knowledge of hepatitis B		1.10	0.02	[1.02–1.19]
Birth place	home		(Ref)	
village clinic		0.37	0.40	[0.04–3.74]
county clinic		0.49	0.55	[0.05–5.00]
other clinic		1.21	0.89	[0.09–15.92]
Age group				
11–15 y old		(Ref)		
8–10 y old		1.268	0.66	[0.44–3.65]
0–7 y old		2.327	0.04	[1.03–5.24]
Intercept		1.80	0.13	[0.58–62.97]

chi-square = 0.003). The TBD rate in county-level and over-hospitals was significantly higher compared with village hospitals (p-value = 0.008). Within the SGM group, the TBD rate was significantly different among different age groups (Pearson chi-square = 0.012), with the youngest age group having a significantly higher TBD rate compared with the 8–10 y old (Pearson chi-square 0.030) and the oldest age group (11–15 y old) (person chi-square 0.044).

Comparison of differences for FGM, SGM and LG children

We used the chi-square analysis to explore the main differences among each group (FGM, SGM and LG). There were significant differences in TBD for mother's HBV knowledge (Pearson chi-square = 0.007), first vaccination place (Pearson chi-square < 0.001) and mother's education level (Pearson chi-square < 0.001) among 3 types of children. Birthplace, age variable and policy for first vaccination were not significantly different between each group (Pearson chi-square > 0.05). For the mother's HBV knowledge, there were no significant differences between FGM and LG children, but there was significant differences between FGM and SGM (Pearson chi-square < 0.05) and between SGM and LG (Pearson chi-square < 0.05). As for mother's education level, SGM and LG were not significantly different, but there were significant differences between FGM and LG (Pearson chi-square < 0.001) and between SGM and FGM (Pearson chi-square < 0.001). As shown in Table 2, gender, age, birth place and government policy were significant factors determining higher than average TBD rates for FGM and significantly lower than average TBD rates for SGM and LG. Similarly, gender, age, birth place and government policy explained higher LG TBD rates than for SGM children (except for 8–10 year-old SGM children). For HBV knowledge and mother's education levels, TBD rates for SGM children were lower than average level and TBD rates for FGM children were higher than average. In general, when vaccinated in registration location or when the first vaccine was covered by policy, the TBD rate were higher compared with those vaccinated outside their registration location or first vaccine was not covered by policy.

Discussion

Surprisingly, the timely birth dose rate for migrant children was not significantly different than for local Beijing-born children, which is at variance with previous studies.[12,13,17] To further explore this result our research analyzed different timely birth dose rates forLG, FGM, and SGM children. SGM had soignificantly lower TBD rates than those in LG and FGM groups, which was mainly explained by the lower level of SGM mother's HBV knowledge and education level. This suggests 2 recommendations. First, we recommend the need to differentiate between migrants types (FGM versus SGM) and their place of vaccination. Beijing-born second generation migrant children, had the lowest TBD rate, especially compared with FGM. Our data have identified SGM children as a special group in Beijing, where SGM without a local Hukou had lower TBD rates than other children. Even though planned immunization in China applied to all newborns, making effective vaccinations freely available,[2] there remained barriers creating limitations on the operation of the policy. One policy implication is to review the operation of the immunization policy and processes to ensure that SGM children are not neglected. Health authorities need to focus on second generation migration children as an 'at risk' group.

Second, our data suggest that planned immunization, the National Implementation Plan and Regulation 2005 for free vaccinations performed worse in Beijing than other areas in China. Beijing had lower vaccination rates (77.33%) than other places in China (87.31%), even excluding SGM. For Beijing LG children, birthplace was one of the most important factors explaining TBD rates, which means better medical conditions, such as county and higher-level hospitals, promoted higher TBD rates for newborns who have Beijing registered residence. One recommendation is to improve health worker knowledge of HBV vaccinations for lower level health care facilities in Beijing. Improved health

worker HBV knowledge should be used to better inform parents about HBV and HBV vaccinations, improving parent's HBV knowledge.

Our results also indicate that the main factors associated with the TBD rate differ across the 3 children groups. For Beijing-born second generation migrant children, the policy environment was more important than for LG and FGM. The youngest SGM age group (0–7 y old) was born in the most favorable policy environment where neonates enjoy free vaccination service covering vaccine and vaccination fee, but the Hukou system constrained their access to vaccinations. Health factors have long been recognized the importance Hukou reform, which would significantly aid vaccination of SGM children. To make up for these constraints, remedial measures like "catch up" screening and vaccination programmes for SGM should be investigated.[14] Establishing immunization registries and electronic databases are also effective measures to track the immunization status and provide timely reminders to parents.[8]

Our research suffered from 2 main limitations. First, the sample size was relatively small, drawn from only 3 villages in Daxin county, but fortunately with a low rate of missing data. Second, our research questionnaire did not include some potential relate TBD factors, such as the annual family income at the time of the child's birth.

We draw the following conclusions: that SGM children need particular attention compared with local children and FGM children in timely birth dose of hepatitis B vaccination. SGM children, due to low TBD rates in Beijing and the lack of a Beijing Hukou providing access to free vaccinations, made SGM an 'at risk' group. Compared to other provinces in China, TBD rates were low in Beijing for local-born Beijing children, both LG and SGM. There is a need for Beijing health facilities to improve their HBV TBD rates. Besides learning from practices in other provinces, we identified better HBV vaccination knowledge by Beijing-based health workers and an information campaign for Beijing-based parents as useful strategies to increase the TBD rates.

Participants and methods

Study population and sample procedure

Our sample of pre-15 y old children formed part of a larger cross-sectional household survey of 2682 people, aged 0–93 years, from 858 households, located in 3 villages[1] in the Daxing District of Beijing stratified on the distance to vaccination places (short, medium or long). The aim of the stratified sample was to ensure representative coverage adjusted for distance from vaccination place.

During 2012, the household interviews were conducted by trained staff. The questionnaires included questions about vaccination history, demographic information, knowledge about hepatitis B and government HBV vaccination policy. A pilot survey was performed before starting the field survey. Participation was voluntary and the participants were carefully informed about their right to refuse to answer any question. Since hepatitis B is associated with social stigma, the questionnaire minimizing the perceived sensitivity among participants. For instance, interviewees were not asked about their infection status and no biological samples were collected.

[1] Daxing, a suburb in Beijing, is designated a county-district, which comprises subareas that are still called villages.

Measurement of variables

Definition and measurement of dependent variables

Our study investigated the factors determining whether a child received their first vaccine against hepatitis B within the first 24 hours of life. Therefore "vaccinated first dose at birth within 24 hours or not" was the dichotomous 'yes-no' dependent variable.

Definition and measurement of dependent variables

Migrant status. We hypothesize that migrant status was a key factor affecting timely birth vaccination. Geng *et al* (2010) analyzed children's timely vaccination coverage status for Dinghai district of Zhoushan municipality, which showed the timely HBV coverage rate was 95% for the local population, but only 74.4% for the migrant population. To explore whether migrant status was important in our study, we categorized children into 2 groups, migrant and non-migrant local generation (LG) children.

Knowledge of hepatitis B. Knowledge of hepatitis B of parents is another important factor influencing perinatal HBV vaccinations. In a study of failed timely child vaccinations in Yunnan province, Hu (2009) found only 56% of the 189 mothers have knowledge of hepatitis B, which impacted negatively on TBD.[18] In Gansu province, only 48% of guardians were aware of the need to vaccinate within 24 hours of birth in 2005,[25] which was a significantly influential factor in TBD. Although no national data are available on HBV knowledge, a survey conducted in Gansu in 2010 reported 83% of mothers knew about the need of the hepatitis B birth dose within 24 hours.[4] Given these diverse data on HBV knowledge levels, we asked 4 questions to assess mothers' hepatitis B knowledge level (scored 1 for a correct response; 0 for "don't know" and −1 for an incorrect answer).[18] As shown in Table 1, on a 0–19 HBV knowledge scale, migrant mothers' knowledge (6.18) was higher than Beijing mothers (5.55).

Policy for first vaccination. Recent research identified the impact of government vaccination policy on TBD vaccination rates.[19,27,28] From 2005, all children were covered for free HBV vaccine and vaccinations, but 31% of children born after 2005 did not receive an HBV vaccination within the first 24 hours of birth. The policy variable was given the value of 1 if the policy guaranteed a free vaccine and free vaccination of the HBV first dose.

Mother's education level. Previous research identified higher parental education levels with increasing first timely vaccinations,[26] therefore we investigate the mother's education level as a factor associated with timely birth dose. Following Zhu *et al* (2014), we separated the mother's education level into 3

categories: low—6 or less years of primary school; medium—7–8 y of middle school education; and high—more than 9 y education.[20]

Birthplace. Ma *et al* (2011), Cui F *et al.* (2007) and Hu (2006) emphasized the importance of birthplace for timely first dose HBV vaccination. Birthplace was a proxy for access to medical facilities and HBV medical knowledge. Following their work, we defined birthplace by 4 locations: county-level and above hospital, village hospital, at home and others.[21,22,23]

First vaccination place. After 2005, free vaccination services (vaccine and vaccinations) and after 2002 free vaccine, were available in the child's registered residence location (Hukou). For Beijing LG, Beijing was the place of first vaccination and for FGM their place of vaccination was their Hukou outside Beijing. For SGM children, they vaccinated in Beijing, without a Beijing Hukou, but they did not enjoy the same benefits from the 2005 and 2002 vaccination policies as the Beijing LG group. We expected that access to free hepatitis B vaccine and free vaccinations increased TBD.

Age Variable. In China, hepatitis B vaccine was included in planned immunization in 1992, which promoted hepatitis B vaccination, but made the vaccine and vaccination self-paying. In 2002 hepatitis B vaccine was included in National Implementation Plan (NIP), but a vaccination fee was still required. In 2005, the Government issued a regulation making neonatal vaccination service, including vaccine and inoculation service fee, free. Timely birth dose rate increased with government funded HBV neonatal vaccination service. We separated age into 3 groups to reflect the total government policy environment for all 3 doses of the HBV vaccine: age 0–7 y old who enjoyed free inoculation service given by nurse and free HBV vaccine; age 8–10 y old who only paid for the inoculation service, but not the HBV vaccine; and age 11–15 y who paid for both the vaccine and vaccination.

Statistical analysis

We used Microsoft Access to double input all household data, which was checked for consistency. We performed multivariate analyses in STATA 11.1 to analyze associations between whether child vaccinated in 24 hours or not with first vaccination place and gender, knowledge of hepatitis B, mother's education level, birth place and age group. After finding no difference between migrant and non-migrant groups, but significant difference between LG, FGM and SGM, we compared the TBD rate among different children group (LG, FGM, SGM) by using chi-square tests. Finally we compared TBD rate within each child group by different birthplace, first vaccination place, gender, degree of knowledge of hepatitis B, mother's education level and age group by SPSS version 21.

Ethics

Participants were informed that they could refuse to answer any question. The questionnaire did not ask about infection status, and no biological samples were collected. The project was approved by the Medical Ethics Committee at the Shandong University School of Medicine (Grant No. 201001052).

Disclosure of potential conflicts of interest

None of the authors has any conflicts of interest.

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Authors' contributions

All authors have read and approved the final manuscript.

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