



BMJ Open Cross-sectional hospital-based study on the seroprevalence of hepatitis B virus markers among healthcare workers, NWR, Cameroon

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ABSTRACT

Background Hepatitis B virus (HBV) infection is a major public health issue worldwide, with about 257 million people reported to be chronic carriers by the WHO fact sheet updated in 2018. HBV can be contracted via direct contact with infected body fluid and infection is almost always asymptomatic. Although healthcare workers (HCWs) are at high risk of HBV infection, little is known about the prevalence of the various HBV markers among HCWs in Cameroon. The present study was taken to evaluate the prevalence of different HBV serological markers among HCWs in the North-West Region of Cameroon.

Methods This cross-sectional hospital-based study was carried out between April and September 2017 during which 395 HCWs were recruited. The serum of the HCWs were tested for the presence of HBV core antibody, hepatitis B surface antibody, hepatitis B e antibody and hepatitis B surface antigen using Monalisa ELISA kits produced by BIO-RAD laboratories. Data were analysed using SPSS V.20.0.

Results Among the 395 participants, 270 (68.4%) of them were females, 187 (47.3%) had been exposed to HBV, 145 (36.7%) had resolved the infection, 42 (10.6%) were current HBV carriers, 10 (2.5%) were infective, 36 (9.1%) were vaccinated and 172 (43.5%) were still susceptible. Exposure to HBV, past infection and susceptibility were significantly associated with age while the rate of vaccination was significantly associated with the job of the HCW in the health facilities.

Conclusion The prevalence of HBV exposure and infection among HCWs obtained in this study was high while the level of vaccination in this at-risk population was low. Adequate steps should be taken to sensitise this population on HBV and the vaccination procedure.

INTRODUCTION

Hepatitis B virus (HBV) infection is a viral infection that attacks the liver and can cause either an acute and self-resolving, or a chronic disease.¹ The HBV, made of a partially double-stranded DNA, belongs to the family of Hepadnaviridae. This virus found in both blood and body fluids of infected persons

Strengths and limitations of this study

- Monalisa ULTRA ELISA kits with 100% sensitivity and specificity of 99.28% was used to determine hepatitis B virus (HBV) serological markers.
- Stratified sampling technique, which permits estimation of population parameters for groups within population was used for sampling.
- The hepatitis B surface antibody (anti-HBs) titre was not quantified thus the percentage of healthcare workers considered to be vaccinated in this study is higher than the actual percentage with a protective level of anti-HBs.
- Liver biopsy was not done to prove the complete clearance of the virus in resolved infection and serum HBV DNA was not measured since there is no kit available yet to determine this marker.
- The present study covers a cross-section of health professionals, so caution should be taken while generalising the results.

can be transmitted to the mucus membrane or blood stream of non-infected persons.¹ According to the WHO fact sheet updated in July 2018, an estimated 257 million people are infected with HBV worldwide and more than 887 000 people died in 2015 due to complications of HBV including cirrhosis and hepatocellular carcinoma.² The level of HBV varies widely across WHO regions with the WHO African and WHO Western Pacific Region sharing the greatest burden (6.1% and 6.2% of the population, respectively). In Cameroon, a sub-Saharan African country, HBV infection is considered hyperendemic with a prevalence rate estimated at 11.5%.³

HBV infection is preventable with the presence of a vaccine which confers over 96% protection to recipients.^{4,5} In Cameroon, the HBV vaccine (Zilbrix, a DTPw-HBV combination vaccine) was first introduced into the expanded programme on immunisation (EPI) administered to babies at 6 weeks, 10

weeks and 14 weeks.⁶ The monovalent birth dose implemented in 2017 is limited to babies born of HBV-positive mothers. This vaccine administered during early childhood can only provide some level of protection during early adulthood.⁵⁻⁷

Healthcare workers (HCWs) whose job is to care for the sick and injured are often exposed to blood and other body fluids in the course of their work. Consequently, they are at increased risk of infection with blood borne viruses such as HIV, HBV and hepatitis C virus.⁸ The risk of infection for health workers depends on the prevalence of the disease in the patient population and the nature and the frequency of exposures.⁹ HCWs, when infected, are at risk of transmitting HBV to their patients.⁹ Because of the risk associated with their occupation, WHO recommends that all non-infected HCWs be vaccinated against HBV.⁸

A national survey in Cameroon on the prevalence of HBV among HCWs reported a national seroprevalence of 8.75% current infection¹⁰ while a recent study carried out among HCWs in this region reported a prevalence of 10.6%.¹¹ Very little work has been done on the various HBV serological markers (Hepatitis B core antibody (anti-HBc), Hepatitis B surface antibodies (anti-HBs), Hepatitis B e antibody (anti-HBe) and Hepatitis B e antigen (HBeAg)) to evaluate exposure, natural immunity (past or resolved infection), infectivity, vaccination (acquired immunity) and susceptibility.^{12 13} In this study, we therefore set out to evaluate the different serological markers associated with HBV infection (anti-HBc, anti-HBs, Hepatitis B surface antigen (HBsAg) and anti-HBe). These serological markers were used to evaluate the prevalence of exposure, natural immunity, current infection, infectivity, acquired immunity and susceptibility to HBV among HCWs in our setting. Knowledge on these HBV epidemiological features can assist in the development of specific programmes such as vaccination campaigns for susceptible HCWs and guide health policy makers in prioritising and optimising treatment of infected and/or infective HCWs. This in turn can help public health surveillance institutions in our resource-limited setting to optimise the available resources.

MATERIALS AND METHODS

Study design and setting

This was a cross-sectional hospital-based study conducted between April and September 2017. The study included 22 health facilities in the Bamenda health district (1 regional hospital, 3 CMAs (Centre medical d'arrondissement), 6 mission hospitals, 5 government health centres and 7 private hospitals). Testing stations were set up in the various wards of the health facilities. Over 70% of HCWs in the various health facilities were recruited for this study.

Case definition

In this study, exposure was defined as being tested positive for the anti-HBc only, natural immunity (past/resolved

infection) was being tested positive for anti-HBc and anti-HBs, current infection was defined as being tested positive for HBsAg, infective subjects were those who were tested positive for HBsAg and negative for anti-HBe, vaccinated subjects were those who were tested positive for anti-HBs only while susceptible (naïve) subjects were those who were negative for all HBV serological markers. Being tested positive implies they were reactive for the marker of interest.

Sample size and justification

Sample size was determined using the formula proposed by Scott Smith for determining population proportion sample size¹⁴: $X=Z\text{-score}\times SD\times(1-SD)/MOE$. The proportion of HCWs in the NWR was obtained from a registry which published the national proportions of HCWs per region in 2015.¹⁵ The confidence level was 95%, giving a Z-score of 1.96, a margin of error (MOE) of ± 5 and an SD of 0.5. The calculated sample size using this formula was 385 persons.

Sample collection

All HCWs present in the Bamenda Health District during the study were invited to participate in this study. HCWs who consented to the study were asked to sign a consent form, fill a self-administered questionnaire after which 4mL of blood was collected from them into a red cap (dry) tube. Identification number was used to link participant's laboratory results and the questionnaire. A standardised questionnaire designed by the researcher was used to collect sociodemographic data and HCWs category. HCWs included medical doctors, nurses, laboratory technicians, dentist, pharmacist and hospital auxiliary staff (cleaners, carriers, launders).

HBV serology

Monalisa ELISA kits produced by BIO-RAD laboratories with sensitivity and specificity greater than 99% were used to qualitatively determine the different HBV serological markers. Monalisa HBsAg ULTRA ELISA kit was used to test for the presence of HBsAg, Monalisa Anti-HBs PLUS ELISA kit (BIORAD, Marnes-La-Coquette-France) was used to test for the presence of anti-HBs, Monalisa Anti-HBc PLUS ELISA kit was used to test for the presence of anti-HBc while Monalisa HBe Ag-Ab PLUS ELISA kit (BIORAD, Marnes-La-Coquette-France) was used to test for the presence of anti-HBe.

Statistical analysis

Statistical analysis was performed using the Statistical software IBM SPSS Statistics V.22.0 for mac. Continuous data were expressed as median values with first and third IQRs. Categorical data were expressed as percentages. Pearson's χ^2 ($p<0.05$) was used to assess the significance among study variables. OR was calculated using binary logistic regression.

RESULTS

Characteristics of study population

A total of 395 HCWs from the different hospitals in this region participated in the study. Among these, 68.4%

Table 1 Baseline characteristics of the study population

Variables	Frequency (395)	Percentage (100%)
Sex		
Male	125	31.6
Female	270	68.4
Age intervals (years)		
16–25	166	42.0
26–35	155	39.2
36–45	50	12.7
46–65	24	6.1
Job		
Nurses	224	56.7
Lab technicians	90	22.8
Medical doctors	17	4.3
Dentist	15	3.8
Pharmacist	8	2.0
Auxiliary staff	41	10.4

n, frequency.

(n=270) were women (table 1). The 16–25 years age group represented 42% (n=166) of the study population. The median age of the study population was 27 years (IQR, 23–32 years). Nurses were the most represented in the HCWs category (n=224, 56.3%).

Exposure to HBV

Anti-HBc was used to determine exposure to HBV (table 2). Of the 395 HCWs who participated in this study, 187 (47.3%) were tested positive for anti-HBc. A statistically significant association was observed between exposure and age (p value <0.001). Exposure to HBV significantly increased with age and HCWs belonging to the 46–65 years age group had a probability greater than 3.5 times of being exposed to HBV when compared with those belonging to the 16–25 years age group. There was no significant association between sex, HCWs category and exposure. However, exposure was relatively lower among dentist (n=4, 26.7%) than among other HCWs. Prevalence of exposure was similar between sexes.

Natural immunity against HBV (HBV clearance)

A combination of anti-HBc and anti-HBs was used to evaluate natural immunity against HBV (past/resolved infection) (table 2). One hundred and forty-five (77.5%) HCWs who had come in contact with HBV had effectively cleared the virus. Natural immunity was significantly associated with age (p value <0.05), and was highest in the 36–45 years age group (n=27, 54.0%). HCWs belonging to the 36–45 years age group showed a three times significantly greater probability of resolving the infection when compared with HCWs belonging to the 16–25 years age group. There was no significant correlation between ability to clear the HBV, sex and HCWs category.

Current HBV infection

The presence of HBsAg was used to determine current HBV infection (table 3). HBsAg was detected in 42 of the 395 HCWs (10.6%). There was no statistically significant association between sex, age, HCWs category and current infection. HBsAg infection was higher among females (n=33, 12.2%; 1.795, 95% CI (0.831 to 3.875)) than among males (n=9, 7.2%). Majority of HBsAg infected HCWs belonged to the 46–65 years age group (n=4, 16.7%) and were dentist (n=2, 13.3%).

HBV infectivity among HCWs

The presence of HBsAg and the absence of anti-HBe were used to evaluate HBV infectivity (table 3). Among the 10.4% of HCWs infected with HBV, 23.8% (n=10) of them and 2.5% of all the HCWs in this study were infective. There was no significant association between sex, age, job and being HBV infective. More females were infective (n=8, 3.0%) compared with males (n=2, 1.6%). The 46–65 years age group recorded the highest prevalence of infective HCWs (n=2, 8.3%) and were pharmacist (n=1, 12.5%).

Acquired immunity (vaccinated) HCWs

The absence of anti-HBc and the presence of anti-HBs were used to determine vaccinated HCWs (table 2). Among the 208 HCWs who had never been exposed to HBV, 17.3% (n=36) of them and 9.1% of the 395 study participants were vaccinated. There was a statistically significant association between being vaccinated and HCWs category (p value <0.05). Nurses (n=15, 6.7%; 0.197, 95% CI (0.056 to 0.695), p value=0.012) and auxiliary staff (2, 4.9%; 0.141, 95% CI (0.023 to 0.874), p value=0.036) had a significantly lower probability of being vaccinated when compared with dentist. Males and females had a similar prevalence of acquired immunity (12 (9.6%) males and 24 (8.9%) females). Most of those vaccinated belonged to the 26–35 years age group (n=15, 9.7%) and were dentist (n=4, 26.7%). There was no significant association between acquired immunity, sex and job.

Susceptible HCWs

Susceptibility was determined by the absence of anti-HBc, anti-HBs and HBsAg in serum (table 3). Among the 395 HCWs who participated in this study, 43.5% (n=172) of them were still susceptible to HBV. A statistically significant association was observed between age and susceptibility (p value <0.001). Susceptibility significantly decreased with age and was highest in the 16–25 years age group (n=90, 54.2%). There was no significant association between susceptibility, sex and HCWs category.

DISCUSSION

HBV is a major cause of chronic hepatitis, liver cirrhosis and hepatocellular carcinoma. As a viral infection, which can be transmitted via percutaneous and mucosal

Table 2 Distribution of HBV profile group (n=395)

Variables n (%)	Exposure 187 (47.3)			Past infection 145 (36.7)			Vaccination 36 (9.1)		
	n (%)	OR (95% CI)	P value ^b	n (%)	OR (95% CI)	P value ^b	n (%)	OR (95% CI)	P value ^b
Sex									
Male (n=125)	57 (45.6)	1		48 (38.4)	1		12 (9.6)	1	
Female (n=270)	130 (48.1)	1.108 (0.724 to 1.695)	0.637	97 (35.9)	0.899 (0.581 to 1.394)	0.635	24 (8.9)	0.919 (0.444 to 1.902)	0.819
P value	0.358			0.357			0.476		
Age									
16–25 (n=166)	60 (36.1)	1		46 (27.7)	1		16 (9.6)	1	
26–35 (n=155)	79 (51.0)	1.836 (1.175 to 2.870)	0.008	60 (38.7)	1.648 (1.031 to 2.634)	0.037	15 (9.7)	1.004 (0.479 to 2.108)	0.991
36–45 (n=50)	32 (64.0)	3.141 (1.626 to 6.068)	0.001	27 (54.0)	3.062 (1.596 to 5.877)	0.001	3 (6.0)	0.598 (0.167 to 2.143)	0.43
46–65 (n=24)	16 (66.7)	3.533 (1.428 to 8.741)	0.006	12 (50.0)	2.609 (1.094 to 6.223)	0.031	2 (8.3)	0.852 (0.183 to 3.962)	0.838
P value	<0.001			0.003			0.869		
Job									
Dentist (n=15)	4 (26.7)	1		2 (13.3)	1		4 (26.7)	1	
Lab technicians (n=90)	35 (38.9)	1.750 (0.516 to 5.929)	0.369	27 (30.0)	2.786 (0.588 to 13.197)	0.197	11 (12.2)	0.383 (0.104 to 1.414)	0.15
Medical doctors (n=17)	8 (47.1)	2.444 (.552 to 10.833)	0.239	7 (41.2)	4.550 (0.771 to 26.835)	0.094	2 (11.8)	0.367 (0.057 to 2.372)	0.292
Nurse (n=224)	116 (51.8)	2.954 (0.913 to 9.555)	0.071	88 (39.3)	4.206 (0.927 to 19.090)	0.063	15 (6.7)	0.197 (0.056 to 0.695)	0.012
Pharmacist (n=8)	3 (37.5)	1.650 (0.264 to 10.313)	0.592	2 (25.0)	2.167 (0.244 to 19.276)	0.488	2 (25.0)	0.917 (0.128 to 6.556)	0.931
Auxiliary staff (n=41)	21 (51.2)	2.887 (0.789 to 10.573)	0.109	19 (46.3)	5.614 (1.122 to 28.092)	0.036	2 (4.9)	0.141 (0.023 to 0.874)	0.035
P value	0.187			0.147			0.039		

Data are n (%); p value <.05 is considered significant.
value of superscript b denotes P-value of subsection.
n, Frequency.

Table 3 Distribution of HBV profile group (n=395)

Variables n (%)	Current infection 42 (10.6)		Infectivity 10 (2.5)		Susceptibility 172 (43.5)				
	n (%)	OR (95% CI)	P value ^b	n (%)	OR (95% CI)	P value ^b	n (%)	OR (95% CI)	P value ^b
Sex									
Male (n=125)	9 (7.2)	1		2 (1.6)	1		56 (44.8)	1	
Female (n=270)	33 (12.2)	1.795 (0.831 to 3.875)	0.136	8 (3.0)	1.878 (0.393 to 8.974)	0.43	116 (43.0)	0.928 (0.606 to 1.422)	0.732
P value	0.089		0.337				0.407		
Age									
16–25 (n=166)	14 (8.4)	1		4 (2.4)	1		90 (54.2)	1	
26–35 (n=155)	19 (12.3)	1.517 (0.732 to 3.141)	0.262	3 (1.9)	0.799 (0.176 to 3.630)	0.772	61 (39.4)	0.548 (0.352 to 0.854)	0.008
36–45 (n=50)	5 (10.0)	1.206 (0.412 to 3.531)	0.732	1 (2.0)	0.827 (0.090 to 7.568)	0.866	15 (30.0)	0.362 (0.184 to 0.713)	0.003
46–65 (n=24)	4 (16.7)	2.171 (0.651 to 7.246)	0.207	2 (8.3)	3.682 (0.637 to 21.290)	0.145	6 (25.0)	0.281 (0.106 to 0.745)	0.011
P value	0.529		0.313				< 0.001		
Job									
Dentist (n=15)	2 (13.3)	1		0 (0.0)	–		7 (46.7)	1	
Lab technicians (n=90)	8 (8.9)	0.634 (0.121 to 3.323)	0.59	0 (0.0)	–		44 (48.9)	1.093 (0.366 to 3.269)	0.873
Medical doctors (n=17)	1 (5.9)	0.406 (0.033 to 4.997)	0.482	1 (5.9)	2.500 (0.147 to 42.440)	0.526	7 (41.2)	0.800 (0.197 to 3.246)	0.755
Nurse (n=224)	28 (12.5)	0.929 (0.199 to 4.333)	0.925	7 (3.1)	1.290 (0.155 to 10.774)	0.814	93 (41.5)	0.811 (0.284 to 2.315)	0.696
Pharmacist (n=8)	1 (12.5)	0.929 (0.071 to 12.136)	0.955	1 (12.5)	5.714 (0.319 to 102.386)	0.236	3 (37.5)	0.686 (0.119 to 3.963)	0.673
Auxiliary staff (n=41)	2 (4.9)	0.333 (0.043 to 2.610)	0.295	1 (2.4)	1		18 (43.9)	0.894 (0.273 to 2.932)	0.854
P value	0.687		0.217				0.896		

Data are n (%); p value <0.05 is considered significant.
value of superscript b denotes P-value of subsection.

exposure to infective body fluids, HBV stands as a serious nosocomial infection in healthcare settings. The current study aimed at evaluating the seroprevalence of the different HBV serological profiles among HCWs in the NWR of Cameroon showed a high HBV burden in this population. A number of epidemiological and cross-sectional studies have reported marked variation in the prevalence of the various HBV serological profiles among HCWs within and out of the country.^{10–13 16–18} HBV prevalence in this at-risk group seems to vary with the HBV prevalence in the general population.

Exposure to HBV

The prevalence of HBV exposure obtained in the current study was high (47.3%) and significantly associated with age. This rate of exposure is relatively higher than the 19% obtained by Tatsilong *et al* in Yaoundé (the capital of Cameroon) in 2016.¹² The difference in prevalence could be because of the difference in the diagnostic technique used, given that Tatsilong *et al* worked with the one-step, rapid strip test which has a relatively lower sensitivity and specificity when compared with the ELISA technique used in this study.^{19–22} Besides, the distribution of the HBV vaccine in the expanded programme on immunisation (EPI) administered to babies was first introduced in Yaoundé and subsequently to other regions.⁶ This HBV childhood vaccine has been proposed to provide some level of protection against HBV during early adulthood (protection which wanes as you grow older) and might justify the increase in the rate of HBV exposure with age.^{5–7 23} Finally, older HCWs have spent a longer time in the hospital compared with the younger HCWs most of who are starting in the field.

Natural immunity against HBV (HBV clearance)

The prevalence of natural immunity among HCWs exposed to HBV was high and was significantly associated with age. In effect, it is known that the clinical course and outcome of HBV infection is greatly influenced by the age at infection, the level of HBV replication and the host immune status.²⁴ This might justify the relatively low level of resolved infection in the 16–25 years age group (27.5%) which increased up to the 36–45 years age group (54.0%) and finally dropped in the 46–65 years age group (50%). However, the prevalence of natural immunity was comparable between the sexes even though males had a lower probability of resolving the infection when compared with females. The similarity in prevalence of natural immunity is contrary to what is anticipated given that women generally show a stronger innate and adaptive (humoral and cellular) immune responses when compared with males.²⁵ This similarity in prevalence of natural immunity may be justified by the fact that in countries with high prevalence of HBV, exposure to HBV often occurs during birth and early childhood and infection may progress for 20–25 years in a subtle manner as stated above. The EPI evoked earlier might have reduced the level of exposure to HBV during childhood justifying

the seemingly high prevalence of HBV natural immunity among those exposed to HBV. The reason why this disease is self-limiting in some people and not in others have not yet been fully understood. However, it is believed that the host's immune system and the genome of the infecting HBV might play an important role in determining the outcome of the disease in healthy adults.

Current HBV infection

The prevalence of HBV infection obtained in this study was high (10.6%) given that they exist a safe and competent vaccine. The prevalence of HBsAg positivity is higher than the 8.75% obtained by Bilounga Ndongo *et al* in the NWR in their national survey among HCWs in Cameroon.¹⁰ The difference in prevalence could be justified by the fact that the national survey focused on the regional hospital (which represents the government reference hospital in this region) and used a different technique (rapid strip test). The same study mentioned above reported a prevalence of 5.4% in Yaoundé and 24% in the Far North Region, while Loriette *et al*, working in the Far North Region of Cameroon recorded a prevalence of 18% in 2015.^{10 18} This alternating prevalence could be a reflection of the cultural and climatic differences existing between the different ethnic groups alongside the diverse geographical scenery of the country.¹⁰

HBV infectivity among HCWs

HBeAg is a serological marker that indicates the presence of HBV DNA in blood circulation in wild-type HBV. As the immune system clears HBV DNA, HBeAg reduces in the blood circulation as anti-HBe appears.^{26 27} Mutations in some cases can result in HBV DNA being present in blood circulation in the absence of HBeAg.^{26 27} However, because there is no ELISA kit to determine the presence of HBV DNA in serum, we defined infectivity as the presence of HBsAg and absence of anti-HBe. This classification of infectivity is the best classification using the ELISA kits but is a limitation to the study given that some infected HCWs can go undetected. Among the 10.4% of HCWs infected with HBV, 23.8% of them were infective. The persistence of HBeAg in blood is always associated with progress towards a liver disease as well as an increase probability of transmitting the virus. Even though there exist a management guide proposed by WHO in 2015, this high prevalence of infectivity among infected HCWs might be because of the elevated cost involved in managing the disease.^{9 28}

Acquired immunity (vaccinated) HCWs

According to the 'CDC updates HBV vaccination guidelines for HCWs' (2014), healthcare personnel should be vaccinated against HBV before exposure to blood or body fluids and should receive serological testing to assess for anti-HBs.²⁹ Still, just 9.1% of HCWs in our setting showed acquired immunity. HCWs belonging to the 16–25 years age group were the most vaccinated. This might be because of the expanded immunisation

invoked earlier.^{6 7 23} But most probable is the fact that some institutions now ask for proof of HBV vaccination in none-infected individuals before hire or matriculation. Overall, the low prevalence of HCWs vaccinated against HBV might either be due to inappropriate sensitisation on HBV or the cost of the HBV vaccine.

Susceptible HCWs

HBV susceptibility in our study was high (43.5%) and was inversely proportional to age. The statistically significant association between age and susceptibility to HBV might be explained by the decrease in childhood and maternal transmission of HBV due to the expanded immunisation explained above.^{6 7 23} Unfortunately, this infant vaccine cannot provide adequate protection in adulthood and most parents never go for the booster dose because of the cost of the vaccine reducing childhood HBV transmission but increasing the number of susceptible adult HCWs. More so, duration in the hospital increases with age. Thus, the younger HCWs whose duration in health-care settings is less than that of older HCWs and who still have a longer period to work in this setting have not been exposed to HBV nosocomial risk factors like older HCWs and have a higher risk of eventually getting exposed when compared with older HCWs.

CONCLUSION

This study revealed a considerable burden (10.6% current infection) of HBV infection in the Bamenda health District, North West Region of Cameroon. Among the infected HCWs, over 23.8% of them were infective. These infective HCWs are at risk of infecting their patients. Subsidising management of HBV for HCWs might reduce the prevalence of infective HCWs and consequently the probability of HBV nosocomial infection from HCWs to their patients. Prevalence of HBV vaccination was low (9.1%) while prevalence of exposure (47.3%) and susceptibility (43.5%) to HBV were high. There is thus a high need for sensitisation of HCWs in this area on HBV transmission and prevention. The sensitisation along with an effective and massive vaccination campaign should be carried out in this region not only among HCWs but in the population in general.

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Patient consent for publication Not required.

Ethics approval Ethical clearance for the study was obtained from the National Ethics Committee of Cameroon (N°2017/02/871/CE/CNERSH/SP). Authorisation to carry out research in the NWR was obtained from the regional delegation. Authorisations to access different hospitals were obtained from the directors or the in-charge of the hospitals. Authorisation to access health centers was obtained from the district medical officer and the chief of centers of the health facilities in this region. Written informed consent was obtained from each participant.

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement Data are available in a public, open access repository (<https://doi.org/10.6084/m9.figshare.13503231.v1>).

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