Determinants of incomplete childhood hepatitis B vaccination in Sierra Leone, Liberia, and Guinea: Analysis of national surveys (2018–2020)

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Abstract

Vaccination against hepatitis B virus (HBV) is effective at preventing vertical transmission. Sierra Leone, Liberia, and Guinea are hyperendemic West African countries; yet, childhood vaccination coverage is suboptimal, and the determinants of incomplete vaccination are poorly understood. We analyzed national survey data (2018–2020) of children aged 4–35 months to assess complete HBV vaccination (receiving 3 doses of the pentavalent vaccine) and incomplete vaccination (receiving <3 doses). Statistical analysis was conducted using the complex sample command in SPSS (version 28). Multivariate logistic regression was used to identify determinants of incomplete immunization. Overall, 11,181 mothers were analyzed (4,846 from Sierra Leone, 2,788 from Liberia, and 3,547 from Guinea). Sierra Leone had the highest HBV childhood vaccination coverage (70.3%), followed by Liberia (64.6%) and Guinea (39.3%). Within countries, HBV vaccination coverage varied by socioeconomic characteristics and healthcare access. In multivariate regression analysis, factors that were significantly associated with incomplete vaccination in at least one country included sex of the child, Muslim mothers, lower household wealth index, <4 antenatal visits, home delivery, and distance to health facility vaccination (all *p* < 0.05). Understanding and addressing modifiable determinants of incomplete vaccination will be essential to help achieve the 2030 viral hepatitis elimination goals.

Highlights

- Sierra Leone, Guinea, and Liberia are highly endemic for HBV; yet, childhood vaccination coverage remains suboptimal.
- The HBV vaccination coverage from recent national surveys was 70.3% in Sierra Leone, 64.5% in Liberia, and 40.0% in Guinea.
- Predictors of incomplete vaccination included Muslim mothers, lower household wealth index, <4 antenatal visits, home delivery, and distance to health facilities.
- Addressing socioeconomic and healthcare access barriers is essential for achieving the 2030 viral hepatitis elimination goals.

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Introduction

The global burden of hepatitis B virus (HBV) remains a major public health and developmental challenge. According to World Health Organization (WHO) estimates, there were 296 million

chronic cases of HBV worldwide in 2021 [1]. Sub-Saharan Africa (SSA) is disproportionately impacted by the HBV epidemic – about 6.1% of the population live with chronic HBV infection, which accounts for approximately 20% of the global burden [1]. In SSA, the HBV infection is most commonly acquired through vertical transmission or horizontally through close contact during early childhood [1, 2]. In response to the global problem of HBV, the Global Health Sector Strategy [3] and the Sustainable Development Goals [4] have endorsed the elimination of HBV as a public health threat by the year 2030.

The most effective method of preventing HBV is through vaccination [4]. Timely administration of the HBV birth dose vaccine given within the first 24 h of life followed by an additional 2 or 3 doses is 98%–100% effective at preventing mother-to-child transmission (MTCT) and has been instrumental in reducing the incidence of the HBV infection globally [1, 5]. The WHO and other international guidelines recommend universal HBV screening of pregnant women and vaccination of all non-immune newborns and adults [6–8]. However, in many countries in SSA, the HBV vaccine is not given at birth but is administered as part of the pentavalent vaccine (HBV, diphtheria, tetanus, pertussis, and Haemophilus influenzae type B) at 6, 10, and 14 weeks postpartum [9]. Despite this, vaccination coverage has remained low in many SSA countries. Several factors have contributed to the low coverage rates, including inadequate immunization programme funding, fragile health systems, and limited knowledge of the risks of HBV infection and the benefits of vaccination [9–11]. Thus, understanding and addressing modifiable determinants of suboptimal vaccination will be crucial to meeting the HBV elimination goals.

Sierra Leone, Liberia, and Guinea are neighbouring West African countries with similar cultural, socioeconomic, and demographic characteristics. Guinea is the most populous of the three countries (15.5 million), while Sierra Leone and Liberia had population estimates of 8.14 million and 5.18 million in 2021, respectively [12]. Furthermore, the three countries share a recent history of civil warfare (1990–2001) and new public health challenges, including the largest Ebola outbreak in history (2014–2016) – all of which have aligned to further weaken the already fragile local healthcare systems [13, 14]. Additionally, all three countries are grappling with major HBV epidemics. According to recent estimates, the national prevalence of chronic HBV cases was 13.0% in Sierra Leone [15], 13.5% in Liberia [16], and 11.7% in Guinea [16], indicating hyperendemic levels of HBV infection in all three countries. Guinea initiated childhood HBV vaccination in 2006, followed by Sierra Leone in 2007 and Liberia in 2008 [9]; however, the HBV birth dose vaccine has not been introduced into the childhood immunization schedule and all three countries are yet to implement national HBV control policies due to limited resources and other constraints [9].

Prevention of MTCT of HBV through HBV vaccination is essential to achieve the viral hepatitis elimination goals in Sierra Leone, Guinea, and Liberia. However, there is a paucity of studies assessing HBV vaccination coverage rates and barriers to the uptake of HBV vaccination in the population. To better inform vaccination strategies in Sierra Leone, Liberia, and Guinea, we used recent national survey data from the three countries to estimate national HBV vaccination coverage levels. Furthermore, we explored sociodemographic, economic, and healthcare factors serving as potential barriers to HBV vaccination in the three West African countries.

Methods
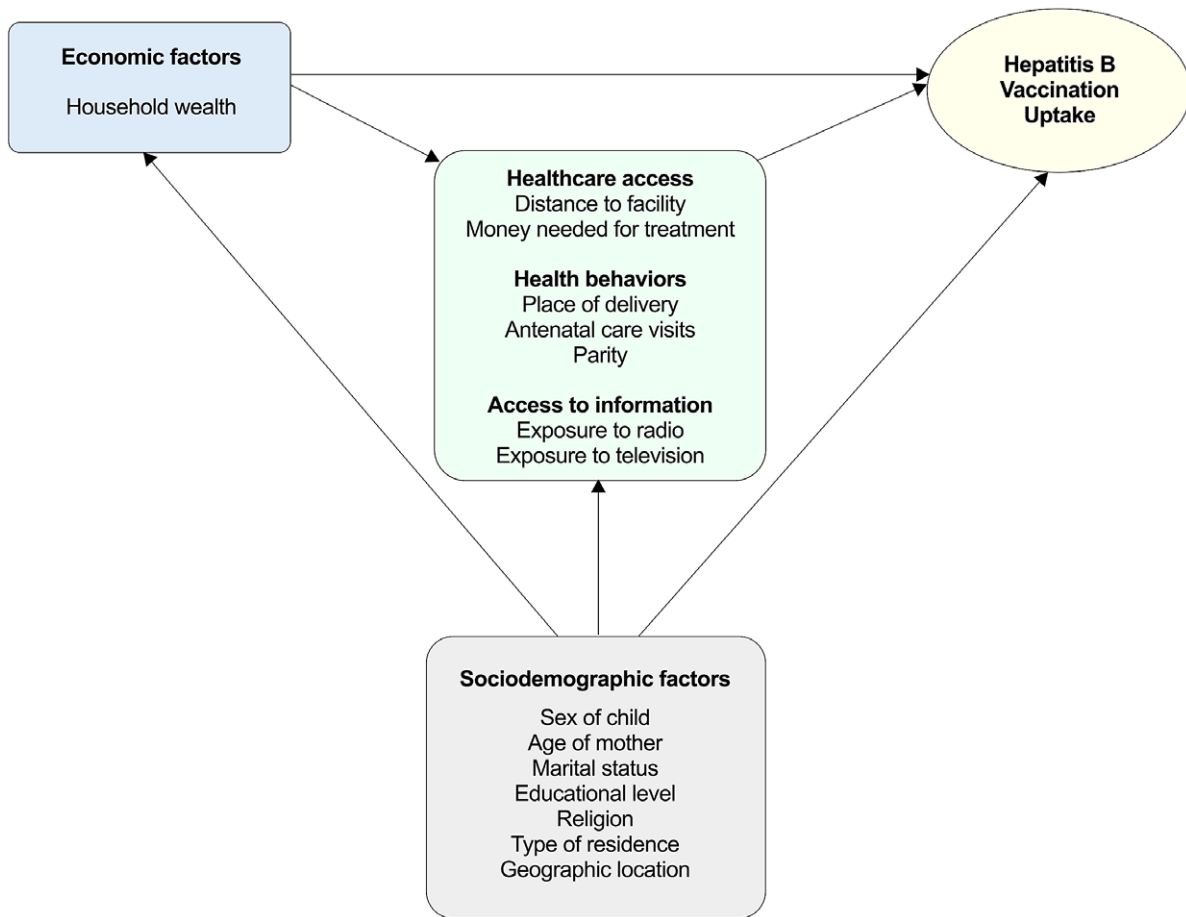
Conceptual framework

Our conceptual framework was guided by the *Strategic framework for research on immunization in the WHO African Region — Immunization and Vaccine Development* by the WHO [17] and other relevant literature that have described facilitators and barriers to childhood vaccination in low- and middle-income countries [18]. These frameworks outline crucial objectives, such as enhancing vaccine safety and efficacy, promoting research and development of new vaccines, strengthening immunization programmes, improving vaccine supply and delivery, and increasing community engagement and demand for vaccination services [17, 18]. Facilitators and barriers that have been strongly associated with vaccination coverage include lack of knowledge and awareness among the population, vaccine hesitancy, inadequate health infrastructure and human resources, social and cultural factors, and limited access to vaccines and vaccination services [17, 18]. For the purpose of our study, our modified conceptual framework proposes that childhood HBV vaccination uptake in Sierra Leone, Liberia, and Guinea is determined by sociodemographic and economic factors either directly or through the mediation of other factors such as healthcare access, health behaviours, and access to information (Figure 1). Understanding these factors is the first essential step towards crafting evidence-based policy aimed at improving vaccination coverage and ultimately lessening the burden of HBV and other vaccine-preventable diseases in this setting.

Survey methodology

We conducted a secondary analysis of data from the most recent Demographic and Health Surveys (DHS) carried out in Sierra Leone (2019), Liberia (2019–2020), and Guinea (2018). DHS are nationally representative cross-sectional surveys that are regularly conducted in over 90 developing countries to provide information on key population and health indicators. More information on sampling methods and data collection procedures are described in detail in the individual country DHS reports [19–21]. Briefly, the surveys employed a stratified, two-stage cluster probability sampling design and utilized the latest country census sampling frame to identify strata. To ensure representativeness, the size of strata was allocated non-probabilistically, with larger strata 'under-sampled' while smaller strata were 'over-sampled'. Within each stratum, census enumeration areas were then selected as the primary sampling units in proportion to size. Finally, a fixed number of households were selected within the enumeration areas using equal probability systematic sampling. All women aged 15–49 years who permanently resided at or slept in a selected household on the night prior to the survey were eligible to participate. Consenting participants were interviewed using a standardized women's questionnaire. The interview response rates were > 98% in all three countries [19–21].

Measures

The primary outcome variables were 'complete hepatitis B vaccination coverage' and 'incomplete hepatitis B vaccination coverage' among children aged 4–35 months in Sierra Leone, Liberia, and Guinea, respectively. During DHS, information on routine

Figure 1. Conceptual framework of complete HBV immunization Arrows represents a causal link.

childhood vaccination was collected by asking eligible mothers about the vaccination status of their child (the index case) in the three years preceding the survey. Information on vaccination was provided in two ways: (1) written vaccination records or health cards and (2) verbal reports. The responses provided were recorded as follows: 'no', 'vaccination date on card', 'vaccination marked on card', 'reported by mother', and 'don't know'. To estimate hepatitis B vaccination coverage for each of the 3 recommended doses, we assessed the responses recorded under the variables 'received pentavalent 1', 'received pentavalent 2', and 'received pentavalent 3', respectively, given that hepatitis B vaccination is administered as the pentavalent vaccine in Sierra Leone, Liberia, and Guinea. The overall coverage for each of the 3 recommended doses was estimated by summing all 3 affirmative responses, i.e. 'vaccination date on card', 'vaccination marked on card', and 'reported by mother'. Thus, the primary outcome of 'complete hepatitis B immunization' was defined as having received all 3 doses of the pentavalent vaccine as reported under the variable 'received pentavalent 3'. 'Incomplete hepatitis B immunization' was defined as having missed at least 1 of the 3 recommended doses and was a composite of the responses 'no' and 'don't know' recorded under the variable 'received pentavalent 3'. We excluded children aged <4 months from the analysis as the third dose of the pentavalent vaccine is administered at 14 weeks.

Where necessary, we recoded variables. The explanatory variables for incomplete HBV vaccination included sex of the child (male vs. female), mother's relationship status (recoded as 'single' vs. 'married'), religion (recoded 'Christian' vs. 'Muslim'), educational level (recoded as 'no education' vs. 'primary or higher'), type of place of residence (urban vs. rural), and country region. The effect of adolescent motherhood on vaccination coverage was assessed as a binary variable (recoded as '15–19 years' vs. ≥ '20 years'). Household wealth index was recoded as a binary variable 'poor' (poorest and poorer quintiles) vs. 'rich' (middle, richer, and richest quintiles). The number of antenatal visits was recoded as a binary variable ('0–3' vs. '≥4') in accordance with the WHO recommendation of a minimum of 4 antenatal visits for favourable pregnancy outcomes [22]. Parity was similarly recoded as a binary variable ('1–4' vs. '5') in accordance with current regional fertility rates reported by DHS from each country [19–21]. We assessed the effect of healthcare access on vaccination coverage using the variables 'money for treatment' ('big problem' vs. 'not a big problem') and 'distance to health facility' ('big problem' vs. 'not a big problem'). We recoded the variable 'place of delivery' as 'home' vs. 'health facility'. Finally, we assessed access to mass media as a source of health information on vaccination coverage using the variables 'exposure to radio', 'exposure to television', and 'exposure to internet' (recoded as 'yes' vs. 'no', respectively).

Statistical analyses

We used the complex command package of SPSS Version 28.0 (IBM Corp, NY, USA) to perform statistical analyses, taking into account the complex two-stage cluster sampling design and weighting. Sociodemographic and health characteristics were reported using summary statistics. Categorical variables were expressed as unweighted frequencies (weighted percentages), and vaccination coverage estimates were presented as percentages with 95% confidence intervals (CI). We used the Pearson chi-square test to evaluate differences between characteristics. To identify factors associated with incomplete hepatitis B immunization, we employed logistic regression. In the final multivariable logistic regression model, only explanatory variables with $p < 0.20$ in the univariate analysis were included, with statistical significance set at $p < 0.05$ for all analyses and presented crude odds ratios and adjusted odds ratios (aOR) with 95% CI. Furthermore, we found no evidence of collinearity among explanatory variables (Supplementary Material, available on the Cambridge Core website).

Ethical approval

The protocols for the DHS methodology and data collection procedures were approved by the institutional review boards or ethics committees at ICF Macro, the Sierra Leone Ethics and Scientific Review Committee, the University of Liberia Pacific Institute for Research and Evaluation, and the Guinea National Ethics Committee for Health Research (Comité National d'Ethique pour la Recherche en Santé). Written permission to use the respective country datasets was granted by DHS.

Results

Characteristics of survey respondents

Of a total of 11,181 mothers included in the analysis, 4,846 were from Sierra Leone, 2,788 from Liberia, and 3,547 were from Guinea (Table 1). The children were aged 4–35 months, and the ratio of males to females was roughly 1:1 across countries. A minority of respondents were adolescent mothers and single (Table 1). Guinea had the highest proportion of mothers with no education (73.2%), compared with Sierra Leone (51.6%) and Liberia (33.5%) ($p < 0.001$). The majority of respondents were Muslim in Sierra Leone (79.6%) and Guinea (87.9%), whereas in Liberia Christians formed the majority (82.5%). Roughly half (52.9%) of the households selected in Liberia were in urban areas, whereas in Sierra Leone and Guinea about two-thirds of households were in rural areas. In each country, an equal proportion of households were selected across wealth quintiles.

Regarding health-seeking and healthcare access, mothers in Sierra Leone and Liberia had better health indicators in comparison to Guinea. More mothers in Sierra Leone (74.1%) and Liberia (81.4%) accessed antenatal care services 4 or more times during pregnancy, while in Guinea antenatal care attendance was low (33.7%). Similarly, a higher proportion of mothers from Guinea reported delivery at home (43.6%), compared to 14.0% and 16.3% in Sierra Leone and Liberia, respectively. A larger proportion of respondents from Sierra Leone considered money for healthcare payments and distance to healthcare facilities a greater problem compared to the other two countries. On the other hand, information through mass media (radio/television) was more accessible in Guinea, while internet access was more widely available in Liberia.

Table 1. Baseline sociodemographic and health characteristics of index child and households by country

Characteristics	Sierra Leone	Liberia	Guinea	p-values
Unweighted N (weighted %)	4,846 (100)	2,788 (100)	3,547 (100)	
Sex of child				
Male	2,441 (50.0)	1,358 (49.3)	1843 (51.7)	0.110
Female	2,405 (50.0)	1,430 (50.7)	1708 (48.3)	
Age of mother, *years*				
15–19	455 (9.4)	346 (11.7)	378 (11.0)	<0.001
20–34	3,310 (69.1)	1768 (66.7)	2,374 (67.0)	
≥ 35	1,081 (21.5)	674 (21.6)	795 (22.0)	
Mother's current marital status				
Single	747 (15.5)	841 (33.5)	231 (6.6)	<0.001
Married	4,099 (84.5)	1947 (66.5)	3,316 (93.4)	
Mother's educational level				
No education	2,625 (51.6)	1,108 (33.5)	2,592 (73.2)	<0.001
Primary	707 (15.3)	877 (26.8)	432 (11.6)	
Secondary	1,384 (30.3)	762 (36.3)	436 (12.6)	
Higher	130 (2.8)	41 (3.4)	87 (2.7)	
Mother's religion				
Christian	967 (20.4)	2,353 (82.5)	305 (10.5)	<0.001
Muslim	3,877 (79.6)	364 (14.9)	3,207 (87.9)	
Others	2 (0)	71 (2.6)	35 (1.6)	
Household wealth index (quintile)				
Poorest	1,209 (22.8)	917 (24.0)	819 (21.8)	<0.001
Poorer	1,119 (21.7)	773 (21.9)	760 (21.9)	
Middle	1,021 (20.5)	553 (18.1)	651 (18.8)	
Richer	876 (18.9)	315 (18.9)	720 (19.8)	
Richest	621 (16.2)	230 (17.0)	597 (17.6)	
Type of residence				
Urban	1,497 (35.3)	932 (52.9)	1,096 (31.2)	<0.001
Rural	3,349 (64.7)	1856 (47.1)	2,451 (68.8)	
Number of antenatal visits				
0–3	390 (8.4)	334 (9.8)	1963 (54.5)	
4+	3,605 (74.1)	2,183 (81.4)	1,171 (33.7)	
Do not know/ missing data	851 (17.6)	271 (8.7)	413 (11.9)	
Parity				
1–4	3,593 (74.7)	1876 (72.9)	2,488 (70.5)	<0.001
5+	1,253 (25.3)	912 (27.1)	1,059 (29.5)	
Place of delivery				
Home	702 (14.0)	470 (16.3)	1,631 (43.6)	<0.001
Government hospital	1,367 (28.8)	673 (26.7)	420 (11.2)	
Government health centre	2,126 (44.1)	219 (5.5)	915 (27.0)	

(Continued)

Table 1. (Continued)

Characteristics	Sierra Leone	Liberia	Guinea	p-values
Government post	531 (10.4)	2 (0.1)	377 (12.4)	
Private facility	120 (2.7)	1,424 (51.5)	204 (5.8)	
Money for treatment				
Big problem	3,533 (71.3)	1,190 (38.3)	2,213 (62.0)	<0.001
Not a big problem	1,313 (28.7)	1,598 (61.7)	1,334 (38.0)	
Distance to health facilities				
Big problem	2,433 (48.3)	1,077 (32.2)	1732 (47.5)	<0.001
Not a big problem	2,413 (51.7)	1711 (67.8)	1815 (52.5)	
Exposure to radio				
Yes	1871 (40.8)	1,484 (54.4)	2,118 (59.7)	<0.001
No	2,975 (59.2)	1,304 (45.6)	1,429 (40.3)	
Exposure to television				
Yes	953 (22.5)	697 (30.9)	1,432 (41.6)	<0.001
No	3,893 (77.5)	2091 (69.1)	2,115 (58.4)	
Exposure to internet				
Yes	383 (8.7)	329 (19.5)	448 (12.5)	
No	4,463 (91.3)	2,459 (80.5)	3,099 (87.5)	
Received the first dose of HepB vaccine (pentavalent 1)				
Vaccination date on card	3,374 (69.2)	1,636 (57.1)	1,446 (42.0)	<0.001
Vaccination marked on card	81 (1.8)	85 (3.1)	76 (2.3)	
Reported by mother	1,095 (22.9)	779 (29.7)	638 (18.0)	
No or do not know	296 (6.1)	288 (10.1)	1,387 (37.7)	
Received the second dose of HepB vaccine (pentavalent 2)				
Vaccination date on card	3,097 (63.2)	1,505 (52.6)	1,230 (36.0)	<0.001
Vaccination marked on card	82 (1.9)	81 (3.1)	81 (2.3)	
Reported by mother	791 (16.6)	608 (23.1)	375 (11.4)	
No or do not know	876 (18.3)	594 (21.1)	1861 (50.3)	
Received the third dose of HepB vaccine (pentavalent 3)				
Vaccination date on card	2,778 (56.9)	1,338 (46.9)	1,036 (30.7)	<0.001
Vaccination marked on card	81 (1.8)	72 (2.8)	89 (2.6)	
Reported by mother	533 (11.6)	379 (14.9)	208 (6.7)	
No or do not know	1,454 (29.7)	999 (35.4)	2,214 (60.0)	

(Continued)

Table 1. (Continued)

Characteristics	Sierra Leone	Liberia	Guinea	p-values
Country regions				
Sierra Leone				
Eastern	963 (21.3)		–	
Northern	1,119 (19.6)		–	
North Western	908 (19.0)		–	
Southern	1,239 (21.5)		–	
Western	617 (18.6)		–	
Liberia				
North Western	–	419 (8.5)	–	
South Central	–	704 (43.5)	–	
South Eastern A	–	434 (6.7)	–	
South Eastern B	–	478 (5.5)	–	
North Central	–	753 (35.7)	–	
Guinea				
Boké	–	–	490 (10.2)	
Conakry	–	–	355 (13.1)	
Faranah		–	469 (10.4)	
Kankan	–	–	554 (17.7)	
Kindia	–	–	470 (14.8)	
Labé	–	–	455 (11.9)	
Manou	–	–	323 (7.0)	
N'Zérékoré	–	–	431 (15.0)	

Complete hepatitis B vaccination coverage by respondent characteristics

Table 2 shows complete hepatitis B vaccination coverage by respondent sociodemographic and health characteristics. Sierra Leone had the highest overall vaccination coverage at 70.3% (95% CI 68.5–72) and Liberia at 64.6% (95% CI 61.3–68.0), while Guinea had the lowest overall vaccination coverage at 39.3% (95% CI 36.3–42.4). There were variations in vaccination coverage within and between countries based on sociodemographic and healthcare access (Table 2). In Sierra Leone, older mothers, Christians, those delivering at private facilities, and those near healthcare facilities had significantly higher coverage. In Liberia, male children, wealthier households, ≥ 4 antenatal visits, and government health centre deliveries had higher coverage. Guinea's vaccination coverage varied by factors like education, wealth, urban residence, ≥ 4 antenatal visits, government hospital deliveries, and internet access (Table 2).

Predictors of incomplete hepatitis B vaccination

Tables 3 and 4 display the results of univariate and multivariate regression analyses of factors associated with incomplete hepatitis B vaccination coverage. In Sierra Leone, being an adolescent mother (aOR 1.36, 95% CI 1.05–1.75), being a Muslim (aOR 1.28, 95% CI 1.03–1.59), lower wealth index (aOR 1.20, 95% CI 1.00–1.43), and distance to health facility (aOR 1.20, 95% CI 1.01–1.43) were associated with higher odds of incomplete immunization, while being a

Table 2. Complete HBV immunization coverage rates overall and by sociodemographic and health characteristics

Characteristics	Sierra Leone			Liberia			Guinea		
	Coverage[a] %	95% CI	*p*-value	Coverage[a] %	95% CI	*p*-value	Coverage[a] %	95% CI	*p*-value
Overall weighted %	70.3	68.5–72.1		64.6	61.3–68.0		39.3	36.3–42.4	
Sex of child									
Male	68.5	66.6–70.3	0.053	66.9	64.3–69.5	0.042	39.5	37.2–41.7	0.865
Female	71.4	69.5–73.2		62.4	59.7–65.0		39.2	36.9–41.5	
Age of mother, *years*									
15–19	65.2	60.8–69.7	0.042	65.7	60.3–71.1	0.419	41.4	36.5–46.3	0.104
20–34	69.8	68.3–71.4		63.5	61.2–65.8		40.2	38.2–42.2	
35–49	72.2	69.5–75.0		67.4	63.5–71.4		35.6	32.2–38.9	
Mother's marital status									
Single	69.3	66.0–72.7	0.746	65.2	62.0–68.4	0.744	44.3	37.9–50.8	0.174
Married	70.0	68.6–71.4		64.3	62.0–66.6		39.0	37.3–40.6	
Mother's educational level									
No education	68.3	66.5–70.2	0.191	60.1	56.8–63.4	0.161	35.4	33.5–37.2	<0.001
Primary	72.0	68.7–75.3		64.8	61.2–68.4		39.5	34.8–44.3	
Secondary	71.2	68.8–73.5		68.4	65.3–71.4		55.6	51.0–60.3	
Higher	73.8	66.3–76.5		68.1	58.1–78.1		70.7	61.3–80.1	
Mother's religion									
Christian	74.3	71.5–77.0	0.012	70.9	66.3–75.5	0.067	53.9	48.8–59.0	<0.001
Muslim	68.8	67.3–70.3		63.7	61.6–65.7		36.8	35.1–38.5	
Household wealth index (quintile)									
Poorest	67.0	64.2–69.8	0.173	55.0	51.1–59.0	0.014	23.4	20.4–26.4	0.001
Poorer	69.2	66.4–72.0		64.6	60.6–68.6		36.1	32.7–39.5	
Middle	72.4	69.6–75.2		67.6	63.3–71.9		38.2	34.5–41.9	
Richer	72.3	69.3–75.2		70.1	66.6–74.8		44.7	41.0–48.4	
Richest	69.1	65.8–72.3		68.2	63.8–72.6		58.2	54.3–62.1	
Type of residence									
Urban	70.8	68.6–73.0	0.493	67.6	65.1–70.1	0.062	52.6	49.6–55.55	<0.001
Rural	69.4	67.8–71.1		61.3	58.5–64.0		33.3	31.4–35.2	
Number of antenatal visits									
0–3	64.9	60.2–69.6	0.058	47.5	41.2–53.7	<0.001	29.4	27.4–31.5	0.001
4+	71.0	69.5–72.5		67.4	65.3–69.4		55.3	52.4–58.1	
Parity									
1–4	70.1	68.6–71.6	0.729	66.4	64.2–68.6	0.049	40.9	39.0–42.8	0.007
5+	69.5	66.8–72.1		59.8	56.2–63.5		35.6	32.6–38.5	
Place of delivery									
Home	65.9	63.3–69.5	<0.001	51.6	46.8–56.4	<0.001	23.6	21.4–25.7	0.001
Government hospital	68.3	65.8–70.7		70.0	66.6–73.5		58.3	53.4–63.2	
Government health centre	71.4	69.5–73.3		72.1	64.5–79.7		49.0	45.9–52.2	
Government post	72.3	68.4–76.3		–	–		52.2	47.5–56.9	
Private facility	74.5	66.8–82.2		65.1	62.5–67.7		48.3	41.4–55.2	
Getting medical help for self: money for treatment									
Big problem	69.4	67.8–70.9	0.112	65.3	62.3–68.3	0.647	35.1	33.1–37.1	<0.001

(*Continued*)

Table 2. (*Continued*)

Characteristics	Sierra Leone			Liberia			Guinea		
	Coverage[a] %	95% CI	*p*-value	Coverage[a] %	95% CI	*p*-value	Coverage[a] %	95% CI	*p*-value
Not a big problem	71.2	68.8–73.6		64.2	61.8–66.6		46.2	43.6–48.9	
Distance to health facilities									
Big problem	68.0	66.1–70.0	0.032	64.1	60.8–67.4	0.773	32.1	29.9–34.3	<0.001
Not a big problem	71.6	69.9–73.4		64.9	62.6–67.1		45.9	43.6–48.1	
Exposure to radio									
Yes	70.6	68.5–72.6	0.514	67.3	64.8–69.8	0.051	43.2	41.1–45.3	<0.001
No	69.5	67.8–71.2		61.4	58.6–64.2		33.6	31.1–36.1	
Exposure to television									
Yes	70.3	67.5–73.0	0.822	67.4	64.1–70.7	0.294	47.6	45.0–50.2	<0.001
No	69.8	68.3–71.3		63.4	61.1–65.6		33.4	31.4–35.5	
Exposure to internet									
Yes	69.6	65.2–74.1	0.918	70.8	66.8–74.8	0.111	57.7	53.1–62.3	<0.001
No	69.9	68.6–71.3		63.1	61.0–65.2		36.7	35.0–38.4	
Country regions									
Sierra Leone									
Eastern	73.1	70.3–75.8	0.058	–	–		–	–	
Northern	66.5	63.4–69.5		–	–		–	–	
North Western	67.6	64.5–70.6		–	–		–	–	
Southern	73.1	70.4–75.8		–	–		–	–	
Western	68.6	65.6–71.7		–	–		–	–	
Liberia									
North Western	–	–		70.1	63.9–76.2	0.427	–	–	
South Central	–	–		63.9	61.0–66.7		–	–	
South Eastern A	–	–		57.7	50.2–65.2		–	–	
South Eastern B	–	–		65.8	57.8–73.7		–	–	
North Central	–	–		65.4	62.3–67.1		–	–	
Guinea									
Boké	–	–		–	–		27.6	23.0–32.3	<0.001
Conakry	–	–		–	–		55.5	50.9–60.1	
Faranah				–	–		39.4	34.4–44.4	
Kankan	–	–		–	–		48.0	44.1–51.9	
Kindia	–	–		–	–		38.8	34.6–43.0	
Labé	–	–		–	–		17.1	13.5–20.7	
Manou	–	–		–	–		25.1	19.6–30.5	
N'Zérékoré	–	–		–	–		47.8	43.5–52.1	

[a]Complete HBV immunization coverage was defined as completing all 3 series of vaccines administered at 6, 10, and 14 weeks after birth and was estimated as a composite of 'vaccination date on card', 'vaccination marked on card', and 'reported by mother' (Table 1).

female child was associated with lower odds of incomplete vaccination (aOR 0.86, 95% CI 0.74–0.99). In contrast, in Liberia, female children (aOR 1.83, 95% CI 1.30–2.59), less than 4 antenatal visits (aOR 1.83, 95% CI 1.30–2.59), and home delivery (aOR 1.48, 95% CI 1.02–2.13) were significantly associated with incomplete immunization. Similarly, in Guinea, healthcare factors were the dominant predictors of incomplete immunization, i.e. <4 antenatal visits (aOR 2.31, 95% CI 1.87–2.85) and home delivery (aOR 2.18, 95% CI 1.74–2.74). Additionally,

in Guinea, being a Muslim (aOR 1.96, 95% CI 1.28–2.99) and being a resident in the Labé region (aOR 2.58, 95% CI 1.49–4.48) were significantly associated with incomplete immunization.

Discussion

To the best of our knowledge, this is the first population-based study to estimate national hepatitis B vaccination coverage rates

Table 3. Univariate analysis of factors associated with incomplete HBV immunization[a]

Characteristics	Sierra Leone		Liberia		Guinea	
	Crude odds ratio (95% CI)	*p*-value	Crude odds ratio (95% CI)	*p*-value	Crude odds ratio (95% CI)	*p*-value
Sex of child						
Male	Ref	0.053	Ref	0.042	Ref	0.518
Female	0.87 (0.76–1.00)		1.22 (1.01–1.47)		1.01 (0.88–1.16)	
Age of mother, *years*						
15–19	1.27 (1.02–1.58)	0.034	0.95 (0.68–1.32)	0.748	0.91 (0.72–1.15)	0.413
20+	Ref		Ref		Ref	
Mother's marital status						
Single	1.03 (0.85–1.26)	0.746	0.96 (0.77–1.21)	0.744	0.80 (0.58–1.10)	0.174
Married	Ref		Ref		Ref	
Mother's educational level						
No education	1.17 (1.02–1.34)	0.030	1.34 (1.06–1.70)	0.014	2.49 (1.98–3.14)	<0.001
Primary or higher	Ref		Ref		Ref	
Mother's religion						
Christian	Ref	0.012	Ref	0.067	Ref	<0.001
Muslim	1.32 (1.06–1.61)		1.39 (0.98–1.96)		2.00 (1.37–2.94)	
Household wealth index quintiles						
Poorest and poorer	1.19 (1.00–1.42)	0.046	1.50 (1.15–1.96)	0.003	2.07 (1.65–2.59)	<0.001
Middle, richer, and richest	Ref		Ref		Ref	
Type of residence						
Urban	Ref	0.493	Ref	0.062	Ref	<0.001
Rural	1.06 (0.88–1.28)		1.32 (0.99–1.79)		2.22 (1.72–2.86)	
Number of antenatal visits						
≤4	1.32 (1.00–1.74)	0.058	2.28 (1.58–3.29)	<0.001	2.96 (2.46–3.56)	0.001
4+	Ref		Ref		Ref	
Parity						
1–4	Ref	0.729	Ref	0.049	Ref	0.007
5+	1.03 (0.88–1.22)		1.33 (1.00–1.76)		1.25 (1.06–1.47)	
Place of delivery						
Home	1.24 (1.01–1.52)	0.037	1.92 (1.34–2.74)	<0.001	3.44 (2.78–4.26)	0.001
Facility	Ref		Ref		Ref	
Money needed for treatment						
Big problem	1.09 (0.92–1.30)	0.326	0.95 (0.78–1.17)	0.646	1.59 (1.28–1.98)	<0.001
Not a big problem	Ref		Ref		Ref	
Distance to health facilities						
Big problem	1.19 (1.02–1.39)	0.032	1.04 (0.82–1.31)	0.773	1.79 (1.47–2.19)	<0.001
Not a big problem	Ref		Ref		Ref	
Exposure to radio						
Yes	Ref	0.514	Ref	0.051	Ref	<0.001
No	1.05 (0.90–1.23)		1.29 (1.00–1.68)		1.49 (1.25–1.82)	
Exposure to television						
Yes	Ref	0.822	Ref	0.274	Ref	
No	1.02 (0.83–1.25)		1.19 (0.87–1.63)		1.82 (1.47–2.22)	<0.001

(*Continued*)

Table 3. (*Continued*)

Characteristics	Sierra Leone Crude odds ratio (95% CI)	*p*-value	Liberia Crude odds ratio (95% CI)	*p*-value	Guinea Crude odds ratio (95% CI)	*p*-value
Exposure to internet						
Yes	Ref	0.918	Ref	0.111	Ref	<0.001
No	0.99 (0.75–1.30)		1.42 (0.92–2.19)		2.38 (1.75–3.13)	
Country regions						
Sierra Leone						
Eastern	0.81 (0.59–1.10)	0.169	–		–	
Northern	1.10 (0.81–1.51)	0.536	–		–	
North Western	1.05 (0.77–1.43)	0.756	–		–	
Southern	0.80 (0.59–1.09)	0.163	–		–	
Western	Ref		–		–	
Liberia						
North Western	–		0.81 (0.54–1.22)	0.303	–	
South Central	–		1.07 (0.75–1.53)	0.714	–	
South Eastern A	–		1.38[a] 0.91–1.09)	0.124	–	
South Eastern B	–		0.98 (0.64–1.50)	0.937	–	
North Central	–		Ref		–	
Guinea						
Boké	–		–		2.40 (1.44–3.98)	<0.001
Conakry	–		–		0.73 (0.44–1.22)	0.229
Faranah	–		–		1.41 (0.80–2.47)	0.234
Kankan	–		–		0.99 (0.58–1.71)	0.977
Kindia	–		–		1.45 (o.88–2.38)	0.148
Labé	–		–		4.44 (2.67–7.38)	<0.001
Manou	–		–		2.74 (1.62–4.63)	<0.001
N'Zérékoré	–		–		Ref	

[a]Incomplete HBV immunization was a composite variable defined as completing 0, 1, or 2 of the recommended 3 HBV vaccine doses administered at 6, 10, and 14 weeks after birth.

and identify factors associated with incomplete HBV vaccination among children in Sierra Leone, Liberia, and Guinea, three West African countries with a high burden of HBV infection. Sierra Leone had the highest national vaccination coverage at 70.3%, while Liberia and Guinea had lower coverage rates at 64.7% and 40%, respectively. Our estimates were slightly lower than coverage rates compiled jointly by WHO and the United Nation's Children's Emergency Fund (WHO/UNICEF), which reported a 95% vaccination coverage rate for Sierra Leone in 2019, 70% for Liberia in 2020, and 47% for Guinea in 2018 [23]. Furthermore, the coverage rates from our study were lower than those reported by other West African countries such as Senegal (93%), the Gambia (88%), Burkina Faso (91%), and Mali (77%) [23]. The differences in vaccination coverage among the three countries could be attributed to various factors, including sociocultural and healthcare service-related factors, as well as variations in the data sources used to calculate the estimates. The WHO/UNICEF estimates relied on both administrative data from healthcare providers and population-based surveys and focussed on children aged 12–35 months [23]. In contrast, our estimates were solely based on

population-based surveys and included younger children aged 4–35 months, who were more likely to lag in completing the vaccine series [19–21].

Annually, around 820,000 people die from complications of chronic HBV infection worldwide [1]. In many endemic countries in SSA, there are still entrenched disparities and inequities in access to quality healthcare including HBV screening, treatment, and prevention services, despite the availability of an effective HBV vaccine since 1982 and the WHO's call for the global elimination of viral hepatitis as a public health threat by 2030 [4]. In our examination of disparities in HBV vaccination coverage based on key sociodemographic, economic, and healthcare access factors, we identified significant intra- and intercountry differences in vaccination coverage. Of the factors examined, higher rates of vaccination coverage were observed for facility-based delivery in Liberia and Guinea. Other factors that were associated with higher vaccination coverage in more than one country were antenatal care visits, higher household wealth quintiles, fewer births, religion (Christianity), and within proximity to a healthcare facility. In Guinea, higher maternal level of

Table 4. Multivariate analysis of factors associated with incomplete HBV immunization[a]

Characteristics	Sierra Leone Adjusted odds ratio (95% CI)	*p*-value	Liberia Adjusted odds ratio (95% CI)	*p*-value	Guinea Adjusted odds ratio (95% CI)	*p*-value
Sex of child						
Male	Ref	0.037	Ref	0.041		
Female	0.86 (0.74–0.99)		1.25 (1.01–1.56)			
Age of mother, *years*						
15–19	1.36 (1.05–1.75)	0.019				
20+	Ref					
Mother's marital status						
Single					1.67 (0.85–1.60)	0.342
Married					Ref	
Mother's educational level						
No education	1.10 (0.94–1.30)	0.243	1.19 (0.91–1.56)	0.195	1.13 (0.87–1.46)	0.373
Primary or higher	Ref		Ref		Ref	
Mother's religion						
Christian	Ref	0.027	Ref	0.408	Ref	0.002
Muslim	1.28 (1.03–1.59)		1.18 (0.80–1.72)		1.96 (1.28–2.99)	
Household wealth index quintiles						
Poorest and poorer	1.20 (1.00–1.43)	0.050	1.27 (0.94–1.71)	0.126	1.20 (0.92–1.58)	0.179
Middle, richer, and richest	Ref		Ref		Ref	
Type of residence						
Urban			Ref	0.671	Ref	0.781
Rural			1.09 (0.73–1.63)		1.05 (0.73–1.51)	
Number of antenatal visits						
≤3	1.29 (0.98–1.69)	0.070	1.83 (1.30–2.59)	<0.001	2.31 (1.87–2.85)	<0.001
4+	Ref		Ref		Ref	
Parity						
1–4			0.85 (0.63–1.16)	0.303	0.97 (0.80–1.16)	0.707
5+			Ref		Ref	
Place of delivery						
Home	1.08 (0.86–1.36)	0.527	1.48 (1.02–2.13)	0.038	2.18 (1.74–2.74)	<0.001
Facility	Ref		Ref		Ref	
Money needed for treatment						
Big problem					1.07 (0.85–1.35)	0.163
Not a big problem					Ref	
Distance to health facilities						
Big problem	1.20 (1.01–1.43)	0.034			1.17 (0.95–1.44)	0.574
Not a big problem	Ref				Ref	
Exposure to radio						
Yes			Ref	0.289	Ref	0.137
No			1.17 (0.88–1.55)		1.13 (0.94–1.37)	
Exposure to television						
Yes					Ref	0.245
No					1.16 (0.90–1.49)	

(*Continued*)

Table 4. (*Continued*)

Characteristics	Sierra Leone Adjusted odds ratio (95% CI)	p-value	Liberia Adjusted odds ratio (95% CI)	p-value	Guinea Adjusted odds ratio (95% CI)	p-value
Exposure to internet						
Yes			Ref	0.792	Ref	0.176
No			1.06 (0.67–1.70)		1.27 (0.90–1.79)	
Country regions						
Sierra Leone						
Eastern	0.84 (0.58–1.21)	0.340	–		–	
Northern	1.09 (0.75–1.57)	0.663	–		–	
North Western	1.01 (0.70–1.45)	0.955	–		–	
Southern	0.75 (0.52–1.09)	0.133	–		–	
Western	Ref		–		–	
Liberia						
North Western	–		0.70 (0.47–1.02)	0.064	–	
South Central	–		1.22 (0.78–1.89)	0.737	–	
South Eastern A	–		1.26 (0.82–1.94)	0.289	–	
South Eastern B	–		0.90 (0.57–1.41)	0.629	–	
North Central	–		Ref		–	
Guinea						
Boké	–		–		1.38 (0.82–2.32)	0.228
Conakry	–		–		0.79 (0.46–1.37)	0.402
Faranah	–		–		0.72 (0.40–1.29)	0.263
Kankan	–		–		0.65 (0.36–1.18)	0.158
Kindia	–		–		0.96 (0.57–1.61)	0.871
Labé	–		–		2.58 (1.49–4.48)	<0.001
Manou	–		–		1.44 (0.80–2.59)	0.220
N'Zérékoré	–		–		Ref	

[a]Incomplete HBV immunization was a composite variable defined as completing 0, 1, or 2 of the recommended 3 HBV vaccine doses administered at 6, 10, and 14 weeks after birth.

education, access to information through mass media, and payments for health services were additional factors that were associated with vaccination coverage. Similar findings have been observed in other African countries [24–27].

Furthermore, we assessed independent predictors of incomplete vaccination coverage. Healthcare access indices predominated as were the most important factors. Children born to mothers who had fewer than four antenatal care visits had 1.83- to 2.3-fold higher odds of not completing vaccination in Liberia and Guinea. Similarly, home delivery was significantly associated with incomplete vaccination coverage in the two countries. In contrast, in Sierra Leone, children with mothers who considered distance to health facilities a 'big problem' were significantly less likely to complete the vaccination series. These findings are not surprising, as antenatal care attendance and delivery in healthcare facility provide opportunities for educating mothers on the benefits of vaccination and other vital maternal and child health services [28]. Taken together, our findings are in agreement with others who have suggested that HBV infection is fundamentally a disease of poverty [29, 30]; thus,

HBV control efforts should aim to address socioeconomic inequities to achieve elimination targets [9, 29, 30].

Another notable finding was the observed impact of religion on HBV vaccination uptake. Children of Muslim mothers were less likely to complete the HBV vaccination series in Sierra Leone and Guinea, which have majority Muslim populations. Studies from elsewhere corroborate these findings. A recent systematic review from the United Kingdom found that being Muslim played a role in parents' decision-making about routine childhood vaccination [31]. However, these findings warrant more careful interpretation, as there is no conclusive evidence to suggest that Muslims are less likely to vaccinate compared with people of other religious or cultural backgrounds. For example, a study from Malaysia found that the majority of Muslim parents surveyed had positive attitudes towards childhood immunizations and believed that vaccines were permissible under Islamic law (or 'Sharia') [32]. In contrast, studies have found that Evangelical Christians in the United States [33] and in Nigeria [34] have been the most hesitant to vaccinate against coronavirus-19 compared with other religious

groups. Overall, these findings suggest that vaccine acceptance is a complex issue that is influenced by a multitude of factors, including level of education, access to healthcare, trust in healthcare providers, and cultural, religious, and political beliefs [31–34]. To improve vaccine uptake among all communities, it is important to address concerns and provide accurate information about vaccine safety and efficacy.

Our study did not directly assess the impact of the HBV birth dose vaccination on HBV vaccine completion rates as it has not been implemented in any of the three countries that were examined. However, the HBV birth dose vaccination is an important factor to consider when examining the suboptimal coverage rates observed in our study. The WHO has reported that as of 2021, only 14 of the 47 countries in the WHO African region have integrated the HBV birth dose vaccine into their national immunization programmes and about 1 in 5 newborns in this region receive the birth dose vaccine [35]. In addition to preventing the MTCT of HBV, multiple studies, mostly from high-income settings, have shown that timely administration of the HBV birth dose vaccine is associated with 1.8- to 3-fold higher completion rates of the three-dose HBV vaccine series, as well as other routine childhood vaccines [36–38]. In the few countries in SSA where the HBV birth dose has been implemented, impact assessment studies have highlighted barriers such as implementation cost, a high proportion of births taking place outside of health facilities (e.g. home births), limited access to skilled birth attendants, and inadequate knowledge of HBV among health workers and parents as major factors limiting the successful implementation of the birth dose vaccination [35, 38–40]. Thus, effective implementation of the HBV birth dose vaccination in SSA requires a comprehensive approach that addresses health system strengthening, awareness-raising, delivery platforms, vaccine supply chain management, and multisectoral collaboration and partnership. By extension, successful implementation of these strategies can enhance HBV vaccination coverage overall and reduce the burden of HBV infection in SSA.

It is important to acknowledge the limitations of our study, which can impact the generalizability of our findings. These pertain to the use of secondary data sources, potential recall biases in data collection, challenges in determining causal links, and under-sampling of certain populations. To address some of these limitations, it would have been useful to obtain additional sources of survey coverage data and explore country-specific correlates of complete HBV vaccination in more detail. Nevertheless, the DHS are carefully planned surveys thatemploy rigorous methodology, which adds to the validity of the study's findings. Overall, while the limitations should be considered when interpreting the results, our study provides valuable insights into the prevalence and socio-demographic and healthcare correlates of childhood HBV vaccination coverage in the three countries examined.

Conclusion

In summary, we found suboptimal levels of HBV vaccination coverage among children in Sierra Leone, Liberia, and Guinea. Within countries, vaccination coverage varied based on sociodemographic characteristics and healthcare access factors. Being a male child, Muslim mothers, low household wealth index, low antenatal clinic attendance, home delivery, and proximity to health facilities were important determinants of incomplete HBV vaccination. These findings underscore the critical need to address socio-economic and healthcare inequities that are contributing to suboptimal HBV vaccination uptake and stalling progress towards achieving the 2030 global viral hepatitis elimination targets in these endemic countries.

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