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COVID-19-related knowledge, attitudes and practices: a mixed-mode cross-sectional survey in Liberia

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ABSTRACT

Objectives To examine the knowledge, attitudes and practices (KAP) of COVID-19 of rural and urban residents in Liberia to inform the development of local social and behaviour change communication strategies.

Design Cross-sectional, mixed-mode (online and telephone) survey using non-probability sampling.

Setting All 15 counties in Liberia with a focus on Maryland County.

Participants From 28 May to 28 June 2020, data were collected from a total of 431 adults aged 18 years and older (telephone 288 (66.8%); online 143 (33.2%)) out of a total of 741 contacts.

Main outcome measures KAP scores. Frequencies and proportions were calculated, followed by univariate and multivariable analyses to examine the association between KAP scores and the sociodemographic variables.

Results Around 69% of the online survey respondents were younger than 35 years of age, compared with 56% in the telephone interviews. The majority (87%) of online respondents had completed tertiary education, compared with 77% of the telephone respondents. Male participants, on average, achieved higher knowledge (52%) and attitude scores (72%), in contrast to females (49% and 67%, respectively). Radio (71%) was the most cited source for COVID-19 information, followed by social media (63%). After controlling for sociodemographic variables, adaptive regression modelling revealed that survey mode achieved 100% importance for predicting knowledge and practice levels with regard to COVID-19.

Conclusions The survey population demonstrated moderate COVID-19 knowledge, with significant differences between survey mode and educational level. Correct knowledge of COVID-19 was associated with appropriate practices in Maryland County. Generalisation of survey findings must be drawn carefully owing to the limitations of the sampling methods. Yet, given the differences in knowledge gaps between survey modes, sex, education, occupation and place of residence, it is recommended that information is tailored to different audiences.

Strengths and limitations of this study

- ► To our knowledge, this paper provides the first empirical evidence on the knowledge, attitudes and practices (KAP) about the COVID-19 pandemic of people in Liberia.
- ► We applied a vigorous and replicable mixed-mode (online and telephone) survey during the first wave of the pandemic, where face-to-face interviews and random sampling were not possible.
- ► This mixed-mode approach yielded a sample of N=431 adults aged 18 years or older, capturing the knowledge and misconceptions of people across rural and urban Liberia.
- ► The survey was developed based on existing validated tools, with the telephone-administered interview guide reflecting the online survey questions, allowing comparison of KAP indicators across survey modes.
- ► Although our non-random sample included individuals from across Liberia, a large number of respondents were from Maryland County, many of whom were university students, which has implications for generalisability across other counties.

INTRODUCTION

The global spread of COVID-19 caused by the highly contagious SARS-CoV-2 occurred in Liberia amid a backdrop of further socioeconomic decline and a slow recovery from the devastating 2014–2016 Ebola virus disease (EVD) outbreak. While the majority of high-income countries have not experienced an infectious disease outbreak of this magnitude for decades, the West African EVD epidemic was the largest outbreak of Ebola recorded in history, causing severe human, social and economic loss in primarily three countries, Guinea, Liberia and Sierra Leone.[1]

With the arrival of COVID-19, Liberia immediately began to put the lessons learnt from the 2014–2016 EVD outbreak into practice. It was one of the first countries in West Africa to swiftly respond by imposing a nationwide curfew, screening at airports, implementing travel restrictions, widespread

temperature checks and hand washing stations in public areas.[2 3] The people were aware of basic preventive measures such as handwashing and social distancing.[4] The Liberian government established a coronavirus task force in January 2020 to oversee its national preparedness and response.[2 5 6] They mobilised hundreds of contact tracers, isolated people who tested positive for COVID-19, quarantined those who might have been in contact with the virus and reopened five Ebola intensive care units.[6 7] President George Weah released an upbeat song 'Let's Stand Together To Fight Coronavirus', to raise awareness about reducing coronavirus transmission, locally and globally. The first imported case of COVID-19 was identified in Liberia on 16 March 2020.[8] Subsequent measures culminated in the declaration of a state of emergency on 11 April 2020 and complete lockdowns in designated counties. The state of emergency was lifted on 22 July 2020, with emergency public health legislation remaining in place, including the mandatory use of face coverings in public places.

As of 16 December 2020, Liberia had recorded 1773 confirmed cases and 83 deaths, with around a third of deaths taking place in the community.[9] The incidence of COVID-19 reported in Liberia is significantly less than in many other countries in the region and across the world.[5 10] However, the social and economic effects of the outbreak cannot be underestimated due to restrictions on movement. Despite having platforms in place from the Ebola outbreak such as Ebola treatment units and contact tracing strategies, the decades of disinvestment during the civil war have left Liberia's healthcare system under-resourced and constrained, for surveillance, testing and case management. The country is reported to have up to six ventilators, insufficient personal protective equipment, a chronic shortage of health workers and widespread testing remain a challenge.[5 11] In June 2020, Maryland County, where the present study was initiated, had 15 confirmed cases of COVID-19 and 2 deaths. Specimens from patients with suspected COVID-19 were flown from Harper to the capital Monrovia, located in Montserrado County, for confirmatory tests (Wilson, personal communication).

Rapid research undertaken in Monrovia, Liberia, revealed suboptimal knowledge regarding COVID-19 and widespread myths and misconceptions, which could negatively impact the response mechanisms.[12] There are reports of some caregivers refusing to attend mobile clinics or facilities for routine vaccinations and fear among people that healthcare workers are spreading COVID-19.[3] The importance of public education and community engagement in outbreak responses is well established. Knowledge, attitude and practices (KAP) surveys have helped inform many outbreak responses, including Ebola in Liberia.[13 14] Other studies have measured COVID-19-related KAP within different population groups in sub-Saharan Africa and other parts of the world.[15–25] However, very few peer-reviewed mixed-mode KAP studies have been conducted in COVID-19-affected countries in West Africa during active community transmission periods.

To our knowledge, this is the first mixed-mode KAP survey related to COVID-19 among the general population living in rural and urban areas in Liberia within the first 4 months of the outbreak. It is also the first study to assess the effectiveness of initial COVID-19 messaging at the community level in Maryland County. In April 2020, IPSOS, a global market research company, assessed public support for and the social impacts of public health social measures in Monrovia by computer-assisted telephone interviewing (CATI) using a random digit dial.[12] Then, in August 2020, COVID-19-related public opinion polls were conducted using an unspecified telephone interviewing methodology.[12 26] In Liberia, the rapid spread of mobile phone and internet coverage created possibilities to carry out research during the outbreak through telephone interviews and an online survey.[27 28]

This paper presents a COVID-19 KAP survey, which aims to inform SARS-CoV-2 transmission curtailment measures in Liberia. The specific objectives of this KAP survey were to determine knowledge gaps, practices, trusted information sources and misconceptions that might hinder efforts to stop the spread of SARS-CoV-2 and use the data to inform the development of local social and behaviour change communication strategies. The information provided by this study may be critical in redesigning health education, information and communication materials as the outbreak evolves, leading to better control of COVID-19. The ongoing pandemic highlights the continued risk for SARS-CoV-2 transmission in Liberia and the need to modify existing public health messages and develop new evidence-based ones.

METHODS

Study design and participants

We conducted a concurrent mixed-mode cross-sectional survey to assess the community's KAP relating to COVID-19 in Liberia during the nationwide lockdown period. Adults aged 18 years and over, residing in Liberia, were eligible to participate in the survey. The web-based survey, which was in English, was hosted by Qualtrics, LLC. Telephone interviews were conducted in English, which is the official and commonly used language in Liberia. Where a respondent did not understand a term or question (N=2), the data collector translated to a common local term. Data collection took place from 28 May to 28 June 2020.

Survey instrument and training

The survey instrument was based on the WHO's guidelines on conducting a behavioural insight study related to COVID-19 and other similar COVID-19 KAP studies and was adapted to the local context.[29] An interview guide was developed for the telephone interviews and detailed specific language and appropriateness of content for the telephone conversation. The questionnaire was piloted by telephone on 20 individuals and revised before the main

survey started. On average, it took between 15 and 20 min to complete the survey online or over the telephone. All the data collectors participated in training workshops.

Measured survey variables

The survey included 38 questions divided into four main sections (online supplemental table S1): (a) Sociodemographic characteristics (seven questions); (b) knowledge regarding aetiology, transmission, clinical presentation, preventive measures and sources of information on COVID-19 (11 questions); (c) risk perception and attitudes towards the COVID-19 pandemic (five questions) and (d) actual behaviour and practices in response to the COVID-19 pandemic (five questions). An optional section related to general health perception, adherence to recommendations and household food and financial security changes during the pandemic (five questions). The indicators used to assess COVID-19 KAP were informed by lessons learnt from similar KAP studies on other communicable diseases, especially Ebola.[30 31]

Mixed-mode data collection, study promotion and recruitment

As for all explorative research where no suitable sampling frame exists coupled with adherence to COVID-19 precautions and restrictions, a non-probability sampling approach was employed for this study. However, to improve data coverage, quality and response rates, we decided to use two data collection modes.[27 28 32 33] Alongside a telephone-based survey, we added an online self-reported survey to reach more respondents in a shorter time frame.[27] We enabled the 'Prevent Ballot Box Stuffing' feature on Qualtrics, which prevented participants from completing the same survey more than once using the same web browser.

For the telephone-based survey, we first assembled an initial volunteer opt-in panel consisting of people in the community who were willing to participate in the survey when approached by data collectors and provided relevant contact information. Respondents were given a choice of completing the survey via telephone or online. This strategy created goodwill and reduced costs. One-person call centres were set up where data collectors worked from home to conduct telephone interviews with respondents, entering data directly into Qualtrics via tablet,[34] similar to CATI. Snowball sampling was then used with participants recruited over the telephone, where respondents were encouraged to provide further contacts. When the respondents were called, information was provided about the study and informed consent was obtained in English or in the respondent's preferred local language, before the survey was started.

For the online survey, we adopted a convenience sampling approach. The survey was advertised through diverse channels; at the national level, through the national newspaper FrontPage Africa, advertising in social media and messaging platforms. In Maryland County, the survey was advertised through radio broadcasts, posters displayed in public places in the towns of Harper and Pleebo and flyers distributed to social, traditional and religious organisations. The recruitment materials contained the study description, including the voluntary nature of participation, declarations of confidentiality and anonymity, contact details and a quick response code to the online survey. Recruitment was aimed to be as comprehensive as possible to favour sociodemographic diversity among respondents

Data storage and protection

No identifiable information was collected for the online survey mode. For both the online and telephone-administered surveys, respondents and data collectors were able to review and change answers by using the back button on the survey page. For the telephone interviews, respondents' telephone numbers were recorded separately in notebooks and kept in a secure cupboard for the duration of the study. After data collection, the telephone lists were destroyed.

Data analysis

Data were analysed for respondents who gave informed consent, were 18 years or older and achieved at least 40% progress in the questionnaire, which included completing the sociodemographic questions and the first three questions of the KAP questionnaire. Standard descriptive statistics were used to summarise the survey data, followed by univariate and multivariable analyses to examine the association between KAP scores and the sociodemographic variables. Categories were merged if single cells contained only a few observations. In the analyses, missing values were less than 5% and therefore we did not impute the missing data. A scoring system was developed, to create KAP scores, incorporating questions that contained fact-based quantifiable responses (online supplemental table S1). Briefly, all correct and positive answers were scored +1, while 'Don't Know' and incorrect answers were scored as 0 (online supplemental table S1). Free text answers under 'Other' were screened and allocated points to match existing response items, as appropriate. The association of independent variables with KAP scores was determined by univariate analysis using independent samples t-test, one-way analysis of variance or χ^2 test, as appropriate. In the univariate analysis, missing values were discarded from the total number of survey respondents when calculating the frequencies, so not all denominators are the same. The significance threshold was set at 0.05.

Additionally, multivariable adaptive regression splines (MARS) were performed. Data analysis was performed using Stata V.14.2 SE (StataCorp LLC, College Station, Texas, USA) and SAS V.9.4 TS1M4 (SAS Institute).

RESULTS

Survey response rate

Data were collected from a total of 431 individuals (176, 40.8% female; 254, 58.9% male) out of a total of 741

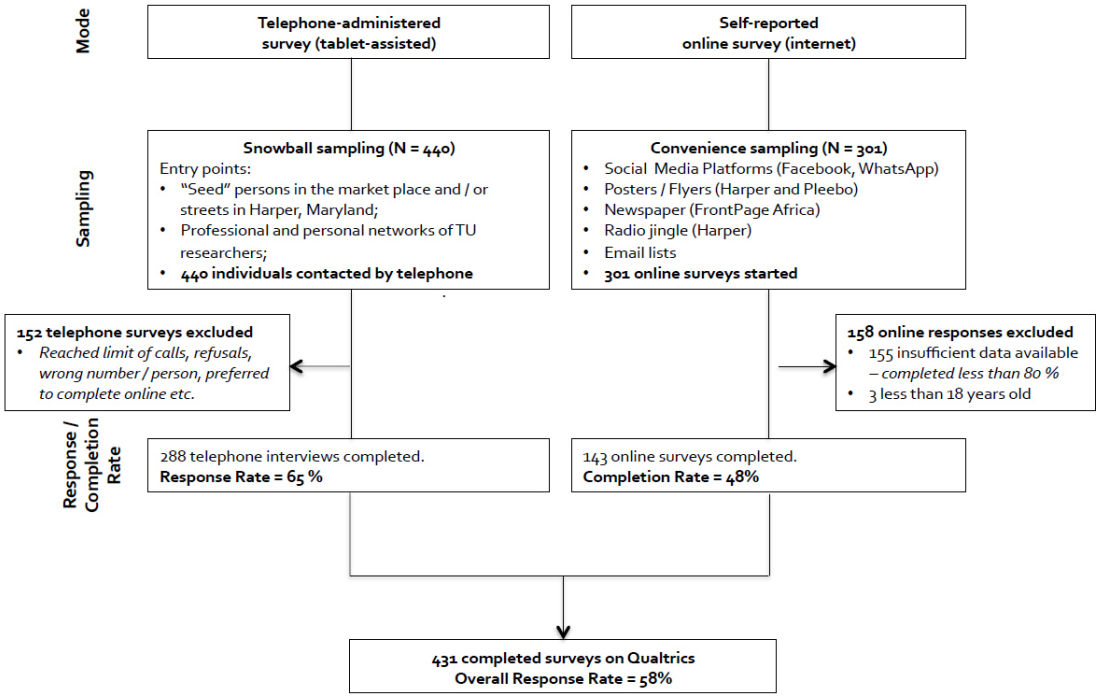

Figure 1 Flowchart of knowledge, attitudes and practices survey procedure in Liberia using two sampling modes. TU, Tubman University.

contacts (figure 1). Of the 440 respondents who were invited to participate in the telephone survey, 288 agreed, giving a response rate of 65.4% compared with a completion rate of 47.5% for individuals who visited the page hosting the online survey (figure 1). Among the 301 individuals who visited the online survey page, 136 (45.2%) did not give informed consent, 3 (1.0%) were younger than 18 years of age and 19 (6.3%) completed less than 40% of the questionnaire and were thus excluded as non-valid (figure 1). Among those who completed the online survey, 108 (75.5%) accessed the web-based survey through social media platforms (Facebook or WhatsApp) and 135 (93.0%) had a tertiary (vocational/university) education level, which was significantly higher than respondents recruited for the telephone surveys ($p<0.001$; online supplemental table S2). As expected, the online survey participants were significantly younger and achieved higher education attainment than those completing the telephone-based survey ($p<0.001$ and $p<0.003$, respectively; online supplemental table S4).

Characteristics of study participants

Table 1 shows the demographic status of 431 survey participants. Briefly, 40.1% of the survey respondents were aged between 25 and 34 years and around two-thirds of the respondents were single (62.9%). Across all respondents, 298 (69.1%) were from Maryland County and 93 (21.6%) were from Montserrado County. The mean household size was 2.8 persons. Almost all participants had received at least primary education (99.5%) and 84.5% had achieved tertiary level education (Table 1 and online supplemental table S3). No gender differences were detected in educational attainment levels and different survey modes (table 1; online supplemental table S4). Of the total respondents, 36.7% were full-time students (table 1). Age ($p<0.001$), education level ($p<0.003$), occupation ($p<0.001$) and place of residence ($p<0.001$) differed significantly between participants in the online and telephone-administered surveys (online supplemental table S4).

General well-being

More than half (57.3%) of survey respondents expressed that their current health status was either excellent or very good (online supplemental table S5_E1). Only 25 (6.3%) participants described their health status as less than good or poor (online supplemental table S5_E1).

Since the start of the outbreak, 226 (57.2%) and 264 (67.0%) respondents reported that access to food supplies and household finances, respectively, had worsened (online supplemental table S5_E4_E5).

Information sources

Radio (70.8%) was the primary COVID-19 information channel cited frequently by survey respondents, followed by social media platforms (63.4%), the internet (44.1%) and television (38.5%) (online supplemental table S5_B2). Of 273 individuals who had heard or learnt about COVID-19 through social media platforms, 157 (57.5%) had through Facebook, followed by WhatsApp (31.5%) and Instagram (10.9%) (online supplemental table S5_B2). The most trusted information sources on COVID-19 were the government/ministry of health and social welfare (68.7%) and health professionals (53.8%) (online supplemental table_S5_B3). Female respondents were less likely to have heard or learnt about COVID-19

Table 1 Study population characteristics by sex

Variable	Category	Total*		Sex				P value†
				Female		Male		
		N	% (95% CI)	n	%	n	%	
Age (years)	18–24	88	20.4 (17.0 to 24.0)	44	25.0	43	16.9	**0.01**
	25–34	173	40.1 (36.0 to 45.0)	75	42.6	98	38.6	
	35–44	108	25.1 (21.0 to 29.0)	43	24.4	65	25.6	
	45–54	43	10.0 (7.0 to 13.0)	13	7.4	30	11.8	
	55–64	10	2.3 (1.0 to 4.0)	1	0.6	9	3.5	
	65–74	7	1.6 (1.0 to 3.0)	0	0.0	7	2.8	
	75 or older	2	0.5 (0.1 to 2.0)	0	0.0	2	0.8	
	Total	431	100.0	176	100.0	254	100.0	
Marital status	Single	271	62.9 (58.0 to 67.0)	122	69.3	148	58.3	**0.002**
	Married living together	105	24.4 (21.0 to 29.0)	29	16.5	76	29.9	
	Married living apart	10	2.3 (1.0 to 4.0)	7	4.0	3	1.2	
	Cohabiting	25	5.8 (4.0 to 8.0)	8	4.5	17	6.7	
	Separated/divorced/widowed	14	3.2 (2.0 to 5.0)	9	5.1	5	2.0	
	Prefer not to answer	6	1.4 (1.0 to 3.0)	1	0.6	5	2.0	
	Total	431	100.0	176	100.0	254	100.1	
Education‡	No formal education	2	0.5 (0.1 to 2.0)	1	0.6	1	0.4	0.31
	Elementary (1–6)	2	0.5 (0.1 to 2.0)	1	0.6	1	0.4	
	Junior secondary school (7–9)	8	1.9 (1.0 to 4.0)	3	1.7	5	2.0	
	Senior high school (10–12)	53	12.3 (9.0 to 16.0)	29	16.6	24	9.5	
	Vocational	18	4.2 (3.0 to 7.0)	9	5.1	9	3.6	
	University	346	80.3 (76.0 to 84.0)	132	75.4	213	84.2	
	Did not answer	2	0.5 (0.1 to 2.0)	1	0.6	1	0.4	
	Total	431	100.0	175	100.0	253	100.1	

Continued

Table 1 Continued

Variable	Category	Total*		Sex				P value†
				Female		Male		
		N	% (95% CI)	n	%	n	%	
Occupation	Unemployed	42	9.7 (7.0 to 13.0)	11	6.3	31	12.2	**<0.001**
	Homemaker	2	0.5 (0.1 to 2.0)	2	1.1	0	0.0	
	Private business	19	4.4 (3.0 to 7.0)	8	4.6	11	4.3	
	Tradesperson	18	4.2 (3.0 to 7.0)	2	1.1	16	6.3	
	Petty trader	11	2.6 (1.0 to 5.0)	7	4.0	4	1.6	
	Farmer	2	0.5 (0.1 to 2.0)	0	0.0	2	0.8	
	Other government employee	31	7.2 (5.0 to 10.0)	5	2.8	26	10.2	
	Driver	1	0.2 (0.0 to 2.0)	1	0.6	0	0.0	
	Health worker	48	11.1 (8.0 to 14.0)	15	8.5	33	13.0	
	Teacher/lecturer	59	13.7 (11.0 to 17.0)	16	9.1	43	16.9	
	Student	158	36.7 (32.0 to 41.0)	91	51.7	66	26.0	
	Other	40	9.3 (7.0 to 12.0)	18	10.2	22	8.7	
	Total	431	100.0	176	99.9	254	100.0	
Residence (county in Liberia)	Bong	2	0.5 (0.1 to 2.0)	0	0.0	2	0.8	0.69
	Gbarpolu	1	0.2 (0.0 to 2.0)	0	0.0	1	0.4	
	Grand Bassa	2	0.5 (0.1 to 2.0)	1	0,6	1	0.4	
	Grand Cape Mount	2	0.5 (0.1 to 2.0)	0	0.0	2	0.8	
	Grand Gedeh	4	0.9 (0.3 to 2.0)	1	0.6	3	1.2	
	Grand kru	2	0.5 (0.1 to 2.0)	2	1.1	0	0.0	
	Lofa	1	0.2 (0.0 to 2.0)	1	0.6	0	0.0	
	Margibi	7	1.6 (1.0 to 3.0)	4	2.3	3	1.2	
	Maryland	298	69.1 (65.0 to 73.0)	125	71.0	173	68.1	
	Montserrado	93	21.6 (18.0 to 26.0)	36	20.5	56	22.0	
	Nimba	5	1.2 (0.5 to 3.0)	1	0.6	4	1.6	
	River Cess	3	0.7 (0.2 to 2.0)	1	0.6	2	0.8	
	River Gee	4	0.9 (0.3 to 2.0)	1	0.6	3	1.2	
	Sinoe County	4	0.9 (0.3 to 2.0)	2	1.1	2	0.8	
	Outside Liberia	3	0.7 (0.2 to 2.0)	1	0.6	2	0.8	
	Total	431	100.0	176	100.2	254	100.1	

Statistically significant p values are indicated in bold.
*The sex of one of the participants was not specified and the total number of participants in the column 'Total' is always one larger than when categorised by sex.
†χ^2 test.
‡School grades are indicated in parenthesis; note that due to rounding error, some percentage totals may not be exactly 100.0%.

through the internet, blogs, websites and WhatsApp than male respondents (47.8% vs 75.2%, p<0.05) (online supplemental table S5_B2), yet were 2.8 times more likely to trust social media platforms to relay reliable health information than male respondents (14.2% vs 5.1%, p<0.001) (online supplemental table S5_B3).

Information gaps

Approximately 90% of respondents expressed a need for additional information about COVID-19 (online supplemental table S5_B10). Two-thirds (66.8%) specifically wanted to know about medical care and treatment options for infected persons, as well as the cause/origin of COVID-19 (49.7%), ways to prevent the spread of SARS-CoV-2 (51.3%) and the signs and symptoms of COVID-19 (40.7%) (online supplemental table S5_B11).

Knowledge: symptoms

Although more than two-thirds of survey respondents knew fever (68.0%) and dry cough (68.2%) were the most common symptoms of COVID-19, only 19.5% and 14.1% of respondents were able to identify tiredness and loss of smell/taste, respectively (online supplemental table S5_B4). Approximately 57.1% of the respondents also identified difficulty breathing, a serious symptom of COVID-19 (online supplemental Table S5_B4). Women were significantly less likely than men to identify difficulty in breathing and loss of smell/taste (p<0.05; online supplemental table S5_B4). Completing the survey online and higher education attainment was also significantly associated with correctly identifying the most common COVID-19 symptoms (figure 2_B4 and online supplemental figure S2_B4).

Knowledge: transmission

Most respondents (76.1%) knew SARS-CoV-2 is transmitted through respiratory droplets when an infected person coughs, sneezes or spits (online supplemental table S5_B5). The other most frequently cited modes of SARS-CoV-2 transmission were: touching an infected individual (71.5%), touching contaminated surfaces that have been touched by an infected person (65.7%) and shaking hands with an infected person (58.9%) (online supplemental table_S5_B5). Only 17 (3.9%) people believed that SARS-CoV-2 is transmitted by a foul odour/smell or by eating bush meat (online supplemental table S5_B5).

Knowledge: treatment

The majority of respondents (74.9%) reported that there was no vaccine available for COVID-19, whereas 18 (4.2%) claimed that a vaccine was available. The remaining 94 respondents (21.8%) did not know or did not provide an answer (online supplemental table S5_B7). Nearly half (48.3%) of the respondents thought that taking antibiotics would be an effective treatment of COVID-19 but only 7.7% believed in visiting spiritual/traditional healers (online supplemental table S5_C3c_i).

Knowledge: prevention

Most (90.0%) of the respondents knew that frequently washing hands with soap and clean water is an effective measure to prevent the spread of SARS-CoV-2 (online supplemental table S5_B6). Other prevention measures that were believed to reduce COVID-19 were: avoiding touching the face with unclean hands (61.5%), avoiding handshakes and hugs (58.5%), keeping distance from symptomatic people (58.9%) and staying at home and reducing person-to-person contact (56.8%) (online supplemental table S5_B6). Male respondents were more likely than females to know the importance of using hand sanitisers, avoid touching the face with unclean hands and staying away from symptomatic persons for the prevention of SARS-CoV-2 (p<0.05) (online supplemental table S5_B6). Completing the survey online and higher education attendance was significantly associated with correctly identifying the measures to reduce the spread of COVID-19 (figure 2_B6 and online supplemental figure S2_B6).

Knowledge: risk

Nearly two-thirds (65.2%) believed that older adults were at increased risk of severe illness from COVID-19 (online supplemental table S5_B8). Male respondents were more likely to know that older adults are at the highest risk of severe illness caused by a SARS-CoV-2 infection than female respondents (p<0.003; online supplemental table S5_B8). Respondents aged between 45 and 54 years were significantly associated with knowing that older people, those with pre-existing medical conditions and pregnant women are at higher risk from a severe illness from COVID-19 (p<0.002; online supplemental figure S2_B8). In general, most of the respondents, including those aged 55 years and above, did not know that being a smoker increases the risk of severe illness from COVID-19 (online supplemental figure S2_B8). Conversely, 85.9% of respondents knew that asymptomatic individuals are able to spread SARS-CoV-2 (online supplemental table S5_B9).

Knowledge: overall

Overall, the mean knowledge score was 21.4 (51.0%; SD 16.0) out of a total possible score of 41 (100.0%) (online supplemental table S1). Factors significantly associated with higher knowledge scores (table 2) were sex (p<0.02), education (p<0.001), occupation (p<0.001) and place of residence (p<0.001). Age, marital status and household size had no association with respondent's knowledge (table 2). Respondents who attained at least tertiary education scored an average of 8 percentage points higher than respondents with lower levels of education (p<0.001; table 2). Knowledge scores of males about COVID-19 were on average 3.5 percentage points higher than those of females (table 2). Moreover, health workers and respondents residing in Maryland County were associated with a higher knowledge of COVID-19 (table 2).

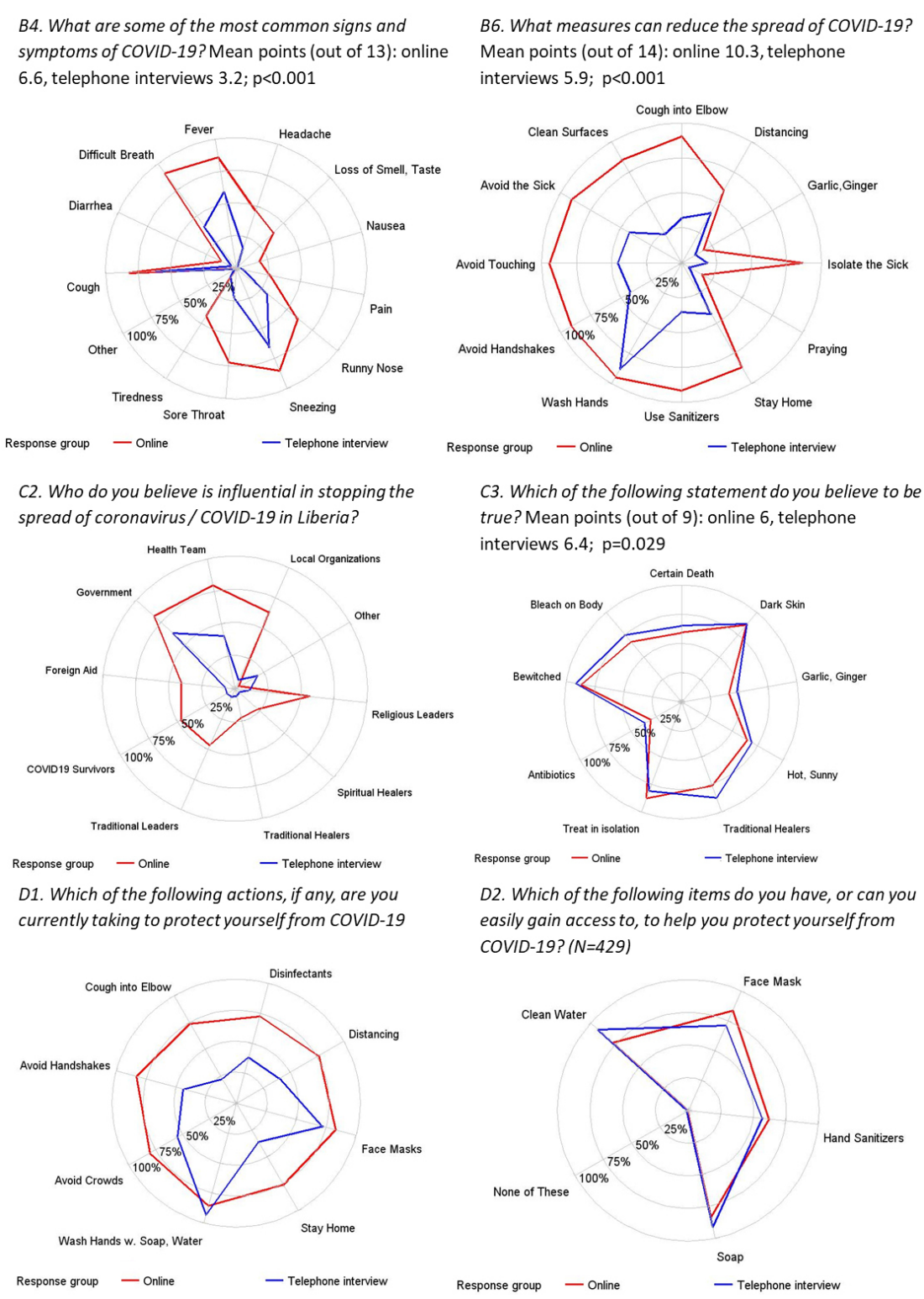

Figure 2 Radar graphs of 'knowledge', 'attitude' and 'practices' by survey mode (N=431 unless noted otherwise) for selected questions. Mean score values for fact-based quantifiable responses are indicated along with the analysis of variance p value.

Attitudes and misconceptions

Around two-thirds of survey respondents (68.2%) believed they were not at all likely or slightly likely to contract COVID-19 (online supplemental table S5_C1). Of respondents who described their health status as poor at the time of the survey, 3 out of 10 (30.0%) believed that they were extremely likely to contract COVID-19. Approximately 68.9% of respondents believed that the Liberian government/Ministry of Health is influential in curbing the spread of SARS-CoV-2, followed by the county health team (53.6%), faith leaders (26.4%), local organisations (26.0%) and those recovered from COVID-19 (20.2%)

Table 2 Achieved scores in the dimensions 'knowledge', 'attitude' and 'practices' (KAP) related to participant characteristics

			Knowledge score (%)			Attitudes score (%)			Practices score (%)		
Variable	**Category**	**N (%)**	**Mean**	**SD**	**P value**	**Mean**	**SD**	**P value**	**Mean**	**SD**	**P value**
Sex	Female	176 (40.9)	48.9	15.0	**0.02***	67.1	21.4	**0.03***	61.6	27.2	0.12*
(N=430)	Male	254 (59.1)	52.4	16.0		71.7	20.3		65.6	25.7	
Age (years)	18–24	88 (20.4)	48.4	16.1	0.11†	70.1	17.5	0.49†	58.9	26.1	0.09†
(N=431)	25–34	173 (40.1)	52.5	15.7		69.2	21.2		67.2	27.9	
	35–44	108 (25.1)	51.3	16.8		67.8	24.4		62.4	27.3	
	45–54	43 (10.0)	51.6	12.5		71.8	18.0		67.3	21.1	
	55 or older	19 (4.4)	44.5	10.4		76.0	14.5		57.1	15.0	
Marital status	Single	271 (62.9)	50.2	14.3	0.68†	68.7	20.3	0.09†	62.4	26.4	0.66†
(N=431)	Married living together	105 (24.4)	52.2	14.6		74.0	20.1		66.7	25.0	
	Married living apart	10 (2.3)	51.7	23.3		60.0	32.8		64.6	41.5	
	Cohabiting	25 (5.8)	53.9	20.4		70.2	25.0		63.4	30.3	
	Separated/divorced/widowed	14 (3.2)	52.0	16.3		61.9	17.3		67.0	18.7	
	Prefer not to answer	6 (1.4)	45.2	13.5		74.1	13.5		74.4	28.2	
Number of people in HH	0 or 1	86 (20.1)	50.6	16.2	0.27†	68.1	23.9	0.69†	65.0	30.2	0.17†
(N=428)	2 or 3	193 (45.1)	49.6	15.1		70.1	19.8		61.3	25.4	
	4 or 5	149 (34.8)	52.4	16.0		70.4	19.7		66.5	24.8	
Education	None/elementary/JSS	12 (2.8)	50.4	13.0	**<0.001†**	59.3	19.1	0.24†	56.4	23.3	**0.008†**
(N=429)	Senior high school	53 (12.3)	42.6	11.9		69.0	18.7		54.1	22.9	
	Vocational	18 (80.3)	57.3	17.8		65.4	20.4		51.8	15.8	
	University	346 (4.2)	51.8	15.8		70.4	21.2		64.9	27.0	
Occupation	Unemployed	42 (9.7)	56.7	17.5	**<0.001†**	70.1	22.0	0.25†	73.3	26.3	**0.02†**
(N=431)	Private business	19 (4.4)	51.6	13.7		63.2	18.2		70.0	21.7	
	Homemaker/farmer/driver	5 (1.2)	48.6	9.9		62.2	39.0		46.2	33.0	
	Tradesperson	18 (4.2)	45.6	11.2		73.5	13.8		62.4	22.8	
	Petty trader	11 (2.6)	38.5	9.0		60.6	14.4		50.3	18.3	
	Other government employee	31 (7.2)	46.6	12.3		77.4	14.5		62.5	21.2	
	Health worker	48 (11.1)	64.7	16.6		68.1	32.4		72.4	33.2	
	Teacher/lecturer	59 (13.7)	47.7	11.5		72.5	19.5		61.9	23.2	
	Student	158 (36.7)	48.7	15.1		68.5	17.1		61.0	25.8	
	Other	40 (9.3)	50.8	16.6		70.8	23.6		62.5	29.4	
Residence (county)	Maryland	298 (69.1)	54.6	17.7	**<0.001†**	66.4	29.1	0.44†	58.8	33.7	**0.03†**
(N=431)	Montserrado	93 (21.6)	48.8	14.3		70.5	19.9		62.6	25.0	
	Other county	40 (9.3)	56.1	17.7		69.0	19.7		70.0	27.0	

Statistically significant p values are indicated in bold.
*Unpaired t-test, equal variances.
†Analysis of variance.
JSS, junior secondary school; HH, household.

(online supplemental table S5_C2). Telephone recruited respondents were less likely to believe that government, public health authorities and faith leaders have the potential to halt the spread of COVID-19 in Liberia than online respondents (figure 2_C2).

Most respondents (85.9%) considered the statement true that every person who contracts SARS-CoV-2 would need to be treated in an isolation centre and nearly a third (30.9%) believed that the majority of COVID-19-infected cases would result in deaths (online supplemental table S5_C3ah). Respondents believed that they could lower their chances or protect themselves from getting infected with SARS-CoV-2 by eating ginger or garlic (34.3%), living in a hot and sunny climate (23.1%), washing with bleach (17.8%) and daily prayer (9.7%) (online supplemental table S5_C3bfd and S5_B6). Female respondents were more likely to believe that eating garlic and ginger or living in a hot climate would have a protective effect against COVID-19 than male respondents (p<0.01; online supplemental table S5_C3bf).

Overall, the mean score for attitudes was 8.3 (69.4%; SD 20.8) out of a total possible score of 9 (100.0%) (online supplemental table S1). Male respondents on average scored 4.6 percentage points higher than females (p<0.03; table 2). After controlling for other factors, female sex (p<0.03) and telephone-administered surveys were associated with belief in negative myths and misconceptions surrounding COVID-19 (figure 2_C3).

Current practices

Recommended practices adhered to by respondents included: washing hands frequently with soap and water (90.9%), wearing face masks (76.1%), avoiding crowded places (63.1%) and maintaining physical distance in public (52.4%) (online supplemental table S5_D1). Almost half (49.4%) of the respondents also reported staying at home and using more hand disinfectants (49.7%) (online supplemental table S5_C1). Male respondents were 1.2 times more likely to use hand disinfectants/sanitisers than female respondents (53.9% vs 43.7%, p=0.04) (online supplemental table S5_C1). Online survey responses and higher education were also significantly associated with taking preventive actions (figure 2_D1 and online supplemental figure S2_D1).

Protective resources that respondents had access to included: clean water (87.5%), soap (88.9%), facemasks (75.4%) and hand disinfectants or sanitisers (58.9%) (online supplemental table S5_D2). Access to facemasks and hand disinfectants was highest among online survey respondents (figure 2_D2). Virtually all respondents (98.8 %) reported washing their hands routinely, but only 41.6% reportedly washed their hands for at least 20 seconds (online supplemental table S5_D3). Nearly all respondents (93.2%) reported that they would first inform a healthcare worker if a family member contracted COVID-19. However, very few (6.1%) would confide in others, including relatives, neighbours and religious leaders (online supplemental table S5_D4).

Overall, the mean score for good practices was 8.3 (63.6%; SD 26.5) out of a total possible score of 13 (100.0%) (online supplemental table S1). Factors significantly associated with better practice scores (table 2) were categories within education (p<0.008), occupation (p<0.02) and place of residence (p<0.03). Respondents who attained at least tertiary education scored an average 8.5 percentage points higher than respondents with lower levels of education (p<0.008; table 2; online supplemental figure S2_D1).

Detailed score analysis

Using KAP scores as outcome variables, MARS modelling was able to identify important variables associated with each KAP dimension by combining regression splines and variable selection methods that allow for two-way interactions.[35] The missing value pattern for the multivariable analysis yielded a total of 391 observations, which covered 90.7% of the survey sample.

Although no age group differences were detected in relation to each of the KAP scores (table 2), the youngest and oldest respondents scored the lowest in the level of knowledge and practices (online supplemental figure S1). After controlling for all sociodemographic variables, the MARS model (table 3) revealed that the survey mode is the strongest independent predictive variable for assessing overall COVID-19 knowledge (symptoms and/or transmission and/or prevention) and practices. Model 1 showed that sex was identified as the second most important predictive variable for determining knowledge, followed by the place of residence, perceived health status, household finances and household size (table 3). The model explained 56.0% of the variance in knowledge scores (table 3). Model 2, assessing overall attitudes, showed that the contribution of occupation, household finances, education, age, sex and perceived health status was important. The model, however, explained only 3.0% of the variance in attitude scores (table 3). For assessing practices, model 3 showed that the second-largest independent predictive variable was the age of the respondents; it explained 37.0% of the variance in practices scores (table 3).

DISCUSSION

This mixed-mode cross-sectional survey involving telephone and online components provided an insight into public KAP related to COVID-19 within urban and rural population subgroups, within the first 4 months of Liberia's outbreak response.

Awareness of COVID-19 and the willingness to carry out appropriate practices were relatively high among our survey population. However, at the time of the study there were very few confirmed cases in Liberia. Our KAP survey results concur with other KAP surveys in Africa that showed that communities were knowledgeable about COVID-19 in the early stages of the outbreak.[18 22 23 36] In Liberia, the 2014–16 Ebola outbreak

Table 3 Non-parametric adaptive regression results for the knowledge, attitudes and practices scores

Scores	Model 1 Knowledge (N=391; GCV R^2=56%)*		Model 2 Attitudes (N=391; GCV R^2=3%)*		Model 3 Practices (N=391; GCV R^2=37%)*	
Variable	**No. of bases**	**Importance(%)†**	**No. of bases**	**Importance(%)†**	**No. of bases**	**Importance(%)†**
Online versus phone interview	1	100.0			6	100.0
Sex	3	4.7	1	31.9		
Age			1	53.4	2	9.0
Marital status						
Number of people in household	1	0.4				
Education‡			2	74.0		
Occupation§			4	100.0		
County¶	5	2.6			1	2.8
Health status	2	1.5	4	20.3	2	0.4
Effect on financial situation	1	1.4	2	81.5		

*Fit controls: maximum number of bases: 21; maximum order of interaction: 2; df per knot: 2; knot separation parameter: 0.05; variable parsimony parameter: 0; missing value handling: omit.
†Criterion for the contribution of each variable. It is defined as the square root of the generalised cross-validation (GCV) value related to a submodel without basis functions, minus the square root of the GCV value of the selected model scaled to 100.
‡'None', 'elementary' and 'junior secondary school' were combined into one category.
§'Homemaker', 'farmer' and 'driver' were combined into one category.
¶Counties categorised as 'Maryland', 'Montserrado' and 'others'.

may have contributed to the population's sensitisation, awareness and protective measures against COVID-19. The perceived likelihood of contracting COVID-19 was relatively lower than reported during the Ebola outbreak when 83.7% felt at risk of contracting Ebola in low incidence counties.[14] The case fatality rate for COVID-19 in Liberia is around 4.7%,[9] much lower compared with that for EVD of around 79.2%,[37] which partly explains the low-risk perception. Individuals who perceived themselves to be in poorer health, however, had a higher self-reported risk of acquiring COVID-19, among our survey sample.

The differences in survey group characteristics could partly explain our key finding that survey mode is the strongest independent factor for determining knowledge and practices. The online survey respondents were predominantly male, significantly younger and had higher education levels than those taking part in the telephone interviews. A few recent online KAP surveys have reported an association between education level and knowledge towards COVID-19, consistent with our results.[17 23 24 38 39]

Other factors associated with higher knowledge scores were sex, occupation and place of residence, which are in line with KAP studies from Iran and China.[17 40] Significantly lower knowledge and attitude scores for women were found in a similar survey in Sierra Leone,[36] which indicates that COVID-19 risk communication should target people with lower educational levels and specifically target women. Men are generally more exposed to information technology and public information in Liberia. False information spreads as rumours among women's groups, without being critically appraised or discussed. The underlying reason could be a lack of basic technical and health education. From field observations, women show better levels of understanding after attending 'show and tell' events (Thomas-Connor, unpublished). Furthermore, our finding of strong associations between increased knowledge and taking important preventative measures such as frequent hand washing with soap and water, wearing facemasks and avoiding crowds suggest that improving community knowledge may increase positive behaviours. Radio was the most cited COVID-19 information channel, similar to findings from a KAP survey conducted in Liberia during the Ebola outbreak.[30] Social media was the second most frequently mentioned source of COVID-19 messages, reflecting results from a KAP survey conducted before the outbreak in Sierra Leone.[36] Both Facebook Messenger and WhatsApp are widespread across Africa.[41] It is reasonable to assume that the online survey respondents had access to and acknowledged the information distributed by national and international health authorities through both traditional and modern communication channels.

In 2020, it was estimated that 938 030 people (19.0% of the population) use the internet in Liberia,[42] which has likely increased since. Due to inherently different characteristics of internet users compared with community residents, diverse public health communication strategies should be applied to avoid a singular focus or medium for information dissemination. For example, for the elderly and people with lower levels of education, in addition to radio and television broadcasts, print media such as posters, bulletin boards, banners and booklets, including

educational imagery such as comic illustrations, would be more helpful. For younger and more educated internet-savvy individuals, dominant internet-based channels and social media are more appropriate. As noted by Sengeh *et al*, monitoring and frequent updates on social media by government authorities should be used to counteract the spread of disinformation about COVID-19.[36 43]

The survey suggests that health professionals and the government of Liberia were perceived to be the most trusted sources of information on SARS-CoV-2/COVID-19, similar to findings from a nationally representative opinion poll in Liberia.[44] However, around a third of the survey respondents believed that most COVID-19-infected cases would result in deaths and that older adults are not at increased risk for severe illness from COVID-19. This finding shows that further sensitisation needs to be carried out so that risk perceptions reflect the actual susceptibility to COVID-19, which is reliably influenced by contextual factors.[45 46] For instance, messages should underscore that older age groups (65 years and above), individuals with pre-existing medical conditions and smokers are at most risk of developing a severe form of COVID-19, resulting in COVID-19 deaths.

While most of our survey respondents indicated that they were following preventative actions to avoid COVID-19 infection, the feasibility of long-term public health measures in low-income settings should be considered. Appropriate measures should be promoted to curb the intrahousehold spread of SARS-CoV-2.[22] Most deprived Liberian communities lack running water, toilet facilities, soap and basic food items.[47] Increasing public education, especially on the use of facemasks and the sufficient provision of water and soap, is the basic measure that should be continually reinforced through government-supported water sanitation and hygiene programmes. The loss of income and aggrieved food security was also a major concern for respondents. Measures such as curfew or personal quarantine, which have shown to be effective in reducing the spread of SARS-CoV-2, have come at high cost in settings where a high share of the aggregate income is generated through informal labour.[48] Two-thirds of our largely educated survey sample would support voluntary home quarantine for up to 14 days. However, it might not be easy to adhere to such regulations for people living in more densely populated areas in Liberia.

Strengths and limitations

The rural and urban sample population and using two data collection modes are major strengths of this study. The two modes allowed us to reach younger and older, internet-savvy and illiterate respondents concurrently. Our telephone-administered interview guide reflected the online survey questions, allowing comparison of KAP indicators across survey modes. Our study adds to the sparse literature on KAP related to COVID-19 in Liberia, giving a unique insight into the knowledge and behaviour of a population that has already been sensitised by a highly contagious and life-threatening disease, Ebola. Our study has nonetheless several limitations. At the height of the COVID-19 lockdown measures in Liberia, it was not feasible to deploy enumerators to the field to collect information from households through face-to-face interviews, so using the two data collection modes was safer and appropriate. Given the limited resources available and the pandemic's time sensitivity, the study focused on Maryland County. However, the online survey reached individuals in Monrovia, the capital, and individuals from other counties. Our survey sample was highly selective, and in relation to the overall Liberian population size,[42] men and those aged 24–45 years are over-represented, but not by a sizeable margin. Therefore, the data are not representative of the general Liberian population and any conclusions for the general public should be drawn carefully. One needs to bear in mind the limitation of observational design such as a cross-sectional study, which does not allow to establish causal relationships. It should also be mentioned that the lack of incentives for participating in the survey might have contributed to the increased selective sample. Given the overall time cost, the online survey participants incurred monetary costs for internet data usage, which might have outweighed the intrinsic motivation to take part, especially among individuals from lower socioeconomic groups. Furthermore, it is possible that respondents may have provided socially desirable responses, which may not always be aligned with actual practices. Notwithstanding these limitations, the survey results reinforce the feasibility and the importance of conducting KAP assessments as an early component of outbreak response using mixed-mode approaches.

CONCLUSION

Although knowledge and awareness of COVID-19 were moderately high, our cross-sectional survey found widespread misconceptions exist, particularly among women and less educated individuals in Liberia. While knowledge does not automatically translate into practice, this study shows a strong association between knowledge and practice in this community. Since the knowledge gap differs between sexes, regions, educational levels and ages, messages must be tailored to different audiences. Furthermore, disease surveillance systems need to be strengthened so that public health campaigns in rural locations such as Maryland County can be well timed and capitalise on existing knowledge and prevailing health information exchange networks that may already exist. Information platforms with a wide reach, including radio and social media platforms, should continue to be leveraged to disseminate reliable and evidence-based information through credible and trustworthy sources.

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Contributors All authors reviewed and approved the methodology and read and approved the final version. JAV and PD dealt with ethical clearance. AD, JBW, ABH and RS drafted and designed the participant recruitment materials. JBW, AD, AV, RS and IT-C supported the training and supervision of the data collection teams. AV and VRL interfaced with the online Qualtrics platform and oversaw data management. JBW, ABH, IT-C, RD-R, LWJ and LCD conducted the telephone interviews and field logistics. NK performed all the steps for data cleaning and produced a clean dataset. AD led the data analysis with support from JBW, ABH and GDN. NK and VRL conducted separate analysis of all data to ensure accuracy and consistency. All authors were involved in drafting different sections of the manuscript: RS, IT-C, LCD, RG-R and VRL drafted the Introduction section; AD, NK, JBW, ABH, VRL and RS drafted the Methods section; RS, PD, AD and NK drafted the Results section and PD and RS drafted the Discussion section. All coauthors contributed to the interpretation of the results and to the preparation and writing of the manuscript. PD and IT-C are joint last authors.

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REFERENCES

1 World Health Organisation. Ebola situation report, 2016. Available: https://apps.who.int/ebola/current-situation/ebola-situation-report-30-march-2016
2 Msf supports efforts to treat COVID-19 in Liberia, 2020. Available: https://www.msf.org/msf-supports-efforts-treat-covid-19-liberia
3 Nepomnyashchiy L, Dahn B, Saykpah R, *et al*. COVID-19: Africa needs unprecedented attention to strengthen community health systems. *Lancet* 2020;396:150–2.
4 Varagur K. How Ebola helped Liberia prepare for covid. MIT Technology Review [Internet], 2020. Available: https://www.technologyreview.com/2020/08/19/1007139/liberia-kateh-covid-coronavirus-ebola/
5 Maxmen A. Ebola prepared these countries for coronavirus - but now even they are floundering. *Nature* 2020;583:667–8.
6 Nations U. Liberia: Ebola contact tracing lessons inform COVID-19 response [Internet], 2020. Available: https://news.un.org/en/story/2020/04/1062582
7 Brown W. Will the legacy of Ebola help Liberia fight coronavirus? The Telegraph [Internet], 2020. Available: https://www.telegraph.co.uk/global-health/science-and-disease/will-legacy-ebola-help-liberia-fight-coronavirus/
8 Liberia: Health Ministry Confirms First Case of Coronavirus. FrontPage Africa [Internet], 2020. Available: https://frontpageafricaonline.com/amp/front-slider/liberia-health-ministry-confirms-first-case-of-coronavirus/
9 Dong E, Du H, Gardner L. An interactive web-based dashboard to track COVID-19 in real time. *Lancet Infect Dis* 2020;20:533–4.
10 Africa CDC. Africa CDC Dashboard - Coronavirus Disease 2019 (COVID-19) [Internet]. Official Regional Collaborating Centre and Member State reports. Africa CDC, 2020. Available: https://africacdc.org/covid-19/
11 El-Sadr WM, Justman J. Africa in the path of Covid-19. *N Engl J Med* 2020;383:e11.
12 Ipsos. Responding to COVID-19: Highlights of a Survey in LIBERIA [Internet], 2020. Available: https://www.ipsos.com/sites/default/files/ct/publication/documents/2020-05/liberia_report_0.pdf
13 Jalloh MF, Sengeh P, Monasch R, *et al*. National survey of Ebola-related knowledge, attitudes and practices before the outbreak peak in Sierra Leone: August 2014. *BMJ Glob Health* 2017;2:e000285.
14 Kobayashi M, Beer KD, Bjork A. Community knowledge, attitudes, and practices regarding Ebola virus disease — five counties, Liberia, September–October, 2014. *MMWR Surveill Summ* 2015;64:714–8.
15 Sengeh P, Jalloh MB, Webber N, *et al*. Community knowledge, perceptions and practices around COVID-19 in Sierra Leone: a nationwide, cross-sectional survey. *BMJ Open* 2020;10:e040328.
16 Ngwewondo A, Nkengazong L, Ambe LA, *et al*. Knowledge, attitudes, practices of/towards COVID 19 preventive measures and symptoms: a cross-sectional study during the exponential rise of the outbreak in Cameroon. *PLoS Negl Trop Dis* 2020;14:e0008700.
17 Zhong B-L, Luo W, Li H-M, *et al*. Knowledge, attitudes, and practices towards COVID-19 among Chinese residents during the rapid rise period of the COVID-19 outbreak: a quick online cross-sectional survey. *Int J Biol Sci* 2020;16:1745–52.
18 Ssebuufu R, Sikakulya F, Binezero SM. Awareness, knowledge, attitude and practice towards measures for prevention of the spread of COVID-19 in the Ugandans: a nationwide online cross-sectional survey. *medRxiv* 2020.
19 Olapegba PO, Iorfa SK, Kolawole SO, *et al*. Survey data of COVID-19-related knowledge, risk perceptions and precautionary behavior among Nigerians. *Data Brief* 2020;30:105685.
20 Karim A, Akter M, Mazid AT. Knowledge and attitude towards COVID-19 in Bangladesh: population-level estimation and a comparison of data obtained by phone and online survey methods. *Epidemiology* 2020.
21 Azlan AA, Hamzah MR, Sern TJ, *et al*. Public knowledge, attitudes and practices towards COVID-19: A cross-sectional study in Malaysia. *PLoS One* 2020;15:e0233668.
22 et alAustrian K, Pinchoff J, Tidwell JB. COVID-19 related knowledge, attitudes, practices and needs of households in informal settlements in Nairobi, Kenya [Internet]. nCoV, 2020. Available: http://www.who.int/bulletin/online_first/20-260281.pdf
23 Hager E, Odetokun IA, Bolarinwa O, *et al*. Knowledge, attitude, and perceptions towards the 2019 coronavirus pandemic: a bi-national survey in Africa. *PLoS One* 2020;15:e0236918.
24 Byanaku A, Ibrahim M. Knowledge, attitudes, and practices (KAP) towards COVID-19: A quick online cross-sectional survey among Tanzanian residents. [Internet]. Infectious Diseases (except HIV/AIDS), 2020. Available: http://medrxiv.org/lookup/doi/10.1101/2020.04.26.20080820

25 Zogning Makemjio E, Tiotsia Tsapi A, Défo Tamgno E, *et al*. Knowledge and Attitudes of Population Living in Rural and Semi-Rural Areas towards Covid-19 :Case of the Menoua Division, Cameroon. *Ig Sanita Pubbl* 2020;76:159–72.
26 Saifuddin IA. Responding to COVID-19 in African Countries: Data Deck of Polling Results: Liberia [Internet]. Partnership for Evidence-based Response to COVID-19, 2020. Available: https://www.ipsos.com/sites/default/files/ct/publication/documents/2020-09/liberia-data-deck.pdf
27 de Leeuw ED. To mix or not to mix data collection modes in surveys. *J Off Stat*;21:233–55.
28 DeLeeuw ED. Mixed-Mode: past, present, and future. *Surv Res Methods* 2018.
29 World Health Organisation. Survey Tool and Guidance: Rapid, simple, flexible behavioural insights on COVID-19 [Internet]. World Health Organisation, 2020. Available: https://apps.who.int/iris/bitstream/handle/10665/333549/WHO-EURO-2020-696-40431-54222-eng.pdf?sequence=1&isAllowed=y
30 The Liberia Ministry of Health. *National knowledge, attitudes and practices study on Ebola virus disease*. Monrovia, Liberia, 2015.
31 Health Communication Capacity Collaborative. National Knowledge, Attitudes and Practices (KAP) Survey on Ebola Virus Disease in Liberia [Internet]. Johns Hopkins Center for Communication Programs, 2017. Available: https://healthcommcapacity.org/wp-content/uploads/2017/07/Liberia_KAP-II_Report_Final-May-2017_HC3.pdf
32 Greene J, Speizer H. Telephone and web: Mixed-Mode challenge: mixed mode surveys. *Health Serv Res* 2007;43:230–48.
33 Buelens B, Brakel Jvanden, den BJvan. On the necessity to include personal interviewing in Mixed-Mode surveys. *Surv Pract* 2010;3:1–7.
34 et alBhajibhakare S, Chopra A, Gupta P. Transitioning to CATI: Checklists and Resources [Internet]. J-PAL, 2020. Available: https://www.povertyactionlab.org/sites/default/files/research-resources/transitioning-to-CATI-Checklists.pdf
35 Kuhfeld WF, Cai W. Introducing the New ADAPTIVEREG Procedure for Adaptive Regression [Internet]. SAS Institute Inc, 2013. Available: https://support.sas.com/resources/papers/proceedings13/457-2013.pdf
36 Sengeh P, Jalloh MB, Webber N, *et al*. Community knowledge, perceptions and practices around COVID-19 in Sierra Leone: a nationwide, cross-sectional survey. *BMJ Open* 2020;10:e040328.
37 Forna A, Nouvellet P, Dorigatti I, *et al*. Case fatality ratio estimates for the 2013-2016 West African Ebola epidemic: application of boosted regression trees for imputation. *Clin Infect Dis* 2020;70:2476–83.
38 Bates BR, Moncayo AL, Costales JA, *et al*. Knowledge, attitudes, and practices towards COVID-19 among Ecuadorians during the outbreak: an online cross-sectional survey. *J Community Health* 2020;45:1158–67.
39 Reuben RC, Danladi MMA, Saleh DA. Attitudes and practices towards COVID-19: an epidemiological survey in north-central Nigeria. *J Community Health* 2020.
40 et alErfani A, Shahriarirad R, Ranjbar K. Knowledge, Attitude and Practice toward the Novel Coronavirus (COVID-19) Outbreak: A Population-Based Survey in Iran [Internet]. nCoV, 2020. Available: http://www.who.int/bulletin/online_first/20-256651.pdf
41 Kamara M. Changing Cultures: Changing Lives—Mobilising Social Media During a Health Crisis. In: Robertson ME, ed. *Communicating, Networking: Interacting [Internet*. Cham: Springer International Publishing, 2016. http://link.springer.com/10.1007/978-3-319-45471-9_4
42 The World Bank. World Development Indicators, Liberia [Internet]. The World Bank DataBank, 2020. Available: https://data.worldbank.org/country/liberia?view=chart
43 The Economist. How WhatsApp is used and misused in Africa, 2019. Available: https://www.economist.com/middle-east-and-africa/2019/07/18/how-whatsapp-is-used-and-misused-in-africa
44 Partnership for Evidence-based, Response to COVID-19. Responding to COVID-19 in African Countries: Executive Summary of Polling Results: [Internet]. Partnership for Evidence-based Response to COVID-19, 2020. Available: https://www.ipsos.com/sites/default/files/ct/publication/documents/2020-09/liberia-executive-summary.pdf
45 Ferrer R, Klein WM. Risk perceptions and health behavior. *Curr Opin Psychol* 2015;5:85–9.
46 Dryhurst S, Schneider CR, Kerr J. Risk perceptions of COVID-19 around the world. *J Risk Res* 2020:1–13.
47 Ministry of Finance and Planning, Government of Liberia. Liberia's Voluntary National Review. Liberia: Voluntary National Review on the Implementation Status of the 2030 Agenda for Sustainable Development [Internet], 2020. Available: https://sustainabledevelopment.un.org/content/documents/26287VNR_2020_Liberia_Report.pdf
48 Cash R, Patel V. Has COVID-19 subverted global health? *Lancet* 2020;395:1687–8.