

# Prevalence of hepatitis B virus infection and uptake of hepatitis B vaccine among healthcare workers, Makueni County, Kenya 2017

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## ABSTRACT

**Background** Hepatitis B virus (HBV) is a vaccine-preventable infection that can spread in healthcare setting. Data on HBV infections and vaccine in African healthcare workers (HCWs) are limited. We estimated HBV infection prevalence, hepatitis B vaccination status and identified factors associated with vaccination in one Kenyan county.

**Methods** Randomly selected HCWs completed a questionnaire about HBV exposure and self-reported immunization histories, and provided blood for testing of selected HBV biomarkers to assess HBV infection and vaccination status: HBV core antibodies (anti-HBc), HBV surface antigen (HBsAg) and HBV surface antibodies (anti-HBs). Prevalence odds ratios (OR) with 95% confidence intervals (95% CI) were calculated to identify factors associated with vaccination.

**Results** Among 312 HCWs surveyed, median age was 31 years (range: 19–67 years). Of 295 blood samples tested, 13 (4%) were anti-HBc and HBsAg-positive evidencing chronic HBV infection; 139 (47%) had protective anti-HBs levels. Although 249 (80%) HCWs received  $\geq 1$  HBV vaccine dose, only 119 (48%) received all three recommended doses. Complete vaccination was more likely among those working in hospitals compared to those working in primary healthcare facilities (OR = 2.5; 95% CI: 1.4–4.3).

**Conclusion** We recommend strengthening county HCW vaccination, and collecting similar data nationally to guide HBV prevention and control.

**Keywords** healthcare workers, hepatitis B vaccine, hepatitis B Virus, prevalence

## Introduction

An estimated 2 billion persons globally are infected with hepatitis B virus (HBV), and of these, 248 million have chronic hepatitis B infection.<sup>1</sup> A large proportion of countries in Sub-Saharan Africa are endemic, with estimated HBV prevalence ranging from 5 to 10%.<sup>1,2</sup> HBV infection can occur after exposure to blood and other body fluids from an infected person. Modes of transmission include sexual contact, mother to child transmission, blood transfusion and sharing of unsterilized needles.

Healthcare workers (HCWs) are at an increased risk of HBV infection<sup>3,4</sup> because of their frequent exposure to

infected blood and other contaminated body fluids that could potentially expose them to the virus. Occupational exposure to HCWs can occur through accidental sharps injury, muco-cutaneous contact or blood contact with non-

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intact skin. In 2005, WHO estimated that of 35 million health workers globally, 2 million HCWs suffered a needle stick injury annually resulting in 66 000 developing HBV infection following a sharp injury.<sup>5</sup> Hepatitis B vaccine given prior to exposure can prevent this illness in health workers.<sup>3,6</sup> However, hepatitis B vaccine rates among HCWs has been found to be suboptimal in various countries,<sup>5,7,8</sup> with low completion rates of the recommended three dose hepatitis B vaccine series, and HCWs uncommonly checking their hepatitis B antibody levels after vaccination.<sup>7</sup>

The prevalence of HBV infection by positive hepatitis B surface antigen (HBsAg) in Kenya in 2007 was estimated to be 2–5%, while 31% of the Kenyan population was found to have been previously exposed to HBV.<sup>9,10</sup> A study conducted in various hospitals in Kenya 2012–2013, found an HBV prevalence of 50% among patients with jaundice.<sup>11</sup> Kenya introduced universal hepatitis B vaccine for infants in 2002,<sup>12</sup> however, the HBV vaccine is not routinely available for adult populations in Kenya. The national immunization program guidelines of 2013 recommend that HCWs and other at-risk populations be vaccinated against HBV, however, there is no policy for mandatory vaccination among HCWs. Data on HCWs vaccination with HBV vaccine in Kenya are limited, a previous studies done among HCWs Kenya found an hepatitis B vaccine coverage of 12.8%.<sup>13</sup>

In Makueni County in Eastern Kenya, a county hospital record review in 2015 found that 8% of persons screened were HBV-positive by rapid HBsAg detection test, 35% of in-patients with chronic liver disease were HBV-infected (Makueni county health department, unpublished data). This evidence of HBV infection among patients in the county suggests a risk to the HCWs that attend to them. We sought to estimate the prevalence of HBV infection, uptake of hepatitis B vaccine, and factors associated with vaccine completion among HCWs in Makueni County, Kenya, 2017.

## Methods

This was a cross-sectional study conducted during 1 May to 6 June 2017 in Makueni county, Kenya. The county had 225 registered health facilities both public and private owned.<sup>14</sup> The study population included at-risk health workers in the health facilities.

A HCW was defined as an individual who works in a health facility providing healthcare services or involved in maintenance of the health facilities. Health workers at-risk were those that are often exposed to contaminated body fluids from patients. These included doctors and nurses who treat patients, laboratory personnel involved in sample collection, staff who handle hospital waste and soiled laundry,

and mortuary attendants who handle dead bodies. Health facility was defined as a registered place, private or public, that offered healthcare services. Health workers on night duty and health workers away from the facility on the day of the interview were excluded because we were unable to contact them, while clerks, accountants, cooks and administrators were excluded because they were considered not at risk of exposure.

A sample size of 312 health workers was calculated based on the following assumptions: Complete hepatitis B vaccination prevalence of 42%, based on a study in a hospital in Kenya,<sup>15</sup> a precision of 5%, confidence level of 95% and non-response rate of 10% with finite correction.

All eight sub county hospitals were included, because a majority of HCWs are found in these sub county hospitals, 42 health centers, clinics and dispensaries were randomly selected from the Master Health Facility List using the random number generator in Microsoft Excel. Proportionate to size sampling was used to determine the number of HCWs to be sampled from each health facility. HCWs in selected health facilities were identified by simple random selection from the duty roster.

Structured questionnaires were administered to participants by trained interviewers. Interviewers explained the study to participants and obtained informed consent. Variables collected included socio-demographic information, self-reported history on vaccination with hepatitis B vaccine and self-reported occupational sharp injury. The blood sampling procedure was explained to each participant by a laboratory technician and consent was obtained. The 5 mL of whole blood were drawn from each consenting participant into a plain vacutainer bottle. Blood specimens were centrifuged within 6 hours of collection at 1500 revolutions per minute, and the serum was then transferred into cryovials. The serum was frozen at  $-80^{\circ}\text{C}$  for later testing by trained laboratory technicians.

Three commercial ELISA kits were used in this study. Previous exposure to HBV was tested using the Murex Anti-HBc kit following manufacturer's instructions. Current HBV infection was tested using the Murex version 3 HbsAg kit, by Diansorin. Level of protective antibodies was tested using the Murex Anti-HBs kit, with anti-HBs level of  $\geq 10$  IU/L considered protective.

All non-laboratory data were entered into Epi Info for cleaning and analysis. Prevalence and 95% confidence intervals (95% CI) of exposure to HBV infection or vaccine based on serologic findings were calculated, categorizing HCW into: immune after vaccination (HBsAg negative/anti-HBc negative/anti-HBs positive), immune after infection (HBsAg negative/anti-HBc positive/anti-HBs positive),

susceptible to infection (HBsAg negative/anti-HBc negative/anti-HBs negative), chronic infection (HBsAg positive/anti-HBc positive/anti-HBs negative) or indeterminate (HBsAg negative/anti-HBc positive/anti-HBs negative). Outcomes of interest were self-reported vaccination history of any hepatitis B vaccine given, and of completed vaccination series (receipt of three doses). Comparisons of characteristics between vaccination with at least one dose and non-vaccinated study participants, and complete vaccination and incomplete vaccination were made using the chi-square test or Fishers' exact test, and we calculated odds ratios (OR) and 95% CI. Associations between predictor variables and outcomes were estimated using a forward elimination process during multivariate logistic regression, in which factors with a  $P < 0.2$  were included in the model. In the final model of results, a  $P < 0.05$  was considered statistically significant.

Participants were informed of the potential risks and benefits of the study. Participants signed an informed consent form before enrollment. No personal identifiers were used during data collection and the key record identifying the participant was kept confidential and not made available, except to the principal investigator. Ethical approval to conduct this study was obtained from the Moi University Institutional Research and Ethics Committee. The survey was determined to be a non-research public health evaluation by the US Centers for Disease Control and Prevention.

## Results

A total of 312 HCWs were enrolled and interviewed during May and June 2017. The median age of study participants was 31 years (range: 19–67 years). Most HCWs were aged 25–34 years (56%), and 207 (66%) were females. The highest proportion of HCWs were nurses (Table 1). Most HCWs (212; 68%) had at least diploma level of training; 191 (61%) worked in a health center/dispensary facility, and 290 (93%) were employed by the county government (Table 1). The average number of years in practice was 7.4 years (SD = 7 years). Three hundred and two HCWs (97%, CI: 94–98%) were aware of the recommendation for hepatitis B vaccine for health workers. Those unaware were seven cleaners/waste handlers, one HIV testing service provider (HTSP) and two nurses.

A total of 295 (95%) HCWs provided blood specimens for testing of anti-HBc, HBsAg and anti-HBs. We found that 139 (47%) were immune to HBV after vaccination and 13 (4.5%) had chronic HBV infection (Table 2).

The majority of HCWs aware of the recommendation for HBV vaccine 80% (249/302; 95% CI: 75–84%) reported that they had received at least one dose of hepatitis B

**Table 1** Demographic and occupation characteristics of participating HCW by HBV test status in Makueni County, Kenya, 2017

Characteristic	Tested (n = 295; %)	Not tested (n = 17; %)
Age group		
25–34	162 (54.9)	12 (70.6)
35–49	63 (21.4)	2 (11.8)
50+	42 (14.2)	2 (11.8)
<25	28 (9.5)	1 (5.9)
Years practice		
≤5	174 (59.0)	9 (52.9)
>5	121 (41.0)	8 (47.1)
Sex		
Female	194 (65.8)	13 (76.5)
Male	101 (35.2)	4 (23.5)
Staff group		
Nurse	127 (43.1)	10 (58.8)
Doctors/Clinical officer	53 (18.0)	5 (29.4)
Laboratory	44 (14.9)	2 (11.8)
Cleaner/Waste handler	37 (12.5)	0
HTSP	27 (9.2)	0
Other (dental/mortuary)	7 (2.4)	0
Highest level of education		
Higher education	224 (75.9)	15 (88.2)
Basic education	71 (24.1)	2 (11.8)
Health facility level		
Hospitals	181 (61.4)	10 (58.8)
Health center/dispensary	114 (38.6)	7 (41.2)
Employer (facility ownership)		
County government	277 (93.3)	13 (76.5)
Non-county government	18 (6.1)	4 (23.5)

vaccine. However, only 48% of those receiving the vaccine (119/249; 95% CI: 41–54%) had received the required three doses and 12 (4.8%; 95% CI: 2.5–8.0%) had their blood samples taken for routine serologic confirmation of anti-HBs antibodies after vaccination. Doctors and clinical officers comprised the group with the highest proportion vaccinated (52/57; 91%; 95% CI: 81–97%), while cleaners comprised the group that had the lowest proportion vaccinated (19/31; 61%; 95% CI: 42–78%). Among 130 who had not completed the recommended three doses, 85 (85/130; 65%) said that the vaccine was not readily available, 11 (11/130; 8%) thought the duration between the doses was too long, 7 (7/130; 5%) reported that their institution only provided two doses and 6 (6/130; 5%) forgot about the third dose. Only 34 (34/249; 14%) HCWs reported they had paid for any dose of the vaccine. The most of the HCWs (136/249; 55%) had been vaccinated during their

medical training. Only 88 (88/249; 35%) HCWs reported having been issued a vaccination card following the vaccination. Reasons for not being vaccinated at all included vaccine unavailability (45/53; 85%), HCWs concerns about safety (2/53; 4%) and dislike of injections (2/53; 4%).

Vaccination with at least one dose of hepatitis B vaccine did not differ by age or sex. Those with more than secondary school education were three times more likely to report

receipt at least one dose of hepatitis B vaccine compared to those with less than a secondary school education (OR = 3; 95% CI: 1.6–5.6), while the odds of vaccination was lower by 70% among cleaners than nurses (Table 4).

Complete vaccination with the three doses decreased with increase in age, while those that had a vaccination card were five times as likely to have reported complete vaccination compared to those without any vaccination card.

**Table 2** Hepatitis B viral markers among HCWs in Makueni county, Kenya, 2017

Hepatitis B virus infection and immune status	HBsAg	Anti-HBc	Anti-HBs (IU/L)	Frequency	Percentage (95% CI)
Immune after vaccination	–	–	≥10	139	47.1 (41.3–53.0)
Immune after previous infection	–	+	≥10	84	28.4 (23.4–34.0)
Susceptible to HBV infection	–	–	<10	57	19.3 (15.0–24.3)
Chronic infection	+	+	<10	13	4.5 (2.4–7.4)
Indeterminate	–	+	<10	2	0.7 (0.1–2.4)

HBsAg, hepatitis B surface antigen; Anti-HBc, antibodies to hepatitis B core antigen; anti-HBs, antibodies to hepatitis B surface antigen.

**Table 3** Factors associated with receipt of any hepatitis B vaccination among 302 healthcare workers aware of HBV vaccine recommendation<sup>a</sup> in Makueni County, Kenya, 2017

Characteristic	Vaccinated (n = 249)	Not vaccinated (n = 53)	OR (95% CI)	P value	aOR <sup>b</sup> (95% CI)	P value <sup>b</sup>
Age						
<35 years	164 (82.8)	34 (17.2)	1.1 (0.5–2.0)	0.8		
≥35 years	85 (81.7)	19 (18.3)	Ref			
Sex						
Male	87 (85.3)	15 (14.7)	1.4 (0.7–2.6)	0.44		
Female	162 (81.0)	38 (19.0)	Ref			
Staff group/cadre						
Nurses	110 (81.5)	25 (18.5)	Ref			
Cleaner/Waste handler	19 (61.3)	12 (38.7)	0.3 (0.2–0.8)	0.02	0.4 (0.1–0.8)	0.02
Doctor/Clinical officer	52 (91.2)	5 (8.8)	2.4 (0.9–6.5)	0.09	1.7 (0.6–4.8)	0.35
Laboratory	40 (87.0)	6 (13.0)	1.5 (0.6–4.0)	0.4	1.2 (0.5–3.3)	0.66
HTSP <sup>b</sup>	23 (88.5)	3 (11.5)	1.7 (0.5–6.3)	0.4	1.6 (0.4–5.8)	0.48
Years of practice						
≥5 years	109 (85.2)	19 (14.8)	1.3 (0.7–2.5)	0.2		
<5 years	140 (80.5)	34 (19.5)	Ref			
Education level						
Higher education	204 (86.4)	32 (13.6)	3.0 (1.6–5.6)	<0.001		
Basic primary education	45 (68.2)	21 (31.8)	Ref			
Level of health facility						
Hospitals	165 (88.7)	21 (11.3)	3.0 (1.6–5.5)	<0.001	2.6 (1.4–4.9)	0.003
Health center/dispensary	84 (72.4)	32 (27.6)	Ref			
Employer						
County government	233 (82.9)	48 (17.1)	1.5 (0.4–4.6)	0.4		
Non-county government	16 (76.2)	5 (23.8)	Ref			

HTSP, HIV testing service providers; OR, odds ratio; aOR, adjusted odds ratio; CI, confidence interval.

<sup>a</sup>The 10 HCWs stated that they were unaware of the recommendation and are therefore excluded in this analysis.

<sup>b</sup>Results for final model.

Vaccination during training increased the probability of completion compared to vaccinating while already working. There were no differences in completion by staff group or sex (Table 4). Self-reported hepatitis B vaccination with at least one dose was associated with working in a tier three facility (OR = 2.6; 95% CI: 1.4–4.9). Working in a tier three facility (OR = 2; 95% CI: 1.2–3.8) and having a vaccination card were both associated with self-reported completion of the required three doses (OR = 3.9; 95% CI: 2.2–7.0) (Tables 3 and 4).

## Discussion

### Main findings of this study

This study found that the prevalence of HBV infection among HCWs in Makueni County, Kenya, was similar to the estimated HBV prevalence in the adult Kenyan population

from previous studies.<sup>9</sup> This finding was, however, lower than the prevalence of 7% found among HCWs in a similar study in Tanzania.<sup>16</sup> Four in every five HCWs reported receipt of at least one hepatitis B vaccine dose. This coverage with at least one dose was higher than that found in a study done in Zambia where only 19% of HCWs had ever been vaccinated.<sup>17</sup> This high uptake could be attributed to high awareness among HCWs, and the vaccine being provided by either the training institution or by the employer (both county and national government), which would reduce the cost to the HCW. However, reported completion of all three HBV vaccine doses was less common and serologic evidence of effective immunization even less so. This may be caused by the unavailability of the vaccine after the first dose, forgetting the subsequent doses or institutions only providing partial number of doses. HCWs working in hospitals were more likely to have completed the vaccination

**Table 4** Factors associated with hepatitis B vaccine completion among health workers in Makueni County, 2017

Characteristic	Completed doses (n = 119)	Incomplete doses (n = 130)	OR (95% CI)	P value	aOR (95% CI)	P value
Age						
<35 years	87 (73.1)	77 (59.2)	1.8 (1.1–3.2)	0.02		
≥35 years	32 (26.9)	53 (40.8)	Ref			
Staff group/Cadre						
Nurse	49 (44.5)	61 (55.5)	Ref			
Cleaner/Waste handlers	31 (59.6)	21 (40.4)	0.4 (0.1–1.3)	0.1		
Doctors/Clinical officer	18 (45.0)	22 (55.0)	1.8 (0.9–3.5)	0.07		
Laboratory	12 (43.5)	11 (56.5)	1.0 (0.5–2.1)	0.96		
HTSP*	5 (26.3)	14 (73.7)	1.3 (0.6–3.3)	0.5		
Years of practice						
<5 years	61 (53.0)	54 (47.0)	1.5 (0.9–2.4)	0.15		
≥5 years	58 (43.6)	75 (56.4)	Ref			
Education level						
Higher education	103 (43.6)	133 (56.3)	1.8 (0.9–3.6)	0.09		
Basic education	16 (24.2)	50 (75.8)	Ref			
Who paid for vaccine						
Self	20 (58.8)	14 (41.2)	1.7 (0.8–3.5)	0.22		
Institution	99 (46.0)	116 (54.0)	Ref			
Level of health facility						
Hospitals	91 (55.1)	74 (44.9)	2.5 (1.4–4.3)	0.001	2.1 (1.2–3.8)	0.01
Health center/Dispensary	28 (33.3)	56 (66.7)	Ref			
When vaccinated						
During training	53 (40.0)	47 (41.6)	2.2 (1.3–3.7)	0.003	1.9 (0.9–2.7)	0.09
In service	66 (58.4)	83 (60.0)	Ref			
Vaccination card						
Yes	63 (71.6)	25 (28.4)	4.7 (2.7–8.3)	<0.001	3.9 (2.2–7.0)	<0.001
No	56 (34.8)	105 (65.2)	Ref			

HTSP, HIV testing service providers; OR, odds ratio; aOR, adjusted odds ratio; CI, confidence interval.

series doses compared to those working health centers and dispensaries.

### What is already known about this topic

Completion rates of hepatitis B vaccine have been found to be low with most of the HCWs starting the vaccine not completing the schedule.<sup>18,19</sup> In this study, less than half of the HCWs had received the three doses of the vaccine. This is consistent with low completion rates reported in sub-Saharan Africa (4.6–64.4%).<sup>7</sup> The main reason for non-completion is the unavailability of the vaccine after the first dose. In addition, although the vaccine is recommended for HCWs, there are no policies on how it should be given and how to enforce compliance. The high cost and unavailability of the vaccine has been documented as an important barrier to vaccination in previous studies.<sup>20,21</sup> Institutions of learning and health facilities should develop policies for ensuring that the vaccine is provided to the HCWs uniformly.

### What this study adds

Despite the national immunization guidelines recommending the vaccination of high-risk groups including HCW in Kenya, there are gaps in ensuring all HCWs are vaccinated. This study found that cleaners and waste handlers were less likely to have been vaccinated. This is similar to a study among waste handlers in Ethiopia where 7.2% had ever been vaccinated with at least one dose of HBV vaccine.<sup>22</sup> This points to the fact that as a country we don't have clear guidelines on which HCWs should receive the vaccine. In this study, vaccination rates were better among those vaccinated during training and among those with vaccination cards. The government and the training institutions should make arrangements to have adequate vaccines and introduce mandatory/opt out vaccination guidelines for trainees.

### Limitations

This study was conducted in one of the 47 Kenyan counties, and thus its findings may not be generalizable to the entire country. However, across all counties in Kenya, the same policies apply related to national vaccination policies against hepatitis B. The study was designed around having accurate vaccination coverage as an actionable public health priority, therefore, it may not be sufficiently powered to accurately estimate the prevalence of HBV infection among HCWs. All hospitals were sampled in this study; therefore, this may have over represented the HCWs from hospitals. However, because the majority of HCWs in the county work in hospitals, we felt this over-representation was useful.

### Conclusion

The uptake of hepatitis B vaccine among health workers was high. Vaccine series completion rates and serologic evidence of effective immunization, however, were low. The health departments at the county and medical training institutions should ensure consistent and sufficient supply of the vaccine for HCWs to complete the three recommended doses. The uptake and completion was lowest among cleaners and waste handlers; the hospital management teams need to ensure that they plan for the inclusion of these group for vaccination. Similar nation-wide surveys of HCWs on HBV infection and vaccination could provide greater evidence towards HBV prevention and control strategies across Kenya.

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### Disclaimer

The findings and conclusions in this report are those of the authors and do not necessarily represent the official position of the US Centers for Diseases Control and Prevention, the county government of Makueni, or the Kenyan Ministry of Health.

### Author contribution

Conceptualization and designing the study was done by NK, AA and SL. Data collection and sample collection was done by NK. DO, TM and NK did laboratory analysis and interpretation of laboratory results. Data analysis was done by NK, the interpretation of results was done by NK, TM, DO and SL. Drafting of the article was done by NK.

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## Conflict of interest

The authors declare no competing interests.

## References

- Schweitzer A, Horn J, Mikolajczyk RT *et al.* Estimations of worldwide prevalence of chronic hepatitis B virus infection: a systematic review of data published between 1965 and 2013. *Lancet* 2015;**386**:1546–55.
- Ott JJ, Stevens GA, Groeger J *et al.* Global epidemiology of hepatitis B virus infection: new estimates of age-specific HBsAg seroprevalence and endemicity. *Vaccine* 2012;**30**:2212–9.
- Coppola N, De Pascalis S, Onorato L *et al.* Hepatitis B virus and hepatitis C virus infection in healthcare workers. *World J Hepatol* 2016;**8**:273–81.
- Nouetchognou JS, Ateudjieu J, Jemea B *et al.* Accidental exposures to blood and body fluids among health care workers in a Referral Hospital of Cameroon. *BMC Res Notes* 2016;**9**:94.
- Prüss-Üstün A, Rapiti E, Hutin Y. Estimation of the global burden of disease attributable to contaminated sharps injuries among health-care workers. *Am J Ind Med* 2005;**48**:482–90.
- Franco E, Bagnato B, Marino MG *et al.* Hepatitis B: epidemiology and prevention in developing countries. *World J Hepatol* 2012;**4**:74–80.
- Malewezi B, Omer SB, Mwagomba B *et al.* Protecting health workers from nosocomial Hepatitis B infections: a review of strategies and challenges for implementation of Hepatitis B vaccination among health workers in Sub-Saharan Africa. *J Epidemiol Glob Health* 2016;**6**:229–241.
- Maltezou HC, Gargalianos P, Nikolaidis P *et al.* Attitudes towards mandatory vaccination and vaccination coverage against vaccine-preventable diseases among health-care workers in tertiary-care hospitals. *J Infect* 2012;**64**:319–24.
- Ly KN, Kim AA, Umuro M *et al.* Prevalence of Hepatitis B Virus Infection in Kenya, 2007. *Am J Trop Med Hyg* 2016. 10.4269/ajtmh.16-0059.
- Schweitzer A, Horn J, Mikolajczyk RT *et al.* Estimations of worldwide prevalence of chronic hepatitis B virus infection: a systematic review of data published between 1965 and 2013. *Lancet* 2015;**386**:1546–55.
- Ochwoto M, Kimotho JH, Oyugi J *et al.* Hepatitis B infection is highly prevalent among patients presenting with jaundice in Kenya. *BMC Infect Dis* 2016;**16**:101.
- Ministry of Health. National Policy Guidelines on Immunization 2013. (2013).
- Suckling RM, Taegtmeier M, Nguku PM *et al.* Susceptibility of healthcare workers in Kenya to hepatitis B: new strategies for facilitating vaccination uptake. *J Hosp Infect* 2006;**64**:271–7.
- Ministry of Health. Comprehensive National Health Policy Framework. (2011).
- Mbaisi EM, Ng'ang'a Z, Wanzala P *et al.* Prevalence and factors associated with percutaneous injuries and splash exposures among health-care workers in a provincial hospital, Kenya, 2010. *Pan Afr Med J* 2013;**14**.
- Mueller A, Stoetter L, Kalluvya S *et al.* Prevalence of hepatitis B virus infection among health care workers in a tertiary hospital in Tanzania. *BMC Infect Dis* 2015;**15**:386.
- Mungandi N, Makasa M, Musonda P. Hepatitis B vaccination coverage and the determinants of vaccination among health care workers in selected health facilities in Lusaka district, Zambia: an exploratory study. *Ann Occup Environ Med* 2017;**29**:1–6.
- Abiola AO, Omoyeni OE, Akodu BA. Knowledge, attitude and practice of hepatitis B vaccination among health workers at the Lagos State accident and emergency centre, Toll-Gate, Alausa, Lagos State. *West Afr J Med* 2013;**32**:257–62.
- Ogoina D, Pondei K, Adetunji B *et al.* Prevalence of Hepatitis B vaccination among health care workers in Nigeria in 2011–12. *Int J Occup Environ Med* 2014;**5**:362–51–6.
- Tatsilong HOP, Noubiap JJN, Nansseu JRN *et al.* Hepatitis B infection awareness, vaccine perceptions and uptake, and serological profile of a group of health care workers in Yaoundé, Cameroon. *BMC Public Health* 2016;**15**:706.
- Ziraba AK, Bwogi J, Namale A *et al.* Sero-prevalence and risk factors for hepatitis B virus infection among health care workers in a tertiary hospital in Uganda. *BMC Infect Dis* 2010;**10**:191.
- Shiferaw Y, Abebe T, Mihret A. Hepatitis B virus infection among medical waste handlers in Addis Ababa, Ethiopia. *BMC Res Notes* 2011;**4**:479.