


# BMJ Open Assessing factors associated with compliance to preventive measures of COVID-19 in Rwanda: a cross-sectional community survey

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## ABSTRACT

**Objective** To assess the level of compliance with COVID-19 preventive measures and compliance-associated factors in the Rwanda community.

**Design** Cross-sectional study.

**Settings** Country-wide community survey in Rwanda.

**Participants** 4763 participants were randomly sampled following the sampling frame used for the recent Rwanda Demographic Health Survey. Participants were aged between 22 years and 94 years.

**Outcomes** The participants' compliance with three preventive measures (wearing a face mask, washing hands and social distancing) was the main outcome.

**Methods** From 14 February 2022 to 27 February 2022, a cross-sectional survey using telephone calls was conducted. Study questionnaires included different questions such as participants' demographics and compliance with COVID-19 preventives measures. Verbal consent was obtained from each participant. The compliance on three main preventive measures (wearing a mask, washing hands and social distancing) were the main outcomes. Univariate and multivariable logistic regression analyses were performed to evaluate factors associated with compliance (age, gender, level of education, socioeconomic status).

**Results** Compliance with the three primary preventive measures (washing hands 98%, wearing a mask 97% and observing social distance 98%) was at a rate of 95%. The respondents' mean age was 46±11 SD (range 22–98) years. In addition, 69% were female and 86% had attended primary education. Bivariate and regression analyses indicated a significant association among the three primary preventive measures ( $p<0.05$ ). The results showed factors associated significantly between the different models ( $p<0.05$ ): proper mask use and social distancing in the hand washing model; hand washing, social distancing, avoiding handshakes and not attending gatherings in the proper mask use model; hand washing and avoiding handshakes in the social distancing model.

**Conclusion** Compliance with the three key preventive measures against COVID-19 was high in the Rwandan community and these measures were interdependent.

## STRENGTHS AND LIMITATIONS OF THIS STUDY

- ⇒ Using a nationwide sampling framework based on the recent Rwanda Demographic Health Survey ensured a representative sample, thereby enhancing the generalisability of the findings within Rwanda.
- ⇒ A digital approach involving direct telephone calls and trained data collectors reached a big number of participants with a response rate of 76%.
- ⇒ The study had sufficient power to detect significant associations and provide robust estimates of compliance with COVID-19 preventive measures.
- ⇒ The reliance on self-reported data during telephone calls may have introduced social desirability bias, where participants may have over-reported their compliance.
- ⇒ Participants without mobile phones were reached via a community healthcare worker; thus limited privacy during responding could create a bias.

Therefore, the importance of all three measures should be emphasised for effective disease control.

## INTRODUCTION

With over 6.5 million deaths in 2023, the COVID-19 pandemic has posed an unprecedented challenge to public health systems globally,<sup>1</sup> demanding quick adoption of preventive measures to stop its spread. On 14 March 2020, the initial occurrence of COVID-19 was detected in Kigali city, Rwanda. A traveller who did not display symptoms on arrival in Kigali on 8 March became symptomatic on 13 March and subsequently tested positive for COVID-19 on the following day.<sup>2</sup> The number of positive cases and deaths increased in Rwanda despite the implementation of several measures to restrict the spread of COVID-19 such as lockdowns, social distance and many others. By the end

of January 2022, there were 1440 confirmed deaths and 128891 confirmed cases.<sup>2</sup>

At the outset of the pandemic in January 2020, the WHO started advising preventive measures for COVID-19.<sup>3 4</sup> Regular hand washing, social distancing and wearing masks were among the preventive measures. WHO further recommended people to seek medical assistance if they exhibit COVID-19 symptoms, stay at home if they are not feeling well, and cover their mouth and nose when coughing or sneezing. Governments and health organisations all around the world have largely adopted these preventive measures.<sup>5</sup> While health authorities have recommended a number of preventive measures such as physical distancing, mask use, hand hygiene and vaccination, their effectiveness hinges significantly on public adherence or compliance. Understanding the factors influencing adherence to preventive measures becomes crucial for shaping targeted interventions and mitigating the impact of the virus especially in the context of Rwanda, a country that has been recognised for its proactive response to the pandemic.<sup>6</sup>

Through a community-based survey, this study endeavours to comprehensively evaluate the factors influencing compliance with COVID-19 preventive measures in Rwanda. By doing so, it aims to shed light on the determinants that facilitate or hinder the adoption of preventative behaviours. The findings of this research can empower policymakers and healthcare professionals to effectively tackle the ongoing epidemic and enhance public health resilience through tailored interventions informed by the identification of key compliance factors. Preventive measures included the closure of borders, schools, colleges, universities and offices, as well as the shutdown of nightclubs and entertainment venues. Additionally, there were social distancing protocols, reduction in the number of passengers in public transportation, implementation of curfews, restriction of public gatherings and mandatory use of masks. Other preventive measures were discouraging handshaking, isolating sick individuals and using drones as a tool for information dissemination. These preventive measures were disseminated through the media and the COVID-19 situation was reported daily.<sup>7</sup> Since many of these measures may require individuals to change their attitudes and behaviours, people tended to resist preventive strategies as was reported in different studies. This resulted in more people becoming susceptible to COVID-19.<sup>8 9</sup>

Due to the lack of data in the literature, research on the implementation and effectiveness of COVID-19 preventive measures was not sufficiently reported in low-income countries, especially in Africa.<sup>10</sup> Compared with other African countries, Rwanda implemented considerably more consistent and stringent COVID-19-related measures. The country's success in enforcing these measures can be attributed to its population's tendency to adhere to government recommendations and the government's robust enforcement mechanisms.<sup>11</sup> In Rwanda, a survey on knowledge, attitudes and practice among

healthcare workers indicated that 95% of responses appealed to the adoption of preventive measures such as hand washing, social distancing, avoiding crowds, minimising travel, and wearing gloves and face masks. The findings also revealed that having a thorough understanding of COVID-19 and how to prevent it was a contributing factor.<sup>12</sup> Furthermore, the media helped to disseminate preventive measures in the whole entire nation, the whole community was supportive.<sup>13</sup> This study was designed to assess the level of compliance with COVID-19 preventive measures and identify its associated factors in Rwanda.

## METHODS

### Study setting and design

This was a cross-sectional study conducted in 30 districts of Rwanda. The local government in Rwanda is organised into four tiers which include 30 districts as the primary local authorities, along with sectors, cells and villages. The district council is responsible for policymaking and legislation at the district level. It serves as the platform through which citizens, via their representatives, can exercise their decision-making and planning powers to determine the development of the district.<sup>14</sup>

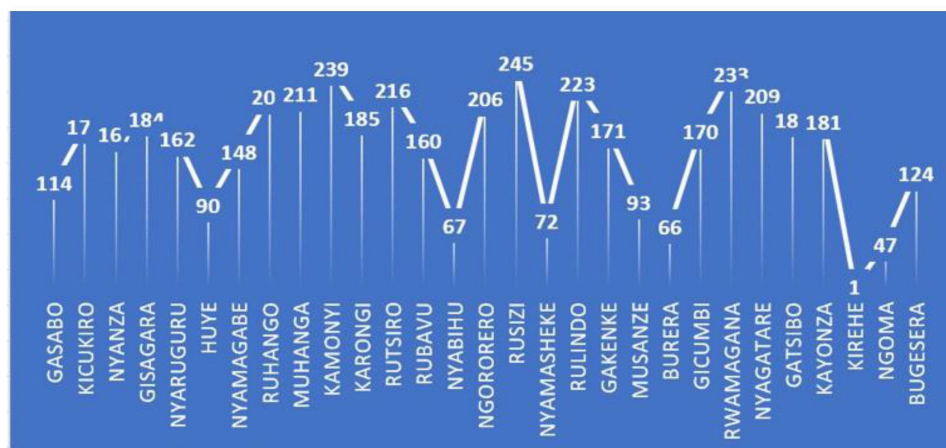
### Study population

This study analysed the data from large country survey collected in a period of 2 weeks, from 14th-27th February 2022. The detailed methodology has previously been documented elsewhere.<sup>15</sup> Participants were randomly selected using a sampling frame derived from the recent Rwanda Demographic Health Survey. This survey is based on data from the fourth Rwanda Population and Housing Census and was provided by the National Institute of Statistics of Rwanda (2020). The minimum required sample size was estimated using the total population of 10486659 inhabitants of Rwanda.<sup>13</sup> With a margin of error of 2% and a confidence level of 95%, the calculated minimum sample comprised 2401 participants. However, to account for potential consent refusals and dropouts, we doubled this number. Consequently, a total of 6248 participants were randomly preselected and contacted nationwide. Out of these, 4763 completed the forms, all within the 2-week study period, yielding an acceptable response rate of 76%. The number of calls made per day varied, and the distribution of respondents by district is shown in figure 1. Participants ranged in age from 22 years to 94 years.

### Data collection

Data were collected between 14 February and 27 February 2022, by 30 trained data collectors via telephone questionnaires. These data collectors, all university graduates, were selected through a competitive process. They received training from the research team on questionnaire usage and telephone interview techniques.

The questionnaire was piloted over three sessions, each involving 20 data collectors using selected investigators



**Figure 1** Number of respondents per district.

and data collectors themselves as mock interviewees. The purpose of this testing was to assess the feasibility of the questionnaire, and not to evaluate demographic similarities between the pretesting participants and the sample population.

Data collectors were supervised by the research team, and each participant received all calls from a designated data collector. Community healthcare workers (CHWs) assisted by lending their telephones to participants who did not have their own. In Rwanda, each village has four CHWs who participate in various Ministry of Health (MoH) programmes and have been provided with mobile telephones by the MoH.<sup>16</sup>

The study questionnaires were initially written in English and then translated into Kinyarwanda and French. These questionnaires covered various demographic questions, such as age, gender, education level (categorised as primary education or below, and secondary education or above), employment status during the COVID-19 period (options included no change in working hours, decreased working hours, increased working hours and job loss) and socioeconomic status.

In addition, the questionnaires included questions about preventive measures, such as face mask usage, hand hygiene, adherence to social distancing and other risk-minimisation practices.

The socioeconomic categories, known as 'Ubudehe' in Kinyarwanda, classify citizens into four groups based on their poverty level, housing situation, employment status and income:

The first category consists of very poor and vulnerable individuals who are homeless and cannot live without assistance. The second category includes citizens who can afford some form of rented or low-quality housing but are not gainfully employed and can only afford to eat once or twice a day. The third category encompasses citizens who are gainfully employed or are employers themselves, including small farmers who no longer rely solely on subsistence farming and owners of small-to-medium sized businesses. The fourth category comprises citizens who are CEOs of large companies or have full-time jobs

with established organisations, industries, companies or government agencies.<sup>17</sup>

### Statistical methods

The data were captured through a digital form and analysed with the statistical package STATA software V.15 (STATA Corp, College Station, Texas, USA) together with the Statistical Package for Social Sciences (SPSS) (IBM Corp. Released 2020. IBM SPSS Statistics for Windows, V.28.0. Armonk, New York, USA). A value of  $p < 0.05$  was considered statistically significant. Numerical data were analysed using the t-test and categorical data using the  $\chi^2$  test.

As the study focused on the community's adherence to the main COVID-19 preventive measures including wearing a face mask, hand washing and social distancing, the outcome variable for the study was the community's compliance with these measures. These outcomes included wearing a face mask, hand washing and social distancing.<sup>18</sup> Wearing a face mask was categorised as '1' for individuals who reported always or often wearing a face mask appropriately, covering their mouth and nose outside of their home in the last 24 hours. It was '0' for those who did not. Hand washing with soap and water or hand sanitising was also categorised as '1' for individuals who reported always or often implementing these measures in the last 24 hours and '0' for those who did not or only did so occasionally. Social distancing was defined as maintaining a distance of at least 2 m from others in the last 24 hours and was categorised as '1' for those who reported always or often maintaining this distance and '0' for those who did not or only did so occasionally. These dichotomised variables were then used as the primary outcomes in the study to assess community compliance with COVID-19 preventive measures.

In this study, bivariate analysis was done to assess the association of each of the three key preventive measures (hand washing, wearing a mask and social distancing) and other preventive measures and the selected factors. The  $\chi^2$  test was conducted to select the factors associated with hand washing, wearing a mask and social distancing



which were considered as response variables. Factors found to be significantly associated with response variables were considered in multivariable logistic regression models of the preventive measures namely hand washing, wearing a mask and social distancing.

### Ethical consideration

The data were collected on telephone call after receiving the participants' verbal consent. The collected data were encrypted and stored in a secured location to ensure participants' confidentiality. A unique identifier was attributed to each participant.

### Patient and public involvement

In conducting this study survey, researchers recognised the vital role of patient and public involvement in shaping the research design and in interpretation of the findings. Prior to the commencement of the study, researchers engaged with the Rwanda Biomedical Centre overseeing the CHWs, and members of the public stakeholders including the National Institute of Statistics in Rwanda to understand their perspectives on COVID-19 preventive measures and the factors influencing compliance. Their insights helped refine the questionnaire and sampling approach, ensuring that the study captured a comprehensive picture of compliance behaviours within the community. The survey itself involved community individuals including both CHWs, eventual COVID-19-positive patients and the healthy population. The survey was carried out in all districts of Rwanda and the sampling method helped to ensure a representative sample. Additionally, on completion of data analysis, we have disseminated and continue to disseminate our findings to the public through community forums and informational sessions, inviting feedback and discussion on how best to translate these findings into strategies for promoting adherence to preventive measures. By actively involving patients and the public throughout the research process, researchers aim to foster a sense of ownership and empowerment within the community, ultimately contributing to more effective public health interventions and improved outcomes in fighting against COVID-19.

## RESULTS

The sample comprised 4763 participants who were surveyed via telephone calls and their characteristics are summarised in [table 1](#). The mean age of the participants was 46±10 years (range 22–94 years). The majority of the participants were female (68.6%) and had a primary education level or below (86%). In terms of employment status during COVID-19, the majority of the participants experienced a decrease in working hours (59%), while 28% reported no change at their work. In addition, 5% reported an increase in working hours while 8% reported job loss. Regarding socioeconomic status (Ubudehe categories), the majority of the participants belonged to category 2 (65%) and these were followed by category 1

**Table 1** Characteristics of respondents

Variables	Total	%
Age (mean±SD, range) (n=3554)	46±10	(22–94)
Age categories, years		
18–29	117	3
30–44	1580	45
45–60	1593	45
>60	264	7
Sex (n=4763)		
Female	3270	69
Male	1493	31
Level of education (n=4763)		
Primary and below	4122	87
Secondary and above	641	13
Employment status during COVID-19 (n=4763)		
No change at my work	1327	28
Working hours decreased	2833	59
Working hours increased	233	5
Lost job	370	8
Ubudehe categories (socioeconomic status) (n=4763)		
Category 1	1587	35
Category 2	2996	65
Categories 3 and 4	6	0
Marital status (n=3550)		
Live with a partner	3298	93
Live without a partner	252	7

(35%). Only a small number of participants belonged to categories 3 and 4 (0%). In terms of marital status, the vast majority of participants reported living with a partner legally (93%).

Regarding preventive measures, the majority of the participants reported appropriate use of face masks (97%), washing hands (98%) and observing social distance (98%). In addition, 10% of the participants reported avoiding handshakes while 61% reported not going to social/family meetings. Regarding overall compliance with the three main preventive measures (washing hands, wearing a mask and observing social distance), 95% of participants reported they had complied with them. In terms of COVID-19 testing, slightly more than half of the participants (51%) reported being tested for COVID-19, while the remaining participants reported not being tested (50%). [Table 2](#) provides details.

Bivariate analysis was used to assess the association of each of the three key preventive measures and other preventive measures, and the selected factors. The factors include gender, age, education level and socioeconomic categories. Other preventive measures included wearing masks appropriately, washing hands, handshaking and social distancing. Findings presented in online

**Table 2** Adherence to preventive measures

Variables	Total	%
Appropriate use of mask (n=4716)		
Yes	4578	97
No	136	3
Washing hands (n=4740)		
Yes	4665	98
No	75	2
Maintaining social distance (n=4704)		
Yes	4606	98
No	98	2
Handshakes (n=4717)		
Yes	482	10
No	4235	90
Not going to social/family meetings (n=4763)		
Yes	2903	61
No	1860	39
Overall compliance (three main preventive measures) (n=4362)		
Yes	4150	95
No	212	5
History of being tested for COVID-19 (n=4763)		
Yes	2330	49
No	2433	51

supplemental table 1 revealed that each one of the three key preventive measures is significantly associated with each one of the other two ( $p<0.001$ ). Observing a social distance (2 m), avoiding handshaking, and attending any social event or gatherings were associated with complying with the above three preventives measures ( $p<0.001$ ). In addition, results indicate that compliance with these measures was significantly associated with factors such as gender, wearing masks appropriately, washing hands, handshaking and attending social events (all  $p<0.05$ ).

In summary, social distancing (2 m) and avoiding handshaking and attending any social or event gatherings were associated with compliance with the three preventive measures. Gender was statistically linked to hand washing. The influence of one of the three key preventive measures was assessed and was significantly associated with each one to another in univariate analysis ( $p<0.001$ ).

Table 3 displays multivariable logistic regression estimation results. Three models of washing hands, wearing a mask appropriately and social distancing were estimated. The findings indicate that gender and appropriate use of mask and leaving a social distance were statistically significant ( $p<0.001$ ) in the washing hands model. Variables like washing hands, leaving a social distance, handshaking and not going to social/family meetings were statistically significant in the wearing a mask appropriately model. Factors like using masks, washing hands and handshaking were statistically significant in the social distancing appropriate model. On the contrary, not going to social/family meetings was not statistically significant in the two models of washing hands and social distancing.

## DISCUSSION

The primary objective of this study was to evaluate the degree of adherence to COVID-19 preventive measures and to identify the factors associated with compliance within the Rwandan community. Although this topic has been largely documented in other places,<sup>19 20</sup> this work only focused on Rwanda's perspective. In fact, the compliance with public rules always follows the local context, the culture and habits of the population. This study is the first one documenting the adherence to COVID-19 preventive measures in the Rwandan community.

Findings from this study showed a high level of compliance with COVID-19 preventive measures. In this regard, 95% of surveyed respondents complied with the main preventive measures (washing hands, wearing a mask and social distancing) and the independent associations of those measures with respect to one another, suggesting

**Table 3** Multivariable analysis

Variables	Washing hands OR (CI 95%)		Wearing a mask appropriately OR (CI 95%)		Social distancing OR (CI 95%)	
	aOR (CI 95%)	P value	aOR (CI 95%)	P value	aOR (CI 95%)	P value
Gender	0.4 (0.22 to 0.66)	0.001	–	–	–	–
Appropriate use of mask	14.6 (7.71 to 27.83)	<0.001	–	–	10 (6.21 to 19.02)	<0.001
Washing hands	–	–	17.4 (9.16 to 33.14)	<0.001	16.3 (8.21 to 32.33)	<0.001
Social distancing	12.6 (6.34 to 25.19)	<0.001	10.7 (6.07 to 18.85)	<0.001	–	–
Handshaking	–	–	0.4 (0.22 to 0.56)	<0.001	0.2 (0.10 to 0.27)	<0.001
Not going to social/family meetings	1.4 (0.82 to 2.46)	0.201	1.4 (1.01 to 2.21)	0.045	1.2 (0.78 to 1.94)	0.358
aOR, adjusted OR.						

that each of the three measures is an uniquely associated factor of the others.

The high level of compliance to preventive measures against COVID-19 in Rwanda was a positive development. It suggests that the population was taking the pandemic seriously and adopting active steps to prevent its spread. This could be attributed to the government's proactive approach—mainly the reinforcement of intermittent lockdowns, curfew hours and public health campaigns to contain the pandemic.<sup>13 21</sup>

The findings from this study revealed that more than 95% of participants followed social distancing, hand washing and appropriate mask wearing measures. These results coincide with those of a study conducted by Ndishimye *et al.*<sup>12</sup> Similar results were also obtained in the study by Vatovec *et al.*, in which 95% of respondents in Vermont (USA) reported knowing exactly what to do to follow recommended actions, and it was said that the political affiliation was a primary influence leading to compliance.<sup>22</sup> However, there were other studies that cited a low level of compliance. This is the case of 49.7% healthcare workers in Ethiopia<sup>8</sup> and 58.5% in Nigeria,<sup>23</sup> among 12.3% residents of Dirashe district, southern Ethiopia<sup>24</sup> and 11.2% patrons of community convenience shops in Ghana.<sup>25</sup> Similarly, it was reported that at the beginning of the COVID-19 pandemic, preventives measures were not respected in sub-Saharan Africa as well as in the Rwandan community. This could be explained by the fact that the population was still confused about some restrictions that impaired social-cultural activities.<sup>26 27</sup>

Considering the adherence to each of the main COVID-19 preventive measures that were assessed in this study, hand hygiene remained the most common practice (98%). Similarly, adherence to social distancing or wearing masks were at a high level (above 95%).

Different findings were found in the study by Ditekemen *et al.*, which revealed that face masks were not used by 54.7% of participants while non-adherence to physical distancing was reported by 41.7% of participants. The same study disclosed that 15.3% of the participants did not observe regular hand washing.<sup>28</sup> This study brought supplementary insights as it was carried out in a neighbouring country. Findings from this study also contrast with the findings from studies in the non-western regions of Ethiopia and Somalia in which 55.4% and 56.2% of respondents, respectively, reported poor compliance with social distancing measures while only 39.4% and 59.1% of respondents, respectively, acknowledged using a mask when going outside their homes.<sup>29 30</sup> Poor compliance was also reported among pregnant women in Ghana. In this country, only 18% and 22%, respectively, could wear face masks and observe social distancing.<sup>31</sup> According to the study, every preventive intervention significantly influenced other preventive measures. This implies a statistical relationship between the measures. This means that people who followed one measure were more likely to follow the others. A similar situation was reported in Spain.<sup>18</sup> This could be explained by the fact that most

of those measures were independently respected by the users who were aware of their importance in the prevention of COVID-19. The finding suggests that promoting compliance with one measure such as wearing masks may lead to increased compliance with other measures as well.

The findings from this study revealed that there is no gender difference in compliance with social distancing and appropriate mask wearing measures but there is a difference in hand washing measures. As far as hand washing is concerned, it was revealed that men washed their hands significantly less than women. This result contrasts with the findings obtained in similar studies conducted in the USA.<sup>22</sup> For example, Galasso *et al.* analysed data from a survey of 21 649 people and found that women were more likely to comply with COVID-19 preventative measures than men.<sup>32</sup> Moreover, this study revealed that the compliance was uniform across different groupings of the population such as age categories, level of education and socioeconomic (Ubudehe) categories. However, according to some studies, compliance with COVID-19 measures can vary based on a variety of factors such as age, education level and cultural norms.<sup>18 33</sup> The study didn't find the association of having high education and the good compliance on preventive measures.<sup>30</sup> During the study period the low rate of avoidance of public places in Rwanda (39.1%) can be attributed to factors such as fear of contracting the virus and government restrictions.<sup>34</sup> This can be compared with a 26.1% proportion of participants who reported not leaving their homes as compliance measures among South African<sup>35</sup> and 31% among Vermont residents.<sup>22</sup>

In bivariate analysis, avoiding handshakes or other skin contacts was also strengthened as a preventive measure among the Rwandan population since it was known that contact with anybody remained the rapid route of transmission.<sup>36</sup> This could explain the low rate (10.2%) of greetings using hands in this study.<sup>21</sup> This finding is similar to the one in another study among the students at the University of Liege (16%).<sup>37</sup>

This study had some limitations. Researchers conducted telephone calls to collect data. This might have introduced a systematic bias because of the lack of face-to-face interviews, limiting the responses' reliability and potentially overestimating compliance within our study population. Therefore, the results of this survey should be interpreted along with other studies used the same method. In addition, researchers omitted the mortality data, making it challenging to directly determine the clinical importance of our findings in terms of morbidity and mortality. Nevertheless, the study design, which is cross-sectional, along with a structured sampling frame, allowed researchers to reach a large and diverse population country-wide.

## Conclusion

This study used a cross-sectional community survey to evaluate the level of compliance with COVID-19 preventive measures and compliance-associated factors in the



Rwandan population. Overall, the high level of compliance with the three main preventive measures (washing hands, wearing a mask, and observing social distance) and their independent associations with one another are promising signs for the control of COVID-19. However, it is important to continue to promote these measures and ensure that individuals have access to the resources and information needed to comply with them effectively. Continued efforts to promote and reinforce preventive measures would be essential to controlling the spread of the virus during the outbreak.

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**Contributors** Conceptualisation and initial draft: RM, CR, MT, SJ, LM. Methodology and analysis: RM, AU, CR, JN, EMutezimana, AN, CM, EMasabo and MT. Introduction and literature review: LM, CR, LT, OB, VA and GR. Final manuscript review: RM, AU, LM, JN, CR, SJ, EMutezimana, VA, OB, JR, EMasabo, CM, GR, MS, MT, SJ and OB. All the authors reviewed the manuscript and approved the final version. RM is responsible for writing this manuscript, ensuring data accuracy, and takes full responsibility for the work and the study's conduct. RM had access to the data and made the decision to publish.

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**Competing interests** None declared.

**Patient and public involvement** Patients and/or the public were involved in the design, or conduct, or reporting, or dissemination plans of this research. Refer to the Methods section for further details.

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**Ethics approval** This study involves human participants and was approved by the Rwanda National Ethics Committee, Rwanda (No.112/RNEC/2021). Participants gave informed consent to participate in the study before taking part.

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**Data availability statement** Data are available upon reasonable request. Data are not publicly available, but access may be obtained from the authors upon reasonable request.

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# REFERENCES

- World Health Organization Dashboard. WHO coronavirus (COVID-19) dashboard with vaccination data. 2022. Available: <https://covid19.who.int>
- Butera Y, Mukantwari E, Artesi M, *et al*. Genomic sequencing of SARS-cov-2 in Rwanda: evolution and regional dynamics. *Genetic Genomic Med* [Preprint] 2021.
- World Health Organization. Coronavirus (COVID-19) events as they happen, 2020. Available: <https://www.who.int/emergencies/diseases/novel-coronavirus-2019/events-as-they-happen>
- OMS. Coronavirus (COVID-19) world health organization rolling updates on coronavirus disease (COVID-19). 2020.
- World Health Organization. Disease outbreak news (DONS). 2020. Available: <https://www.who.int/emergencies/disease-outbreak-news>
- Nkeshimana M, Igiraneza D, Turatsinze D, *et al*. Experience of Rwanda on COVID-19 case management: from uncertainties to the era of neutralizing monoclonal antibodies. *Int J Environ Res Public Health* 2022;19:1023.
- Ministry of Health, Republic of Rwanda. Coronavirus disease 2019, national preparedness and response plan. 2020.
- Zenbaba D, Sahiledengle B, Beressa G, *et al*. Healthcare workers' compliance with COVID-19 preventive measures, and associated factors, in Ethiopia: A systematic review and meta-analysis. *BMJ Open* 2022;12:e060681.
- Asemahagn MA. Factors determining the knowledge and prevention practice of healthcare workers towards COVID-19 in amhara region, Ethiopia: A cross-sectional survey. *Trop Med Health* 2020;48:72.
- Pathak KP, Sanyam SD, Gaire T, *et al*. Perception and challenges of preventive measures of COVID-19 among nepalese frontline health professionals: an unexplored realism. *Front Public Health* 2022;9:1-8.
- Solomon H, Thea DM, Galea S, *et al*. Adherence to and enforcement of non-pharmaceutical interventions (NPIs) for COVID-19 prevention in Nigeria, Rwanda, and Zambia: a mixed-methods analysis. *PLOS Glob Public Health* 2022;2:e0000389.
- Ndishimye P, Menelas N, Nadia H, *et al*. Knowledge, attitudes and preventive practices towards COVID-19 among frontline healthcare workers in Rwanda. *Pub Heal Bul* 2020;2:16-21.
- Bridget H, Julien N, Christian N, *et al*. COVID-19 through the lens of the media. 2020;13-5.
- MINALOC. *The local government system in Rwanda country profile 2017-18*. 2018:176-81. Available: [http://www.clgf.org.uk/default/assets/File/Country\\_profiles/Rwanda.pdf](http://www.clgf.org.uk/default/assets/File/Country_profiles/Rwanda.pdf)
- Nishimwe A, Ruranga C, Musanabaganwa C, *et al*. Leveraging artificial intelligence and data science techniques in harmonizing, sharing, accessing and analyzing SARS-COV-2/COVID-19 data in Rwanda (LAISDAR project): study design and rationale. *BMC Med Inform Decis Mak* 2022;22:214.
- Rwanda Demographic Health Survey, 2019-20 National Institute of Statistics of Rwanda (NISR) [Rwanda], Ministry of Health (MOH) [Rwanda], and ICF. In: *Rwanda demographic and health survey 2019-20 final report*. Kigali, Rwanda, and Rockville, Maryland, USA, 2021.



- 17 Rwandapedia. n.d. Poverty level categories. Available: <https://rwandapedia.rw/hgs/ubudehe/poverty-level-categories>
- 18 Beca-Martínez MT, Romay-Barja M, Falcón-Romero M, *et al.* Compliance with the main preventive measures of COVID-19 in Spain: the role of knowledge, attitudes, practices, and risk perception. *Transboundary Emerging Dis* 2022;69:e871–82.
- 19 Varas S, Elorrieta F, Vargas C, *et al.* Factors associated with change in adherence to COVID-19 personal protection measures in the metropolitan region, Chile. *PLoS ONE* 2022;17:e0267413.
- 20 Ahmadi S, Jorjoran Shushtari Z, Shirazikhah M, *et al.* Social determinants of adherence to COVID-19 preventive guidelines in Iran: A qualitative study. *Inquiry* 2022;59:00469580221084185.
- 21 Issn O, Issn P. *Public health bulletin epidemic curve from outbreak in Rwanda*. 2020.
- 22 Vatovec C, Hanley J. Survey of awareness, attitudes, and compliance with COVID-19 measures among Vermont residents. *PLoS ONE* 2022;17:e0265014.
- 23 Enone LL, Oyapero A, Makanjuola JO, *et al.* Awareness and adherence to COVID-19 preventive measures among oral health care workers in Nigeria. *West Afr J Med* 2022;39:11:1165–73.
- 24 Bante A, Mersha A, Tesfaye A, *et al.* Adherence with COVID-19 preventive measures and associated factors among residents of Dirashe district, southern Ethiopia. *Patient Prefer Adherence* 2021;15:237–49.
- 25 Ameme DK, Odikro MA, Baidoo A, *et al.* Hand hygiene and face mask wearing practices for COVID-19 prevention: a non-intrusive observation of patrons of community convenience shops in Accra, Ghana. *Pan Afr Med J* 2021;40:195.
- 26 Ngarka L, Siewe Fodjo JN, Njamnshi WY, *et al.* Adherence to COVID-19 preventive measures in sub-Saharan Africa during the 1st year of the pandemic: pooled analysis of the international citizen project on COVID-19 (icpcovid) surveys. *Front Public Health* 2022;10.
- 27 Umumararungu CK, Bazubagira AK. Community perceptions about COVID-19 and its socio-economic effects in Rwanda. *IJRBS* 2021;10:302–10.
- 28 Ditekemena JD, Nkamba DM, Muhindo HM, *et al.* Factors associated with adherence to COVID-19 prevention measures in the Democratic Republic of the Congo (DRC): results of an online survey. *BMJ Open* 2021;11:e043356.
- 29 Hailu W, Derseh L, Hunegnaw MT, *et al.* Compliance, barriers, and facilitators to social distancing measures for prevention of coronavirus disease 2019 in northwest Ethiopia, 2020. *Curr Ther Res Clin Exp* 2021;94:100632.
- 30 Ahmed MAM, Siewe Fodjo JN, Gele AA, *et al.* COVID-19 in Somalia: adherence to preventive measures and evolution of the disease burden. *Pathogens* 2020;9:1–11.
- 31 Apanga PA, Kumbeni MT. Adherence to COVID-19 preventive measures and associated factors among pregnant women in Ghana. *Tropical Med Int Health* 2021;26:656–63.
- 32 Galasso V, Pons V, Profeta P, *et al.* Gender differences in COVID-19 attitudes and behavior: panel evidence from eight countries. *Proc Natl Acad Sci USA* 2020;117:27285–91.
- 33 Recio-Vivas AM, Mansilla-Domínguez JM, Belzunegui-Eraso Á, *et al.* Compliance with COVID-19 prevention measures in the Spanish population during the new normal: will the need for greater community involvement be one of the lessons learned? *Int J Environ Res Public Health* 2022;19:15983.
- 34 Iradukunda PG, Pierre G, Muhozi V, *et al.* Knowledge, attitude, and practice towards COVID-19 among people living with HIV/AIDS in Kigali, Rwanda. *J Community Health* 2021;46:245–50.
- 35 Dukhi N, Mokhele T, Parker W-A, *et al.* Compliance with lockdown regulations during the COVID-19 pandemic in South Africa: findings from an online survey. *TOPHJ* 2021;14:45–55.
- 36 Hassan ASJ, Sritharan S, Jayatilaka G. *Hands off: a handshake interaction detection and localization model for COVID-19 threat control*. 2014.
- 37 Renault V, Humblet M-F, Parisi G, *et al.* The first random observational survey of barrier gestures against COVID-19. *Int J Environ Res Public Health* 2021;18:9972.