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SARS-CoV-2 antibody prevalence in Sierra Leone, March 2021: a cross-sectional, nationally representative, age-stratified serosurvey

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ABSTRACT

Introduction As of 26 March 2021, the Africa Centres for Disease Control and Prevention had reported 4 159 055 cases of COVID-19 and 111 357 deaths among the 55 African Union member states; however, no country has published a nationally representative serosurvey as of October 2021. Such data are vital for understanding the pandemic's progression on the continent, evaluating containment measures, and policy planning.

Methods We conducted a cross-sectional, nationally representative, age-stratified serosurvey in Sierra Leone in March 2021 by randomly selecting 120 Enumeration Areas throughout the country and 10 randomly selected households in each of these. One to two persons per selected household were interviewed to collect information on sociodemographics, symptoms suggestive of COVID-19, exposure history to laboratory-confirmed COVID-19 cases, and history of COVID-19 illness. Capillary blood was collected by fingerstick, and blood samples were tested using the Hangzhou Biotest Biotech RightSign COVID-19 IgG/IgM Rapid Test Cassette. Total seroprevalence was estimated after applying sampling weights.

Results The overall weighted seroprevalence was 2.6% (95% CI 1.9% to 3.4%). This was 43 times higher than the reported number of cases. Rural seropositivity was 1.8% (95% CI 1.0% to 2.5%), and urban seropositivity was 4.2% (95% CI 2.6% to 5.7%).

Discussion Overall seroprevalence was low compared with countries in Europe and the Americas (suggesting relatively successful containment in Sierra Leone). This has ramifications for the country's third wave (which started in June 2021), during which the average number of daily reported cases was 87 by the end of the month:this could potentially be on the order of 3700 actual infections per day, calling for stronger containment measures in a country with only 0.2% of people fully vaccinated. It may also reflect significant under-reporting of incidence and mortality across the continent.

Key questions

What is already known?

- No African country has published a nationally representative serosurvey as of October 2021.
- Such data are vital for understanding the pandemic's progression on the continent, evaluating containment measures, and policy planning.

What are the new findings?

- As of March 2021, Sierra Leone had an overall weighted COVID-19 seroprevalence of 2.6% (95% CI 1.9% to 3.4%); this was 43 times higher than the reported number of cases.
- Rural seropositivity was 1.8% (95% CI 1.0% to 2.5%), and urban seropositivity was 4.2% (95% CI 2.6% to 5.7%).

What do the new findings imply?

- These data should strengthen demands for more rapid vaccine deployments in countries like Sierra Leone as part of global vaccine justice, including support for intellectual property waivers and technology transfers.

INTRODUCTION

As of 26 March 2021, the Africa Centres for Disease Control and Prevention (CDC) reported 4 159 055 cases of COVID-19 and 111 357 deaths among the 55 African Union member states,[1] yet no African Union (AU) member states have published a nationally representative COVID-19 antibody serosurvey as of October 2021.

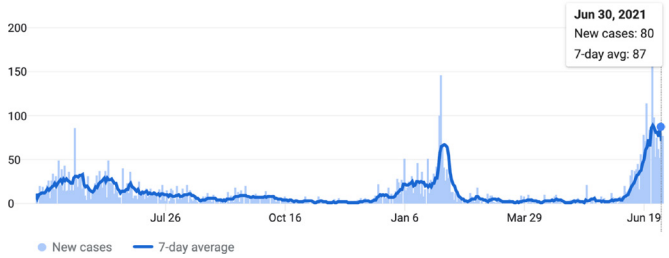

Figure 1 Daily COVID cases in Sierra Leone until from Feb 1, 2020 to June 30, 2021. The country's first case was reported on March 31, 2020. (Source: COVID-19 Dashboard by the by the Center for Systems Science and Engineering at Johns Hopkins University. Accessed July 2, 2021).

Sierra Leone reported 3962 cases (49.5 per 100 000 population) and 79 deaths as of 26 March 2021 (figure 1), with 2.9% of all reverse transcription polymerase chain reaction (RT-PCR) tests becoming positive over the prior 12 months. This relatively low case rate compared with countries in Europe and the Americas could be partly explained by the rapid implementation of stay-at-home measures, mask mandates, border closures, collaboration at regional levels, and a swift response at the continental level.[2] Indeed, Ministers of Health and the Africa CDC convened to develop a continental strategy early in the pandemic.[3 4]

To date, however, all reported data on cases and deaths in sub-Saharan Africa have come from event-based surveillance.[5] Case reporting is influenced by often under-resourced strategies for case finding, testing, and contact tracing, and might underestimate the true burden of SARS-CoV-2 infection.[6] We therefore sought to measure country-wide seroprevalence of SARS-CoV-2 antibodies in Sierra Leone, an AU member state, as such data are vital for understanding the pandemic's progression in the country and on the continent, as well as for evaluating containment measures and policy planning.[7 8]

METHODS

Design

This was a cross-sectional, population-based, age-stratified serosurvey targeting household members aged 5 years or above, regardless of previous or current infection with COVID-19, who resided in Sierra Leone during the period of transmission of SARS-CoV-2 (that is, since the first case was reported on 31 March 2020).

For the purpose of sample size estimation, seroprevalence was estimated at 5%. Considering 95% CIs, a ±5% confidence limit per age group, and approximately ±2% overall, and a design effect of 3, the minimum sample size was calculated to be 1200 households with at least one member of each household selected. This was designed to give a total of 240 individuals for each of the age strata 5–9, 10–19, 20–39, 40–59 and ≥60 years old.

Sampling

The sampling frame was the most recent census conducted by Statistics Sierra Leone.[9] We conducted randomised, multistage sampling, with the first stage consisting of 120 randomly chosen Enumeration Areas (EAs), which are small units that contain 80–120 households each. The EAs were sampled nationally, not by district weight. Within each selected EA, households were identified on a satellite map by numbering them in order west to east, then north to south, a method used in previous peer-reviewed studies.[10–12] After that, 10 households were chosen using a random number generator. One to two members of each household over the age of 5 years were then selected for participation. The selection of individuals was constrained to give a comparable number of individuals for each age stratum. In Sierra Leone, approximately 41% of the population is aged ≤15 years and only about 3.5% is aged ≥65 years.[9] This means that any straightforward random sample of the population will result in an insufficient sample of older adults. For example, a truly random sample of the population that selected 1000 people would include 410 children aged ≤15 years and only 35 adults aged ≥65 years. This would result in a sample too small to give confidence in the estimated seroprevalence of senior adults. To compensate for this, the sampling process was constrained to restrict the number of children selected, and adults were oversampled—in some households, a second participant was recruited if he/she was eligible for the study and represented the older age strata.

We started by selecting individuals from the older strata in a systematic progression from house to house. In this method, the survey team would attempt to capture an individual of each sex in the older strata before progressing to younger strata. If there was not any individual available for the appointed age group, they would skip to the next younger age stratum and choose from that one.

Test validation and sample collection

Fingerstick samples were screened for the presence of both IgM and IgG SARS-CoV-2-specific antibodies using the Hangzhou Biotest Biotech RightSign COVID-19 Rapid Test Cassette, which in U.S. Food and Drug Administration (FDA) testing had combined IgM/IgG specificities of 100% and IgM/IgG sensitivities of 100% for symptomatic cases.[13] We further validated the test with a control panel of 58 serum samples (from 18 persons tested by nasopharyngeal swab—10 who tested negative and 8 positive, with 5 serial dilutions of each positive) and also found combined IgM/IgG sensitivities and specificities of 100%.

All tests were performed at the time of interview and according to manufacturer's instructions. Each participant was notified of their results during the interview. Participants with positive IgM results were referred to the District Health Management Team as an active case.

Data analysis

We collected demographic data on study participants including age, sex, district, number of people per household, occupation, and whether they lived in a rural or urban area (those residing in district capitals were categorised as urban, and the rest as rural). As in other surveys, we categorised the reported occupations into high-risk and low-risk categories on the basis of the risk of exposure to potential COVID-19 cases.[6] For example, occupations such as healthcare workers, shopkeepers or petty traders, transport operators, and those in food service were considered high-risk occupations; on the other hand, farmers, miners, homemakers, and students were considered as being at lower risk of exposure. The information about occupation of the participants was captured as open-ended text and was categorised into high and low risk by the investigators.

The data were analysed to estimate an unadjusted seroprevalence of IgM/IgG antibodies against SARS-CoV-2 with a 95% CI. An individual was deemed seropositive if they were IgM+/IgG−, IgM−/IgG+, or IgM+/IgG+. To estimate the weighted seroprevalence, we post-stratified by district (counting Falaba as part of Koinadugu) and calculated sampling weights as a ratio of the national population to district population (aged >5 years). We also calculated weighted seroprevalence by age group, sex, and area of residence (rural/urban). Lastly we determined whether there were significant differences in seropositivity by demographic variable using the Rao-Scott X^2 test.

Patient and public involvement

Patients or the public were involved in dissemination plans of our research.

Role of the funding source

The funders of the study were not involved in reviewing the study design, writing of the manuscript, or the decision to submit the paper for publication. All authors had access to all the data in the study and had final responsibility for the decision to submit for publication.

RESULTS

In March 2021, we identified 1893 individuals aged 5 years or older from households in 120 EAs. Three hundred forty (18%) of the participants were aged 5–9 years; 384 (20.3%) 10–19 years; 451 (23.8%) 20–39 years; 359 (19.0%) 40–59 years; and 359 (19.0%) >60 years. Slightly more than half of the participants (964, 50.9%) were female; 1174 (62%) were residing in rural areas; and 845 (44.6%) had an occupation with a relatively high risk of exposure to people potentially infected with COVID-19. No individuals reported having previously tested positive for COVID-19 (table 1). The household response rate ranged from 94% to 100% in all districts except for Western Area, where around 15% of targeted households declined participation.

Table 1 Participant characteristics

	Participants (n=1893)
Age, years	
<10	340 (18.0%)
10–19	384 (20.3%)
20–39	451 (23.8%)
40–59	359 (19.0%)
>60	359 (19.0%)
Gender	
Female	964 (50.9%)
Male	929 (49.1%)
Area of residence	
Rural	1174 (62.0%)
Urban	719 (38.0%)
Number of people per household (n=1719)‡	7 (5–9)* (1–45)†
Occupation with high risk of exposure to COVID-19 (n=1892)‡	845 (44.6%)
Current smoker (n=1892)‡	250 (13.2%)
Would accept vaccine if offered (n=1892)‡	1666 (88.0%)
Seropositive	53 (2.8%)
Positive IgM	12 (0.6%)
Positive IgG	44 (2.3%)

*Median (IQR).
†Absolute range.
‡Data are n (%) unless otherwise stated.

The overall weighted and adjusted seroprevalence was 2.6% (95% CI 1.9% to 3.4%). IgM positivity was 0.6% and IgG positivity was 2.3%; only six participants (0.3%) were IgM+/IgG+. Rural weighted seropositivity was 1.8% (95% CI 1.0% to 2.5%) and urban seropositivity was 4.2% (95% CI 2.6% to 5.7%). Stratifying by age group and weighting, 1.7% (95% CI 0.2% to 3.2%) of participants aged 5–9 years tested positive for anti-SARS-CoV-2 antibodies, as did 2.6% (95% CI 0.8% to 4.2%) of those 10–19 years, 1.2% (95% 0.2% to 2.3%) of those 20–39 years, 4.4% (95% CI 2.4% to 6.4%) of those 40–59 years, and 3.6% (95% CI 1.6% to 5.6%) of those 60 years and above (table 2). None of the 35 healthcare workers sampled tested positive. There was a significant difference in seropositivity between rural and urban populations (Rao-Scott X^2 p=0.002). Seropositivity in women was 74% higher than in men, nearly reaching significance (Rao-Scott X^2 p=0.056).

DISCUSSION

Our findings indicate that 2.6% of Sierra Leone's population aged 5 years or older had been infected with

Table 2 Seroprevalence by demographic characteristics

	Participants tested, n	Seropositive participants, n	Unweighted seroprevalence, % (95% CI)	Weighted seroprevalence, % (95% CI)*
Overall	1893	53	2.8 (2.1 to 3.5)	2.6 (1.9 to 3.4)
Age, years				
<10	340	5	1.5 (0.5 to 3.4)	1.7 (0.2 to 3.2)
10–19	384	9	2.3 (1.1 to 4.4)	2.6 (0.8 to 4.2)
20–39	451	6	1.3 (0.5 to 2.9)	1.2 (0.2 to 2.3)
40–59	359	19	5.3 (3.2 to 8.1)	4.4 (2.4 to 6.4)
>60	359	14	3.9 (2.1 to 6.5)	3.6 (1.6 to 5.6)
Rao-Scott X^2 p value			0.0032	0.0548
Gender				
Female	964	33	3.4 (2.4 to 4.8)	3.3 (2.2 to 4.5)
Male	929	20	2.2 (1.3 to 3.3)	1.9 (1.0 to 2.8)
Rao-Scott X^2 p value			0.0939	0.0563
Area of residence				
Rural	1174	24	2.0 (1.3 to 3.0)	1.8 (1.0 to 2.5)
Urban	719	29	4.0 (2.7 to 5.7)	4.2 (2.6 to 5.7)
Rao-Scott X^2 p value			0.0109	0.0023

*Post-stratified by district.

SARS-CoV-2 by March 2021, with an estimated 203 060 infections. This is 43 times higher than the reported number of cases, which may give an idea of the potential disease burden as of 30 June 2021, where the average number of daily reported cases was 87 (representing the onset of the third wave in the country, figure 1).[3] This finding demonstrates that, similar to many other countries,[14] herd immunity is far from being reached in Sierra Leone. Notably, seroprevalence in urban settings was more than double that of rural. This trend has been seen in other surveys and can be explained by higher contact rates and challenges in safe physical distancing in urban areas.[6]

While a total seroprevalence of 2.6% is significantly lower than city and regional estimates across the continent, it represents the first nationally representative SARS-CoV-2 serosurvey to be published by an African nation (of note, West Africa was one of the last regions of the world to be affected by H1N1 influenza in 2009–2010,[15] so a similar dynamic may be occurring here). Chibwana and colleagues found that 12.3% of healthcare workers in Blantyre, Malawi tested positive for SARS-CoV-2 antibodies[16]; Uyoga and colleagues found a crude seroprevalence of 5.6% in Kenyan blood donors[17]; Olayanju and colleagues determined a 45.1% seroprevalence among asymptomatic healthcare workers in Ibadan, Nigeria[18]; and Mulenga and colleagues noted a SARS-CoV-2 prevalence of 10.6% in 6 of 117 districts in Zambia.[19]

Significant under-reporting of cases may be the result of a high prevalence of minimally symptomatic disease in a younger demographic coupled with under-resourced systematic surveillance in the setting of legacies of distrust of authorities and foreign interventions (resulting in the avoidance of testing).[20–29] Indeed, Mwananyanda and colleagues found significant under-reporting of cases in Zambia through postmortem surveillance.[30] Furthermore, (1) limited testing capacity, (2) low acquired immunity to SARS-CoV-2, and (3) less than 0.2% of Sierra Leoneans being fully vaccinated as of 21 May 2021 are extremely concerning in that these present a very large population of susceptible individuals at risk of future variant waves. As reported by Reuters, during the first week of May 2021, Sierra Leone averaged about 556 doses of vaccine administered each day. At that rate, it would take 2809 days (7.7 years) to administer enough doses for 10% of the population.[31] Indeed, both under-reporting of cases and limited vaccination campaigns increase the risk of new variants emerging and circulating in the population before public health authorities have a chance to detect them and prevent their spread.[32] Since India was forced to halt the export of vaccines on account of the devastating second wave there, this timeline could worsen.[33] These data should therefore strengthen demands for more rapid vaccine deployments in countries like Sierra Leone as part of

global vaccine justice, including support for intellectual property waivers and technology transfers.[34]

Our study has two notable limitations. The effects of waning immunity on the performance of the assay we used are unclear, and we therefore may not have fully captured those individuals infected in the first wave of COVID-19 in spring 2020 (figure 1).[35] In addition, the exact sensitivity of the assay for detecting minimally symptomatic infection is not known. Both factors would bias the estimated seroprevalence downwards.

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Competing interests None declared.

Patient and public involvement Patients or the public were involved in dissemination plans of our research.

Patient consent for publication Obtained.

Ethics approval The study was approved by the Sierra Leone Ethics and Scientific Review Committee. It received a Not Research Determination (IRB20-1394) from the Harvard Institutional Review Board as it was deemed Public Health Surveillance.

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