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Screening a nation for hepatitis C virus elimination: a cross-sectional study on prevalence of hepatitis C and associated risk factors in the Rwandan general population

Justine Umutesi,[1] Carol Yingkai Liu,[2] Michael J Penkunas,[2] Jean Damascene Makuza,[1] Corneille K Ntihabose,[1] Sabine Umuraza,[2] Julienne Niyikora,[2] Janvier Serumondo,[3] Neil Gupta,[4,5] Sabin Nsanzimana[1,6]

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For numbered affiliations see end of article.

Correspondence to
Mrs Justine Umutesi;
umujustin@yahoo.fr

ABSTRACT

Objectives We analysed data collected during programmatic screening activities conducted in 2017 to describe hepatitis C virus (HCV) seroprevalence in the general population and identify associated factors.

Design We analysed data collected between June and September 2017. For both seroprevalence and viraemia, variations across demographic and geographic factors were assessed and multivariate regression models were fit to identify factors independently associated with each marker. Geospatial data were examined for visualisation.

Setting HCV screening was organised within each of the 30 districts in Rwanda. One designated location in each district was selected as the screening site and screening took place for 1 week at each site.

Participants This study included 124 223 male and female volunteers. Anti-HCV-positive individuals were followed up with HCV RNA viral load (VL) testing for infection confirmation.

Main outcome measures Two markers were examined: the presence of HCV antibodies and HCV RNA VL.

Results Among 124 223 individuals screened, 11 003 (8.86%, 95% CIs: 8.70% to 9.02%) were positive for anti-HCV. Anti-HCV prevalence varied by age with the oldest age group (>55 year olds) having a prevalence of 16.46% (95% CIs: 16.14% to 16.80%) and the youngest age group (<25 year olds) having a prevalence of 2.20% (95% CIs: 1.93% to 2.50%) (crude OR=8.78). After adjustment for covariates, an association remained between anti-HCV prevalence and age (p<0.001), province (p<0.001) and socioeconomic status (p<0.001). Of the 3771 anti-HCV-positive individuals who had an available HCV RNA VL result, 2099 (55.66%, 95% CI: 54.06% to 57.25%) had a detectable HCV RNA VL. Age was also associated with HCV viraemia (p<0.001).

Conclusion Results suggest that over 55% of individuals who screened positive for HCV-antibodies were chronically infected. Targeted screening for HCV among older individuals is recommended, given the association between age and infection. Further geographical hotspots of HCV infection can also inform targeted screening as Rwanda moves towards HCV elimination.

Strengths and limitations of this study

- The large sample size considered in the study and its coverage of all 30 districts across Rwanda have allowed for unique opportunity to assess hepatitis C virus (HCV) seroprevalence and factors associated with the marker.
- Linkage between serology test results and confirmatory viral load results offers one of the first national-level estimates of HCV viraemic rate in sub-Saharan Africa.
- Our results can be used to target high prevalence populations as Rwanda drives towards eliminating hepatitis C.
- Selection bias due to participant self-selection in the screening campaign could preclude generalisation of findings to the Rwandan population.

INTRODUCTION

An estimated 71 million individuals worldwide are living with chronic hepatitis C virus (HCV),[1] many of whom remain asymptomatic during the early stages yet still require treatment.[2] Untreated HCV is a leading cause of chronic liver disease, cirrhosis and liver cancer,[3] contributing to an increasing burden of mortality.[4] Unless individuals infected with HCV are diagnosed and treated, the burden of mortality due to HCV will continue to increase.

Approximately 20% of HCV infections occur in sub-Saharan Africa (SSA).[5] While the burden of HCV in SSA is estimated to be high compared with Europe and the USA, a lack of representative data has contributed to uncertain and potentially inaccurate prevalence estimates.[6 7] In Rwanda, while previous studies have reported an anti-HCV prevalence of 4.6% among people living with HIV

(PLHIV),[8] 2.6% among antenatal care (ANC) attendants[9] and 2.9% among blood donors,[10] the epidemiology of HCV among the general population is not well-characterised. Moreover, few studies have used national-level data to describe HCV viraemia rate.[11 12]

Historically, the only treatment available for chronic HCV infection was a costly interferon-based therapy administered through injections. The regimen was accompanied by severe side effects, multiple facility visits per week, intensive laboratory monitoring and poor cure rates.[13] Combined, these issues made treatment highly impractical for scale-up in resource-limited settings. With the arrival of direct-acting antivirals (DAAs), an all-oral therapy of short duration with high cure rates,[14] Rwanda expanded HCV treatment to cure and prevent complications from HCV infection using a combination of 3 months oral sofosbuvir 400mg and ledipasvir 90mg or daclatasvir 60mg/30mg, the DAAs that have shown to provide a good outcome in the treatment of HCV where genotype 4 is predominant.[12 15] Velpatasvir 100mg and ribavirin are also prescribed considering the case of patients.[16]

Rwanda was one of the first countries in SSA to launch a nationwide viral hepatitis control programme and has since shown a strong commitment to expand its capacity to screen, diagnose and treat patients chronically infected with HCV. In 2016, the government initiated systematic screening of HCV for all HIV-infected patients enrolled in care. In 2017, other high-risk populations were subsequently identified for screening such as prisoners, female sex workers and healthcare workers. After high-risk groups were targeted, risk factor-based screening was explored[17]; however, historical exposure to practices such as traditional scarification, unsafe medical procedures or unhygienic haircuts is relatively common among uninfected individuals and accurately assessing an individual's risk may be difficult.[18] As an alternative, mass screening campaigns for the general population were employed to gather information to help identify demographic factors that could guide more targeted screening strategies.

The 2017 general population screening campaign screened 124 789 individuals for both hepatitis B and C across all 30 districts in Rwanda. Individuals identified as anti-HCV seropositive through the campaign were linked to confirmatory HCV viral load (VL) testing. If confirmed with chronic viraemic infection, individuals were offered DAA-based treatment free of charge by the Rwandan Ministry of Health.

The endorsement of the World Health Assembly for the elimination of viral hepatitis as a public health threat by 2030 emphasises a commitment towards combatting viral hepatitis on the global stage. While many countries have made progress towards diagnosing and treating HCV patients, countries in SSA have only just begun addressing viral hepatitis. Screening for a largely asymptomatic disease has been acknowledged as a major challenge for low- and middle-income countries (LMICs) in SSA.[17] HCV is often asymptomatic until later disease stages when liver damage has already occurred and oral treatment to eliminate the virus can no longer reverse the degree of liver damage. Therefore, identifying infected individuals at early stages of the disease is critical to reducing hepatic-related morbidity and mortality caused by HCV infection. Understanding factors associated with HCV infection is an important initial step towards the goal of population-level early linkage to care. In Rwanda, an estimated 5 million people or more will require screening over the next 5 years to achieve elimination.[19] A deeper understanding of epidemiology will help identify strategically targetable high-risk population groups and maximise efficiency in case finding.

This study aims to use information collected during the 2017 screening campaigns to assess variations in both anti-HCV prevalence and viraemic rate across demographic and geographic factors through regression models and mapping visualisations. A detailed understanding of the HCV epidemic among the general population in Rwanda is needed to maximise the benefits of the public health response aimed at combatting viral hepatitis as Rwanda progresses towards HCV elimination.[19]

METHODS

The primary aim of this study was to describe the burden of HCV among members of the general public participating in the national screening campaign. A secondary aim was to assess variations in both anti-HCV seroprevalence and viraemia across demographic and geographic factors. Multivariate regression models were used to identify factors independently associated with anti-HCV seroprevalence and chronic HCV infection.

Data source

Data for this study were extracted from the Rwanda Biomedical Centre's (RBC's) anonymous programmatic monitoring database. The analysis included data for 124 223 individuals screened during nation-wide campaign conducted in 2017. Screening efforts were led by the RBC, the implementing agency of the Ministry of Health. Activities were conducted in collaboration with civil society organisations, funding organisations and other government institutions. To ensure equity and national coverage of services, screening was organised at each of the 30 districts in Rwanda. One designated location in each district was selected as the screening site and screening took place for 1 week at each site. Screening activities took place at a hospital, stadium or school. Residents of each district were made aware of the campaign through national-level mass media campaigns such as local radio broadcasting and mobilisation through community health workers and announcements during public and religious gatherings. Blood samples were drawn on site, and demographic information, medical history and geographic residence were collected from participating individuals through laboratory request forms (LRFs). Within 72 hours, samples and LRFs were transported

to 1 of the 13 testing sites across Rwanda and tested on Murex ELISA for anti-HCV (V.4.0; DiaSorin S.p.A., Italy). Individuals who screened positive for anti-HCV were notified through their routine healthcare clinic and were offered a confirmatory HCV RNA VL test through the same clinic. Samples and LRFs collected for the confirmatory HCV RNA VL test were transported to one of the eight testing sites and tested on COBAS AmpliPrep/COBAS TaqMan HCV Test, V.2.0: Quantitative (Roche) with a lower limit of quantification of 15 IU/mL. The turnaround time for laboratory results was 1 to 2 months to coincide with the second dose of hepatitis B vaccine that was also offered during the campaigns.

Screening and confirmatory VL test results along with individuals' demographic information collected through the LRF were entered into the programmatic monitoring database by trained laboratory technicians at the testing sites. Data were compiled and stored at RBC using a password-encrypted Microsoft Excel database. The database consisted of deidentified, individual-level data containing laboratory results for anti-HCV and HCV RNA VL, key sociodemographic information and geographic area of residence.

Study design

The study consists of a retrospective analysis of data collected from programmatic activities during the 2017 general population screening campaign. The study population consisted of voluntary participants of the campaign. Blood samples for anti-HCV seroprevalence were collected between June and September 2017, all of which were included in the study. For HCV VL, the study included individuals who tested positive for anti-HCV during the campaign and had results for a confirmatory HCV VL test recorded between June and December 2017.

Patient and public involvement

While participants were not directly involved in the design of the study, participants helped recruit acquaintances for screening through word of mouth. Results will be disseminated to participants as part of viral hepatitis awareness brochures and posters distributed at health facilities.

Outcome definitions

The primary outcome was an estimate of anti-HCV seroprevalence among screening participants. This estimate was calculated using the number of individuals with a positive anti-HCV screen as the numerator and the total number of valid anti-HCV results as the denominator. Positive anti-HCV results were considered as having either current or past HCV infection. The secondary outcome was viraemic rate defined as proportion of individuals having a detectable HCV RNA VL among individuals who screened positive for anti-HCV and returned for VL testing. Viraemic rate is also interpreted as proportion of chronically infected individuals out of all individuals with evidence of past infection (anti-HCV positive).

Independent variables

Demographic information collected at the time of screening included age, sex, residential location, insurance status and Rwandan categorization of socioeconomic status (SES). All individuals were concurrently screened for hepatitis B virus surface antigen (HBsAg), tested on ELISA.

Data analysis

Analysis was conducted in RStudio (V.3.3.2). Age was categorised into 10-year bands to assess any trends in seroprevalence and viraemic rates with increasing age. Data were described and summarised to assess data quality, missing values and variable distribution.

Anti-HCV seroprevalence

Overall proportion estimates of individuals screened positive for anti-HCV were calculated. All demographic variables available in the dataset were cross-tabulated with the presence of anti-HCV. Pearson's chi-squared test was used to assess differences in anti-HCV prevalence across demographic variables. Crude OR (cORs) were calculated along with 95% CIs and chi-squared p values. Covariates with missing data of over >10% were noted.

To help identify demographic factors associated with anti-HCV prevalence for more efficient screening strategies, multivariate logistic regression modelling was performed. For the multivariate logistic regression models, variable inclusion was assessed by backwards stepwise model selection. Given the relatively large sample size, data sparsity was not deemed to be a limitation; thus, all variables that displayed an association at the level of $p<0.10$ with anti-HCV prevalence were considered. Variables with over 10% missing data were not entered into the multivariate model. ORs were presented with an associated 95% CI and likelihood ratio test p values.

HCV RNA viraemia

The proportion of individuals with detectable HCV RNA VL among those returning for confirmatory testing during the specified time was calculated and presented. All demographic variables available in the dataset were cross-tabulated with having a detectable HCV RNA VL. Pearson's chi-squared test was used to assess differences in detectable HCV RNA VL across demographic variables. ORs were presented with 95% CIs and chi-squared p values.

Mapping

A prevalence map was produced by aggregating the proportion of anti-HCV positive tests by individuals' residential district. To explore the amount of geographic variation that can be accounted for by age, sex and SES, both unadjusted ORs by district and ORs adjusted for age, sex and SES were mapped using R.

Ethical considerations

Approval for the analysis of this programmatic data was granted by the Rwandan Nation Health Research

Table 1 Baseline distribution of covariates and association with anti-HCV prevalence across available demographic factors

	Total (%)	# Positive (%)	Crude OR (95% CI)	P value*	Adjusted OR† (95% CI)	P value‡
Overall	124 223	11 003 (8.86)				
Age (years)						
<25	10 385 (8.52)	228 (2.2)	1	<0.0001	1	<0.0001
25–34	13 139 (10.78)	301 (2.29)	1.04 (0.88 to 1.24)		1.15 (0.95 to 1.4)	
35–44	11 341 (9.3)	379 (3.34)	1.54 (1.3 to 1.82)		1.76 (1.47 to 2.12)	
45–54	38 014 (31.18)	1794 (4.72)	2.21 (1.92 to 2.54)		2.56 (2.19 to 3)	
>55	49 040 (40.22)	8074 (16.46)	8.78 (7.68 to 10.03)		9.93 (8.58 to 11.57)	
Sex						
Female	80 157 (64.59)	7449 (9.29)	1	<0.0001	1	0.0251
Male	43 936 (35.41)	3538 (8.05)	0.85 (0.82 to 0.89)		0.95 (0.91 to 0.99)	
Province						
East	30 836 (24.83)	2488 (8.07)	1	<0.0001	1	<0.0001
Kigali City	13 282 (10.69)	1258 (9.47)	1.19 (1.11 to 1.28)		1.06 (0.99 to 1.15)	
North	17 010 (13.69)	1549 (9.11)	1.14 (1.07 to 1.22)		0.86 (0.8 to 0.92)	
South	31 640 (25.47)	3288 (10.39)	1.32 (1.25 to 1.4)		1.11 (1.05 to 1.18)	
West	31 439 (25.31)	2416 (7.68)	0.95 (0.89 to 1.01)		1.19 (1.11 to 1.26)	
Socioeconomic level (SES)§						
1	16 367 (14.23)	2103 (12.85)	1	<0.0001	1	<0.0001
2	40 877 (35.53)	3910 (9.57)	0.72 (0.68 to 0.76)		0.84 (0.79 to 0.89)	
3	57 418 (49.9)	4282 (7.46)	0.55 (0.52 to 0.58)		0.76 (0.72 to 0.8)	
4	395 (0.34)	17 (4.3)	0.31 (0.19 to 0.5)		0.44 (0.26 to 0.71)	
Health insurance						
Mutuelle	112 339 (90.71)	10 398 (9.26)	1	<0.0001	NA	NA
None	97 (0.08)	4 (4.12)	0.42 (0.15 to 1.15)			
Not mentioned	2901 (2.34)	210 (7.24)	0.77 (0.66 to 0.88)			
Private	694 (0.56)	31 (4.47)	0.46 (0.32 to 0.66)			
RAMA and MMI	7807 (6.3)	328 (4.2)	0.43 (0.38 to 0.48)			
HBsAg results						
Negative	118 737 (96.08)	10 719 (9.03)	1	<0.0001	1	<0.0001
Positive	4843 (3.92)	243 (5.02)	0.53 (0.47 to 0.61)		0.6 (0.52 to 0.69)	

*Chi-squared P value.
†Adjusted for age, sex, province, SES and HBsAg result.
‡ P value from likelihood ratio test comparing models with and without variable.
§9166 (7.38%) missing SES, all other variables less than 2% missing data.
HBsAg, hepatitis B virus surface antigen; HCV, hepatitis C virus; MMI, Military Medical Insurence; RAMA, La Rwandaise d'Assurence Maladie.

Committee (NHRC/2017/PROT/037) and an ethical review waiver was conferred due to the routine nature of the data. Analyses were conducted using a deidentified dataset; the identity of individuals could not be linked in any way to the analytical dataset. All data were stored on password-protected, encrypted digital devices, and access was restricted to only those investigators directly involved in data analysis.

RESULTS

Anti-HCV screening

A total of 124 789 people were screened for HCV during the campaign across the 30 districts of Rwanda, and of these, 124 223 (99.55%) individuals had available screening results. Among those with available screening results, the majority of individuals were female (64.59%), were 49.7 years old (SD=15.78) on average and 90.71%

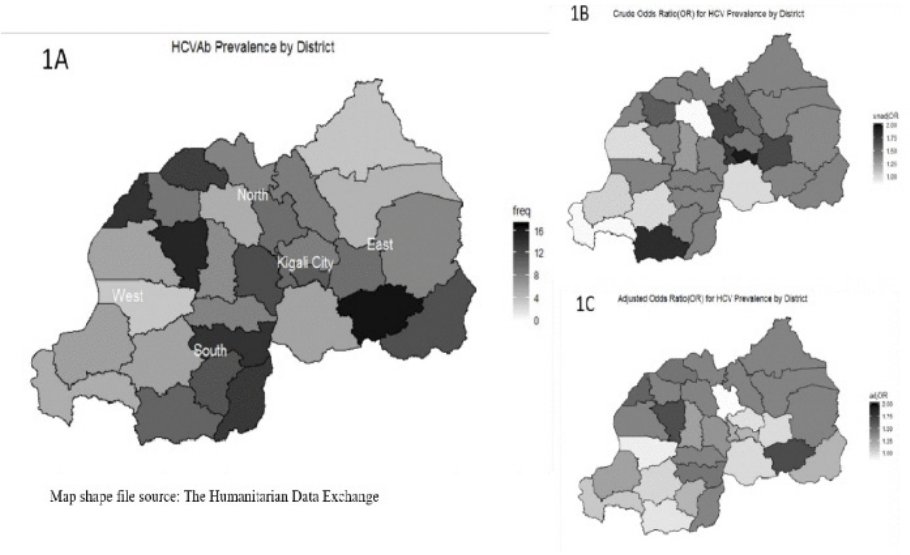

Figure 1 Anti-HCV prevalence by district in Rwanda.

reported participating in the government-sponsored community-based health insurance scheme, Mutuelle; 59.76% were from the two lowest of the four Rwandan SES classifications. Geographically, Eastern Province (24.84%), Southern Province (25.49%) and Western Province (25.25%) constituted larger proportions of the database compared with Northern Province (13.70%) and Kigali City (10.71%) (table 1). No covariates had >10% missing data. Overall, 7.4% of individuals were missing SES data, while all other covariates had less than 2% missing.

Anti-HCV prevalence and associated factors

A total of 11 003 of the 124 223 individuals (8.86%, 95% CI: 8.70% to 9.02%) screened positive for anti-HCV. Anti-HCV prevalence varied by age with the oldest age group (>55 year olds) having a prevalence of 16.46% (95% CI: 16.14% to 16.80%) and the youngest age group (<25 year olds) having a prevalence of 2.20% (95% CI: 1.93% to 2.50%) (cOR=8.78, 95% CI: 7.68 to 10.03, p<0.0001). Men had lower prevalence compared with women (cOR=0.85, 95% CI: 0.82 to 0.89, p<0.0001) and prevalence decreased with increasing SES strata (table 1); 12.85% of individuals from the lowest SES classification screened positive, while only 4.3% of individuals in the highest classification screened positive (cOR=0.35, 95% CI: 0.19 to 0.50, p<0.0001). There was also geographical heterogeneity of anti-HCV prevalence as seen in the differences in the proportion of positive tests across provinces: Southern Province had the highest prevalence (10.39%) and Western Province had the lowest prevalence (7.68%) (p<0.0001). The choropleth map of anti-HCV-positive proportions aggregated by patient's residential district (figure 1A) also showed heterogeneity: district-level anti-HCV prevalence varied between 3.48% and 16.57%. Differences in anti-HCV prevalence were also observed across insurance types with individuals covered through the community-based health insurance scheme having higher positivity rates compared with individuals covered by other insurance providers.

Variables included in the multivariate model were age, sex, province, SES and HBsAg results. Insurance status was excluded as over 90% were covered by the community-based health insurance scheme. After adjustment for other factors associated with positive anti-HCV results, associations remained between anti-HCV positivity and age (p<0.0001), province (p<0.0001), SES (p<0.0001), HBsAg results (p<0.0001) and sex (p=0.0251).

Based on adjusted ORs of provinces (table 1) and district maps comparing unadjusted and adjusted ORs (figure 1B,C), relative differences in anti-HCV prevalence across geographical regions appear to have reduced after adjusting for age, sex, SES and HBsAg, although some evidence of geographical heterogeneity remain.

HCV RNA viraemic rate

Up to December 2017, a total of 3834 individuals who screened positive for anti-HCV during 2017 campaign had a blood sample collected for HCV RNA VL testing, of which 3771 (98.36%) had available results recorded in the programmatic monitoring database. Out of the 3771, 2099 individuals (55.66%, 95% CI: 54.06% to 57.25%) had a detectable HCV RNA VL (table 2). The majority of individuals who returned for HCV RNA VL testing were female (66.7%), from the two lower SES categories (57.32%), and were >55 years of age (77.47%). Among individuals with documented HCV RNA VL results, a greater proportion of individuals resided in Southern Province (31.06%), Eastern Province (24.01%) and Western Province (22.73%) compared with Northern Province (13.34%) and Kigali City (8.86%).

HCV RNA viraemia varied by age group with the oldest group (>55 year olds) having a viraemic rate of 58.55% compared with the youngest group (<15 year olds) who

Table 2 Baseline distribution of covariates and association with viraemic rate (defined as having detectable HCV RNA viral load after testing positive for anti-HCV) among available demographic factors

	Total (%)	# Positive (%)	Crude OR (95% CI)	P value*
Overall	3771	2099 (55.66)		
Age (years)				
<25	59 (1.59)	15 (25.42)	1	<0.0001
25–34	82 (2.21)	33 (40.24)	1.98 (0.95 to 4.11)	
35–44	132 (3.56)	48 (36.36)	1.68 (0.84 to 3.33)	
45–54	562 (15.16)	288 (51.25)	3.08 (1.68 to 5.67)	
>55	2871 (77.47)	1681 (58.55)	4.14 (2.3 to 7.48)	
Sex				
Female	2513 (66.66)	1377 (54.8)	1	0.1322
Male	1257 (33.34)	722 (57.44)	1.11 (0.97 to 1.28)	
Province				
East	905 (24.01)	467 (51.6)	1	0.0067
Kigali City	334 (8.86)	194 (58.08)	1.30 (1.01 to 1.67)	
North	503 (13.34)	309 (61.43)	1.49 (1.2 to 1.86)	
South	1171 (31.06)	643 (54.91)	1.14 (0.96 to 1.36)	
West	857 (22.73)	485 (56.59)	1.22 (1.01 to 1.48)	
SES†				
1	658 (18.58)	385 (58.51)	1	0.3486
2	1372 (38.74)	750 (54.66)	0.86 (0.71 to 1.03)	
3	1509 (42.6)	845 (56)	0.90 (0.75 to 1.09)	
4	3 (0.08)	1 (33.33)	0.35 (0.03 to 3.93)	
HBsAg results				
HBsAg negative	3679 (97.82)	2058 (55.94)	1	0.0661
HBsAg positive	82 (2.18)	37 (45.12)	0.65 (0.42 to 1.01)	

*χ^2 p values.
†229 (6.07%) missing SES, all other variables <5% missing.
HBsAg , hepatitis B virus surface antigen; HCV, hepatitis C virus; SES, socioeconomic status.

had a viraemic rate of 25.42% (cOR=4.14, 95% CI: 2.30 to 7.48, p<0.0001). There were also variations in HCV RNA viraemic rate by province (p<0.0067), with the Northern Province having the highest viraemic rate (58.08%) and the Eastern Province having the lowest (51.6%). There was no statistically significant association between viraemic rate and sex (p=0.1322) or SES (p=0.3486).

Coinfection with HBV

A total of 4843 (3.92%) individuals screened positive for HBsAg. Two hundred and forty-three (0.197%) out of the 123580 with valid results for HBsAg and anti-HCV screened positive for both viruses. Individuals who screened positive for HBsAg had lower prevalence for anti-HCV compared with individuals who screened negative for HBsAg (cOR=0.53, 95% CI: 0.47 to 0.61, p<0.0001). After adjusting for age group, sex, province and SES, the association between screening negative for HBsAg and positive for anti-HCV remained statistically significant (adjusted OR=0.60, 95% CI: 0.52 to 0.69, p<0.0001). Among individuals returning for HCV RNA VL, the point estimate for viraemic rate is lower for individuals who screened HBsAg positive (OR=0.65, 95% CI: 0.42 to 1.01, p<0.0661), although only 82 individuals were HBsAg positive, precluding generalizability.

DISCUSSION

This study capitalises on the available data collected during programmatic HCV screening activities and provides an in-depth description of the previously unknown epidemiology of HCV for the general population in Rwanda. Our analysis indicated that among the 124223 individuals with available screening results, 8.86% were positive for anti-HCV. This prevalence estimate is higher than those reported in other studies conducted in Rwanda[8 9] and is primarily driven by over-representation of individuals above 45 years of age (71.4%) who displayed much higher anti-HCV seroprevalence compared with other age groups. This estimate is reduced to 4.09%, a rate similar to previous studies, when adjusted using the 2012

estimate of the Rwandan population (10 515 973 individuals) where 61.5% of the population were under the age of 25 years.[19] VL testing for HCV RNA has only recently become accessible throughout much of SSA, and this is the first known population-level study in Rwanda with the ability to estimate a viraemic prevalence rate. At the time of data analysis for the current study, among the 11 003 anti-HCV seropositive individuals, 3834 (34.8%) of the positive population had results for HCV RNA VL testing. The main reason for the fall-off in the cascade is that VL screening was still ongoing, and our study specifically aimed to include the results of VL tests collected between June and December 2017. The results of the viraemic rate were 55.66% for the people tested within the timeframe of the study. This is comparable with a study of 324 patients selected from non-HCV-related laboratory referrals conducted at a tertiary Rwandan hospital that estimated a viraemic rate of 59.62%[20] and a study conducted among blood donors in Rwanda that reported a viraemic rate of 56%.[11] Studies in Uganda,[21] Kenya[22] and Malawi[23] have also found low viraemic rates among individuals who screen positive for anti-HCV. One hypothesis for these findings is high rates of false positives for anti-HCV due to cross-reactivity with immunoglobulins from other parasitic diseases such as schistosomiases.[11 21 22 24] Globally, studies have shown considerable variation in viraemic rates with a range of 9%–100% and average of about 66%. This variation reflects differences in the sensitivity and specificity of laboratory tests in as well as true variations between populations.[25] Prevalence of HCV RNA more accurately reflects active chronic infection and is thus a better predictor of treatment need in Rwanda.

The prevalence of HBsAg among the study population was found to be 3.92%. This can be compared with the lowest prevalence of 2.6% found among ANC attendants in Rwanda[9] and the highest of 4.3% among PLHIV in Rwanda.[8] Surprisingly, the current study found a statistical association, indicating that people who tested positive for HBsAg are at a decreased risk of being anti-HCV positive compared with those who tested negative for HBsAg. This finding may be due to a possible selection bias related to the characteristics of the campaign in which healthier populations participated. Potentially, people coinfected with both viruses could be weakened or hospitalised and unable to participate in the campaign.

Among factors associated with anti-HCV seroprevalence and viraemic rate, of particular note is the association between older age and both anti-HCV seropositivity and having a detectable viraemic VL among those anti-HCV seropositive. While the former has been documented among systematic screening of PLHIVs in Rwanda,[8] to our knowledge the latter has not been reported among communities in SSA.[6] Evidence from this study supports conducting birth cohort screening as a strategy for case finding, which is now recommended by the WHO[26] and has been adopted by other countries with success.[27] Other factors associated with anti-HCV seropoprevalence are lower SES and residence within certain districts, although spatial variation in anti-HCV prevalence is reduced after adjusting for other demographic covariates. However, in more refined spatial maps based on individual's residential sector, one administrative-level below district, anti-HCV prevalence varies substantially, from 4% to 25%. These findings suggest localised historical outbreaks, whereby targeted screening of lower-level geographical areas with higher disease burden could be implemented.

The primary limitation of this study is the voluntary nature of individuals participating in the screening campaign. Participants likely resided closer to screening sites and had greater access to information, which could affect the generalizability of these findings to the Rwandan population at large. Follow-up survey studies with robust sampling methods would help produce more generalizable prevalence estimates. The unexpected finding of an association between positivity for HBsAg and lower prevalence of anti-HCV should also be interpreted with caution. An additional limitation is the lack of information surrounding exposure to known risk factors for HCV infection such as blood transfusion, scarification or tattooing.[26] If strong associations between self-reported risk factors and outcomes exist, this information could represent an additional enhancement to future screening strategies. A comparison of different screening strategies should be considered with endpoints of linkage to care as certain screening methods, such as practitioner-based, have been found to exhibit higher rates of patient retention.[26]

The arrival of DAAs signalled a turning point in Rwanda's response to its HCV epidemic. With an increasingly accessible cure, hepatitis elimination, a previously unthinkable notion, has entered national discussions as an achievable possibility.[28 29] Through decentralisation of diagnostic services, treatment scale-up, task-shifting of patient management to lower cadres of healthcare staff, Rwanda has emerged as a leader in hepatitis control in SSA. Rwanda is the second country in Africa to implement a national HCV programme after Egypt,[30] and it will likely be the second African country to implement eradication and population-level scale-up measures by adopting the usage of generic HCV drugs.[31] Rwanda's national hepatitis programme is now moving towards a new phase of diagnosing and treating members of the general population, and experience in shifting its focus from PLHIVs to the general population serves as important model for other LMICs considering similar strategic shifts.

This study leverages data collected from programmatic activities for increased understanding of HCV epidemiology among the general population in Rwanda. Results from this study contribute to the increasing body of evidence describing the epidemic of chronic HCV infection in SSA. The findings are especially important for strategic decisions around more efficient case finding for HCV, a largely asymptomatic infection. Demographic factors associated with higher disease burden such as age can be targeted for more effective screening strategies among the general population.

Author affiliations
[1]Institute of HIV, Diseases Prevention and Control, Rwanda Biomedical Center, Kigali, Rwanda
[2]Hepatitis Unit, Clinton Health Access Initiative, Boston, Kigali, Rwanda
[3]Rwanda Biomedical Center, Kigali, Rwanda
[4]Global Health Equity, Brigham and Women's Hospital, Boston, Massachusetts, USA
[5]Partners in Health/ Inshuti mu buzima, Kigali, Rwanda
[6]Rwanda Biomedical Center, Institute for HIV, Diseases Prevention and Control, Kigali, Rwanda

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