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# Cross-sectional study of chronic hepatitis B virus infection in Rwandan high-risk groups: unexpected findings on prevalence and its determinants

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## ABSTRACT

**Objectives** Using secondary data from 208 079 Rwandans, we determined the prevalence of chronic hepatitis B virus (HBV) infection among high-risk groups and its demographic, geographical and health-related determinants.

**Design** In this cross-sectional study, we obtained and analysed data from a national hepatitis B vaccination and screening campaign conducted in Rwanda in 2017. We performed logistic regression to examine associations between chronic HBV infection and related factors such as risk status and geographical characteristics.

**Setting** Individuals were sampled nationally in all 30 districts across 4 provinces and the city of Kigali and all prisons in Rwanda.

**Participants** The study involves 208 079 individuals at high risk including prisoners and other high-risk groups (oHRG).

**Main outcome** The primary outcome for our study was hepatitis B surface antigens (HBsAg) prevalence.

**Findings** From 208 079 adults participants, 206 517 (99.2%) had valid HBsAg results, 4.3% of 64 944 prisoners and 4.0% of 140 985 oHRG were HBV positive. The prevalence was higher in Northern Province 5.1%, (95% CI 4.8 to 5.4). In multivariate analysis, the odds of infection decreased with increasing age, and hepatitis C antibody positivity reduced the odds for chronic HBV (OR 0.58, 95% CI 0.52 to 0.66 and OR 0.74, 95% CI 0.62 to 0.89 among oHRG and prisoners, respectively). In addition, being female was associated with lower odds of HBV (OR 0.70, 95% CI 0.66 to 0.74 and OR 0.80, 95% CI 0.65 to 0.98 among oHRG and prisoners, respectively).

**Conclusion** We found that individuals below 55 years of age and individuals who belong to high-risk groups (ie, sex workers, injection drug users, men who have sex with men, etc) have a higher probability of chronic HBV infection. Infection with chronic hepatitis C virus was not correlated with chronic HBV infection in our study population. Potential explanations include differential routes of transmission, specific immunological and pathophysiological factors or different effects of health prevention and control programmes.

## Strengths and limitations of this study

- This study used extensive national data from hard-to-reach individuals, with the active participation of local community health workers staff.
- Given the self-selection of study participants, the results of our study are therefore subject to selection bias.
- Underestimation of the prevalence by this study is likely because people chronically infected and debilitated by hepatitis B and/or C may be unable to reach screening sites far from their homes.
- For some populations, including injecting drug users, men who have sex with men, and sex workers, the verification of self-reported status may have escaped the attention of outreach staff, effectively failing to ascertain their true status and thus including some who may not be at high risk.
- Individuals belonging to other high-risk groups could not be disentangled to show a distinct prevalence by category.

## INTRODUCTION

WHO released the first global health sector strategy towards ending viral hepatitis by 2030.[1] In 2019, chronic hepatitis B infection was estimated to affect 296 million people worldwide.[2] Population groups at increased risk of infection include people living with HIV/AIDS,[3] prisoners,[4 5] healthcare providers (HCPs),[6 7] injecting drug users (IDU) and men who have sex with men,[8] female sex workers (FSW)[9] and people of lower socioeconomic status.[10 11]

An estimated 68% of chronic hepatitis B virus (HBV) infections occur in Africa[12] with a prevalence reaching 22%–38% in some countries.[13] Despite widespread infection, limited access to diagnostic tools leaves many infected individuals undiagnosed. Consequently, epidemiological data on chronic HBV from this region are often limited in geographical or temporal resolution while evidence suggest that chronic infection with hepatitis B leads to severe outcomes like liver cancer and death.[14 15]

Rwanda is a landlocked country in east-central Africa, bordered by Burundi to the south, Uganda to the north, Tanzania to the east and the Democratic Republic of Congo to the west. Previous nationwide data from 24 of 30 administrative districts in Rwanda showed a chronic HBV prevalence of 3.9%[16] in the general population, and 2%[17] in a most recent survey that covered all districts of the country. Other smaller studies conducted within specific subpopulations in the country estimated the prevalence to be 2.9% among HCPs from one referral hospital, 4.3% among HIV-positive people,[18] 4.1% among blood donors[19] and 3.7% among pregnant women.[20] However, to our knowledge, there have been no large-scale studies conducted among high-risk groups in Rwanda, such as FSWs, men who have sex with men and people who inject drugs.

Rwanda implemented immunisation against hepatitis B for infants in 2002 in order to prevent HBV transmission.[21] A catch-up vaccination campaign for individuals born prior to 2002 was conducted from June to October 2017 and was coupled with screening for both HBV and hepatitis C virus (HCV) infection. The campaign first targeted people most at risk for infection such as (1) prisoners[22] and (2) other individuals comprehensively defined as other-high-risk groups (oHRG), including people in lower socioeconomic status, individual aged 45 years and above, HCPs,[6 7] IDUs, men who have sex with men[8] and FSWs.[9] Prisoners were screened in their respective prisons, oHRG were invited through the different communication channels and social media (radio, television, WhatsApp messages, online news or newspapers), during religious gatherings, at health facilities or at community events. Samples were collected by nurses and laboratory technicians from National Reference Laboratoryand performed by 13 satellite laboratories equipped with hepatitis B and C testing machines.[23 24]The laboratory report form captured test results and demographic and geographical information of patients but did not document the specific risk groups.

Chronic HBV infection was defined as positive hepatitis B surface antigens (HBsAg).[25] Blood samples were screened for HBsAg and hepatitis C antibody (anti-HCV) using Murex ELISA (V.3 .0, Italy)[18] and Murex ELISA for anti-HCV (V.4.0, Italy), respectively. The objective of this study was to analyse data collected during the 2017 vaccination and screening campaign to investigate chronic HBV prevalence in different high-risk groups across Rwanda and to estimate the demographic and geographical factors associated with chronic infection.

## MATERIALS AND METHODS

### Patient and public involvement

Patients and the public were not involved in the design and planning of this study. However, the results were communicated to them through the health facilities in their catchment area.

### Study design, population and setting

We conducted a cross-sectional analysis of the data extracted from the national database for HIV and viral hepatitis owned by and archived at the Rwanda Biomedical Centre (RBC), the national health implementation institution under the Rwanda Ministry of Health. Our study focuses on data from the HBV screening campaign conducted from June to October 2017 among people aged 15 years and older, including prisoners and other high-risk populations without HBV vaccination.

### Data processing and storage

The original data contained personal identifying data such as names, addresses, blood sample IDs and patient IDs. In compliance with the regulations on the protection of personal data, an authorised employee of the RBC anonymised the data and generated study records according to the list of variables of interest. Variables retained were age, sex, province of residence, socioeconomic status, health insurance and hepatitis B and C screening results. Socioeconomic status was defined as 'poorer' when the person was in ubudehe (A local development programme that classifies citizens into four bottom-up categories, starting with the first category for the poorest, based on assets in terms of land, housing and what families do for a living) category one, 'poor' for category two, 'rich' and 'richer' for category three and four.[26]

### Statistical analysis

The data were analysed after a cleaning process that was carried out with Excel and consisted of correcting typos, renaming, formatting and deleting unrelated or irrelevant information. Duplicates were removed during the anonymisation process, as the current data was received without the possibility of identifying duplicates. We classified age into six categories, 15–24 years, 25–34 years, 35–44 years, 45–54 years, 55–64 years, 65 years and over, where each group has targeted local health services oriented to them.[23 26] Socioeconomic status was assessed according to the 'ubudehe', a four-tiered classification system. Category 1 (16.0% of the population) consists of families without home ownership and can barely afford basic needs. Category 2 (29.8%) consists of individuals who can afford to own or rent a house but cannot obtain a full-tie job. Category 3 (53.7%) consists of individuals with stable job or income such as farmers (beyond subsistence farming) and category 4 (0.5%) consists of senior government officials, individuals with large enterprises or working for international organisations and industries.[27] The place of residence was categorised according to five provinces, North, South, West, East and the city of Kigali (CoK). CoK is the only urban province without land borders with other countries. Given the different ways the study participants were recruited and mobilised, we stratified the analysis by two subpopulation groups, prisoners and oHRG. However, prisoners in the CoK were analysed separately because of differential recruitment due to a shortage of tests, which necessitated selecting only

the most at-risk prisoners, including those suspected of being infected with HBV and their results are presented in online supplemental appendix 1.

Previous studies found differences in prevalence of chronic HBV infection between districts,[16 18] thus our study estimated HBV prevalence for each of the 30 districts in Rwanda. In order to present a readable and more informative epidemiological map, we used the definition of endemicity levels from previous studies. High endemicity (HBsAg prevalence of 8% or more), high intermediate endemicity (HBsAg prevalence of 5%–7%), low intermediate endemicity (HBsAg prevalence of 2%–5%) and low endemicity (HBsAg prevalence less than 2%).[28]

We estimated the prevalence of HBsAg in our study population and further cross-tabulated the covariates with prevalence to assess the prevalence stratified by risk group (prisoners or oHRG) and by sociodemographic characteristics of the population. We used the $\chi^2$ test to test the relationship between categorical variables and selected variables with p<0.1 for inclusion in the multivariate model. We then conducted a backwards stepwise multivariate logistic regression by sequentially eliminating covariates from the full model and comparing reduced and full models using the likelihood ratio test.

We used a two-sided alpha of 0.05 to assess statistical significance. All analyses were carried out with Stata V.14.2.

### Informed consent and data protection

The purpose of primary data collection was not to conduct research, but a routine programmatic activity. Details on the data generating process of the initial screening campaign are available in previously published manuscripts (ie, Umutesi *et al*, BMJ Open, 2019). Briefly, oral informed consent was obtained, including consent to screening, testing and the subsequent follow-up procedures including treatment if necessary or research to inform prevention, control and surveillance strategies.

A data protection concept was developed and approved by Federal Commissioner for Data Protection and Freedom of Information in Germany and a data sharing agreement was signed between the Helmholtz Centre for Infection Research and the RBC. The dataset was deidentified, aggregated and prepared by a third party appointed by the RBC in Rwanda.

## RESULTS

The Rwandan national hepatitis vaccination and screening campaign included 208 349 individuals. After excluding 270 persons under 15 years of age, and another 1562 (0.8%) due to unavailable HBsAg serological results, our analysis included 206 517 participants, of whom 140 985 were oHRG and 65 532 were prisoners (figure 1). Prisoners in the CoK (N=588) were analysed separately, (online supplemental appendix 1), reducing the remaining prison population to 64 944 (table 1).

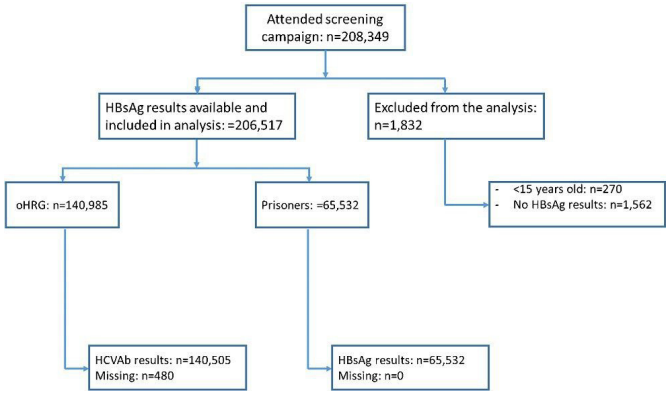


**Figure 1** Study population flow chart. HBsAg, hepatitis B surface antigens; HCVAb, hepatitis C virus antibodies; oHRG, other high-risk group.

### Characteristics, prevalence of chronic HBV and associated factors among oHRG

Overall, the median age was 52 with IQR of 42–61. The majority were females (64.2%), rich or richer (50%) from the western province (31%) and almost all had health insurance (98%). Apart from socioeconomic status, all other covariates had less than 5% missing.

The overall prevalence was 4.0%. Prevalence was highest among individuals between 25–34 years and 35–44 years (5.0% and 5.3%, respectively), men (5.1%), individuals with health insurance (4.6%), individuals living in the eastern and Northern provinces (4.6% and 5.1%, respectively) and people who tested negative for the HCV (4.2%). Hepatitis B and C coinfection was 2.4%, 95% CI 2.1 to 2.6. In the multivariate analysis, age categories less than 55 years of age was statistically associated with chronic hepatitis B, as was residence in all other provinces compared with the southern province. Women and those who were anti-HCV positive had a lower odds of having chronic hepatitis B (table 1).

### Characteristics, prevalence of chronic HBV and associated factors among prisoners

The median age was 48 with IQR of 32–58, the majority were males (94.6%), poorer (98.1%) and had health insurance (98%) and from the southern province (51.7%). Chronic HBV was 4.3% and the highest prevalence was found in the individuals below 45 years. Although few prisoners reported their socio-economic status, we found that poor prisoners were more infected (5.0%). A higher prevalence of chronic HBV was also found among prisoners with health insurance (4.3%) and among those incarcerated in Western provinces (5.2%). Hepatitis B and C coinfection was 2.9% (95% CI 2.4 to 3.4). In multivariate analysis, being younger than 45 years of age was statistically associated with chronic HBV. Being incarcerated in eastern and western provinces compared with the southern province was associated with higher prevalence infection. Similar to oHRG, females and positivity for antibodies to hepatitis C had lower odds of chronic HBV (table 2).

Table 1 Characteristics, prevalence of chronic HBV and associated factors among oHGRs

| | Overall n=141 903 | HBsAg prevalence (%) | Crude OR (95% CI) | P value* | Adjusted OR (95% CI) | P value† |
|---|---|---|---|---|---|---|
| Characteristics | Tested n=140 985 (%) | 5707 (4.0) | | | | |
| Age | | | | | | |
| 15–24 | 10 858 (7.7) | 384 (3.5) | 1 | <0.001 | 1 | <0.001 |
| 25–34 | 13 922 (9.9) | 700 (5.0) | 1.44 (1.27 to 1.64) | | 1.40 (1.23 to 1.61) | |
| 35–44 | 11 764 (8.3) | 626 (5.3) | 1.53 (1.35 to 1.74) | | 1.54 (1.34 to 1.77) | |
| 45–54 | 43 254 (30.7) | 1 768 (4.1) | 1.16 (1.04 to 1.30) | | 1.18 (1.04 to 1.34) | |
| 55–64 | 33 529 (23.8) | 1 235 (3.7) | 1.04 (0.93 to 1.17) | | 1.06 (0.93 to 1.21) | |
| 65+ | 27 658 (19.6) | 994 (3.6) | 1.02 (0.90 to 1.15) | | 1.06 (0.92 to 1.21) | |
| Unknown | 918 (0.6) | | | | | |
| Sex | | | | | | |
| Male | 50 417 (35.8) | 2 549 (5.1) | 1 | <0.001 | 1 | <0.001 |
| Female | 90 416 (64.2) | 3 154 (3.5) | 0.68 (0.64 to 0.71) | | 0.72 (0.68 to 0.77) | |
| Unknown | 1 070 (0.8) | | | | | |
| Socioeconomic status | | | | | | |
| Poorer | 18 133 (14.3) | 648 (3.6) | 1 | 0.003 | Not analysed | |
| Poor | 45 486 (35.8) | 1 758 (3.9) | 1.08 (0.99 to 1.19) | | | |
| Rich | 63 062 (49.6) | 2 601 (4.1) | 1.16 (1.06 to 1.27) | | | |
| Richer | 388 (0.3) | 11 (2.8) | 0.79 (0.43 to 1.44) | | | |
| Unknown | 14 834 (10.0) | | | | | |
| Health insurance | | | | | | |
| No | 470 (0.3) | 23 (4.9) | Not analysed | | Not analysed | |
| Yes | 137 391 (99.7) | 5 562 (4.0) | | | | |
| Unknown | 4 042 (2.8) | | | | | |
| Province | | | | | | |
| South | 29 626 (21.0) | 838 (2.8) | 1 | <0.001 | 1 | <0.001 |
| Kigali | 15 963 (11.3) | 614 (3.8) | 1.37 (1.24 to 1.53) | | 1.29 (1.15 to 1.45) | |
| East | 32 873 (23.3) | 1 528 (4.6) | 1.67 (1.54 to 1.82) | | 1.58 (1.44 to 1.73) | |
| West | 43 613 (30.9) | 1 770 (4.1) | 1.45 (1.34 to 1.58) | | 1.36 (1.24 to 1.49) | |
| North | 18 910 (13.4) | 957 (5.1) | 1.83 (1.66 to 2.01) | | 1.84 (1.66 to 2.03) | |
| Unknown | 918 (0.6) | | | | | |
| Anti-HCV | | | | | | |
| Negative | 127 787 (90.9) | 5 393 (4.2) | 1 | <0.001 | 1 | <0.001 |
| Positive | 12 718 (9.10) | 299 (2.4) | 0.55 (.043 to 0.04) | | 0.58 (0.51 to 0.66) | |
| Unknown | 1 398 (1.00) | | | | | |

*$\chi^2$ p value.
†Likelihood ratio test p value (compare models with and without variable).
HBsAg, hepatitis B surface antigens; HBV, hepatitis B virus; HCV, hepatitis C virus; oHGRs, other high-risk groups.

## Maps

Map displays chronic HBV among oHRG across districts in Rwanda (figure 2). The prevalence ranges from 1.8% in Ruhango to 20.2% in Bugesera district. Most of Rwanda's 30 districts have high intermediate endemicity. Nyarugenge, Gasabo and Kicukiro districts make up the capital CoK, had HBsAg prevalence of 5.4%, 3.3% and 4.2%, respectively. No geographical map was displayed for prisoners as the location of the prisons may not correspond to the prisoner's district of residence.

## DISCUSSION

The national screening campaign underlying this study is one of the largest conducted among people considered to be at high risk of chronic HBV in sub-Saharan Africa.

Table 2 Characteristics, prevalence of chronic HBV and associated factors among prisoners

| | Overall n=66 176 | HBsAg prevalence (%) | Crude OR (95% CI) | P value* | Adjusted OR (95% CI) | P value† |
|---|---|---|---|---|---|---|
| Characteristics | Tested n=64 944 (%) | 2805 (4.3) | | | | |
| Age | | | | | | |
| 15–24 | 6 014 (9.3) | 293 (4.9) | 1 | <0.001 | 1 | <0.001 |
| 25–34 | 11 963 (18.4) | 674 (5.6) | 1.16 (1.01 to 1.34) | | 1.17 (1.02 to 1.35) | |
| 35–44 | 9 316 (14.3) | 477 (5.1) | 1.05 (0.91 to 1.22) | | 1.07 (0.92 to 1.25) | |
| 45–54 | 13 664 (21.09) | 556 (4.1) | 0.83 (0.72 to 0.96) | | 0.84 (0.73 to 0.98) | |
| 55–64 | 13 159 (20.3) | 466 (3.5) | 0.72 (0.62 to 0.83) | | 0.74 (0.63 to 0.86) | |
| 65+ | 10 828 (16.7) | 339 (3.1) | 0.63 (0.54 to 0.74) | | 0.69 (0.58 to 0.81) | |
| Unknown | | | | | | |
| Sex | | | | | | |
| Male | 61 531 (95.4) | 2675 (4.3) | 1 | 0.015 | 1 | <0.001 |
| Female | 2 955 (4.6) | 102 (3.5) | 0.79 (0.64 to 0.96) | | 0.80 (0.65 to 0.98) | |
| Unknown | 458 (0.7) | | | | | |
| Socioeconomic status | | | | | | |
| Poorer | 19 729 (98.1) | 731 (3.7) | 1 | 0.77 | Not analysed | |
| Poor | 99 (0.5) | 5 (5.1) | 1.38 (0.56 to 3.41) | | | |
| Rich | 273 (1.4) | 11 (4.0) | 1.09 (0.59 to 2.00) | | | |
| Richer | 1 (0.0) | 0 | Not analysed | | | |
| Unknown | 46 075 (70.0) | | | | | |
| Health insurance | | | | | | |
| No | 1 018 (1.7) | 41 (4.0) | Not analysed | | Not analysed | |
| Yes | 59 917 (98.3) | 2588 (4.3) | | | | |
| Unknown | 4 009 (6.2) | | | | | |
| Province | | | | | | |
| South | 33 871 (52.2) | 1307 (3.9) | 1 | <0.001 | 1 | <0.001 |
| East | 22 973 (35.4) | 1076 (4.7) | 1.22 (1.13 to 1.33) | | 1.10 (1.00 to 1.20) | |
| West | 8 100 (12.5) | 422 (5.2) | 1.37 (1.22 to 1.53) | | 1.23 (1.10 to 1.38) | |
| North | no data | | | | | |
| Anti-HCV | | | | | | |
| Negative | 60 395 (92.7) | 2650 (4.4) | 1 | <0.001 | 1 | <0.001 |
| Positive | 4 743 (7.3) | 136 (2.9) | 0.64 (0.540.76) | | 0.74 (0.62 to 0.89) | |
| Unknown | 394 (0.6) | | | | | |

*$\chi^2$ p value.
†Likelihood ratio test p value (compare models with and without variable).
HBsAg, hepatitis B surface antigens; HBV, hepatitis B virus; HCV, hepatitis C virus.

We provide epidemiological estimates for prevalence of chronic HBV infection for 64 944 prisoners in four of the five provinces and 140 985 other high-risk individuals screened in newly established sites across the whole country.

Among oHRG, the prevalence of chronic HBV was 4.0%, lower than the 4.3% found among people living with HIV in Rwanda in a previous study[18] and the 4.3% found among prisoners in our study. The prevalence among the two groups studied are higher than the 2.0% observed in the general population according to a recent Rwandan Population Impact Assessment (RPHIA) survey.[17] In general, similar to previous studies, young age was associated with chronic HBV infection.[29] In addition to not having received infant immunisation services, this population aged 25–54 also includes the population that was born, survived, or participated in the 1994 Rwandan genocide and the war that had widespread impact on society and health infrastructure resulting in the exposure to blood and harmful bodily fluids and poverty.

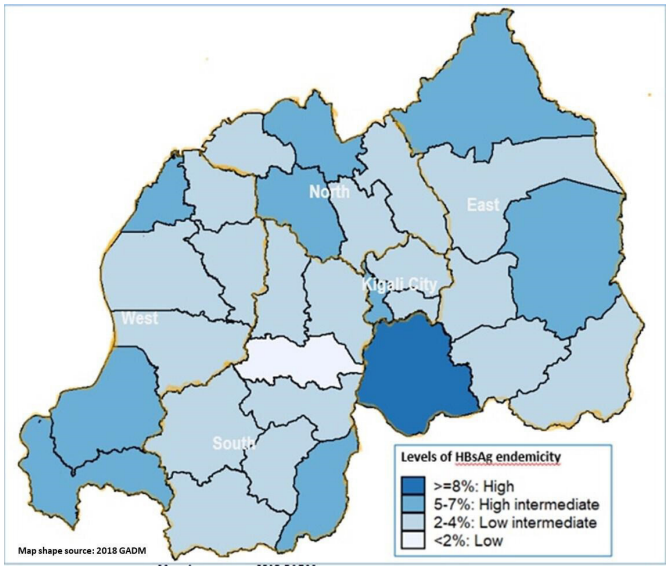


**Figure 2** Chronic HBV endemicity in the high-risk population by districts of Rwanda. HBsAg, hepatitis B surface antigens; HBV, hepatitis B virus.

Sexual activity, drug and alcohol use are also higher among younger population, factor that increases the risk of chronic HBV infection.[30] On the other hand, the decreasing prevalence in older age groups is not consistently described in the literature. Most elderly people infected with HBV were too ill or not available to participate in screening. Older individuals did not benefit from the hepatitis B infant vaccination that was introduced in 2002. In addition, delays in ensuring blood and injection safety likely contributed to transmission and the lack of available screening and diagnosis services likely reduced the probability of early detection and treatment initiation.

Females had lower odds of chronic HBV in the multivariate analysis, corroborating the lower risk of females compared with males found in other studies,[5 31 32] and higher risk of hepatocellular carcinoma among males in Rwanda.[33] This is possibly due to risky behaviour related to dating FSWs and concurrent partnerships. HIV infection, the virus that is highly considered a co-infection for the HBV is relatively high among FSWs in Rwanda (35.5%).[34 35] HIV prevalence was estimated at 10% among men who have sex with men in the CoK,[36] compared with 3% in the general population of the entire country.[17] Our study did not show a higher risk of HBV infection among women, despite an estimated range of 8853–23 495 active sex workers.[35] The availability of targeted screening and linkage to treatment for FSWs conducted by non-governmental organisations operating in Rwanda may have reduced testing among sex workers who were already aware of their HBV status. For this reason, we believe that men who have sex with men and people who inject drugs (generally more males[37]), estimated at a minimum of 5000 and 1000 in Rwanda, respectively,[34] may outnumber FSWs in the 2017 campaign, increasing the number of infected men relative to women. Another reason is exposure to hairdressing salons and barbershops, which are more often used by males in African countries and where poor hygiene and lack of sterilisation can contribute to HBV transmission.[38–40] To address this, since 2015, Rwanda's national viral hepatitis policy included mechanisms for prevention[41] such as requiring a machine to sterilise hair clippers for all hairdressers.

This study found that people with anti-HCV positive were less likely to be infected with chronic HBV, that is, OR=0.63 (95% CI 0.57 to 0.69), which is consistent with another study conducted in Rwanda,[24] and could be explained by reduced participation in screening activities due to potential HCV-related illness. However, it is known that infection with HCV and HBV are often concurrent.[42] Immunological studies show that replication of the two viruses is dominated by HCV rather than HBV in their copresence,[43 44] where HCV reduces the replication of HBV among co-infected individuals.[45] Local possibilities for this difference could also be related to unsafe injections and surgeries, behavioural and cultural factors, including scarification,[46 47] where individuals are at higher risk of exposure to HCV than HBV. We also think that the transmission patterns may be different in Rwanda compared with other high-income countries where, unlike Rwanda where injecting drugs is uncommon, most hepatitis research is currently conducted in addition to a significant proportion of people who engage in both injecting drug use and high-risk sexual practices. However, until contrary evidence in Rwanda is provided, we believe that hepatitis C may conceal hepatitis B infection until they are cured so that HBV can be reactivated. This, therefore, suggests the need for retesting for HBsAg after a negative sustained virological response to HCV. Similarly, our study found that women were less likely to be infected with HBsAg and more likely to be exposed to HCV. Given that HBV and HIV share a common mode of transmission and that women are more exposed to HIV,[17 48] we assume that their HBV is also hidden by HCV until they are cured.

Geographical analysis showed that the highest prevalence was in Bugesera district in Eastern Province, mainly due to potential selection bias, as mentioned by the campaign coordinators. However, another survey conducted in 24 Districts including Bugesera in 2018 also found a high prevalence in this region.[16] We hypothesise this could be related to the environmental characteristics. The region is hot with inadequate water supply which can increase the risk of poor hygiene and increase the risk of HBV transmission. Another characteristic shared by districts with high HBV prevalence is the presence of land border with neighbouring countries with fewer HBV prevention and control measures compared with Rwanda. At the time of campaign, Rwanda was only the second country in Africa, after Egypt, to implement viral hepatitis services,[49] and for this reason, cross-border activities may play an important role in increasing prevalence in these districts.

Our study has limitations. First, the data were obtained from electronic records, which are sometimes prone to

missing data or having unmeasured confounding factors and covariates. Our data set had few missing values, which were distributed similarly for characteristics of variables. Second, selection bias might apply, especially since participation in the campaign was voluntary. In addition, the campaign may have over-selected on healthy people, as participants were required to go to testing sites by themselves, thus inadvertently excluding individuals who were unable to travel. Concerns over privacy or discrimination may have further prevented individuals with suspected chronic HBV infection to present for testing. Further, other HBV markers like hepatitis B core antibody could not be tested for further information on exposures. Important risk behaviours such as blood transfusion history, scarification, HIV status etc. were not collected because of the lack of privacy and ease of dialogue with participants. Finally, the data analysed among the prisoners did not include the prisons in the North Province, nor does the geographical epidemiological profile explain the situation among the prisoners, as they may move from one prison to another or be incarcerated in an area different from their residence. Results for prisoners in the capital CoK, presented in the online supplemental appendix 1, may be subject to significant selection bias and should be interpreted with caution. In addition to displaying districts mapping, in order to inform policy and future planning, we have in online supplemental appendix 2, shown the geographical hotspots of chronic HBV infection by provinces in Rwanda in relation to the general population estimates by RPHIA.

In summary, we found a high prevalence of chronic HBV in other high-risk groups with predominance among young people and male indicating age and gender disparity of chronic HBV in Rwanda. Our results also imply the need for follow-up campaigns and implementation of universal access to inexpensive and high-quality diagnostic tests and vaccines targeting individuals not yet screened. Further research can investigate reasons underlying differential prevalence by district which can direct more targeted control activities.

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