WESTERN OPEN BOOKS

AFRICA'S KNOWLEDGE BRIDGE

EMPOWERING GLOBAL ACCESS TO RESEARCH RESOURCES IN A COVID WORLD

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Africa's Knowledge Bridge

Empowering Global Access to Research Resources in a COVID World

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Cover Image: Denis Ngai, *Black elderly people sitting on chairs in yard of hospital in poor African village*. https://www.pexels.com/photo/black-elderly-people-sitting-on-chairs-in-yard-of-hospital-in-poor-african-village-4483669/

Contents

Articles

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Dedication

This book is dedicated to the resilience of all African people who have weathered the storm of COVID-19, whether through survival, illness or loss. It honours the strength and courage of those who have fought against this formidable adversary and extends heartfelt condolences to those who have tragically succumbed to the virus.

We also extend our deepest gratitude to the dedicated healthcare practitioners across the continent who have tirelessly worked to safeguard the health and well-being of their communities while facing unprecedented challenges.

Furthermore, this dedication extends to the individuals who generously contributed their time and insights to our survey efforts, as well as to the Nigerian Community Association in Queensland (NCAQ) Australia and the Translational Health Research Institute (THRI) of Western Sydney University. These platforms served as invaluable channels for disseminating vital information, combating misinformation and fostering compliance with crucial public health measures. Your collective efforts have played a vital role in promoting understanding, resilience and unity in the face of adversity.

Foreword

I was Dean of the Faculty of Medicine and Health in rural Australia when the COVID-19 pandemic began. Being a public health physician by trade, it was not too long before I left the University sector to return to the coalface and join the response. Those early days of the pandemic were uncertain, everchanging and of high consequence. Fortunately, while COVID-19 is still with us, the tumult of the onset years has retreated a little into history. Nevertheless, it is important not to forget the critical factors that supported and impeded success as we all strove to confront and resolve the challenges brought by the pandemic. By examining and reflecting on what we have learned over those years we can be better placed to respond to the inevitable challenges of future pandemics.

In late 2023, I returned to the Dean of Medicine role, and have since had the privilege of working with the highly regarded and highly committed researchers who have led the publication of *Africa's Knowledge Bridge*. It has been incredibly exciting for me to sit with members of the team to hear about their community-focused approaches and the academic rigour of the research that they and their colleagues undertake.

The value of research lies not solely in generating new knowledge but in putting this knowledge in the hands of the communities who can use it. I have worked in clinical and community practice, and as an academic researcher, educator and an administrator, and I have worked for public health agencies in several governments. My early career was spent in Africa in community-based research; on a global stage, I continue to collaborate with health experts from across the continent. For me, *Africa's Knowledge Bridge* demonstrates the triple helix of entwined practice, research and learning.

Africa's Knowledge Bridge is an authentic account of the pandemic in Sub-Saharan Africa. It carries the energy of the moment. It demonstrates the holistic nature of the challenge. As a collection of contributions, it elegantly captures the multiple voices, perspectives and areas of expertise that came together as the pandemic unfolded, and combined to deliver the solutions we were all seeking.

If there is one lesson we all learned during the COVID-19 pandemic, it is that health is a property of the population and community. We all had a part to play. We were all suddenly aware of the complex world that we live in.

The COVID-19 pandemic evolved at a lightning-fast pace, on an exploding scale. The potential severity of the condition, at an individual and community level, quickly became evident. In a brief time, there were few in the world who had not been affected in some way by the condition or response to the condition. Given the emerging nature of the problem, there was a lack of prior

knowledge of the organism, the transmission pathways, and clinical manifestations and treatment options. Clinical and population health policy decisions needed to be made in the face of deep uncertainty. Resource requirements often outpaced supply. There was tremendous interdependence between elements of the transmission and response systems, and a path of dependence that constrained solutions. The impact of risk behaviours was often multiplicative, rather than having additive effects, and risk variables had a non-linear, non-static relationship. Unintended consequences of interventions and competing public health outcomes needed to be considered. Self-organising solutions, adaptation to the latest information and phase shifts between conditions at different points in the pandemic were all part of the journey.

The complexity of the COVID-19 pandemic developed against the backdrop of social, cultural, economic, political and geographical structures of the populations affected. Where do we start to create academic commentary in a way that can be both inspiring and be of practical use? *Africa's Knowledge Bridge* has achieved this by uniting in one volume voices from across the continent to present different insights. Through the juxtaposition of these perspectives, the book has created an overall narrative that provides the evidence base to coherently appreciate the complex problem. Regions with varying levels of resources and advantages often endure most of the emerging health challenges, and consequently, it is these regions that have the most to offer the world in shining a light on new solutions. *Africa's Knowledge Bridge* has a story for us all.

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Preface

Africa's Knowledge Bridge stands as a testament to the resilience and dedication of researchers striving to comprehend the profound impacts of the COVID-19 pandemic on Sub-Saharan Africa (SSA). In the wake of the unprecedented global crisis, this book emerges as a comprehensive examination of the multifaceted repercussions experienced by the region, encompassing mental health, demographic disparities, vaccine perceptions, and compliance with public health measures.

The scope of this book extends beyond mere observation, delving deep into the heart of the pandemic's effects on SSA through diverse methodologies including web-based surveys, cross-sectional studies, and thematic interviews. By gathering data from SSA residents, diaspora, healthcare workers, and specific demographic groups, this research paints a vivid picture of the challenges faced and the resilience displayed by communities across the region.

Research in this field is of paramount importance due to the critical need to understand the unique dynamics of the pandemic in SSA. With varying impacts observed across different regions and demographics, it becomes imperative to discern the underlying factors contributing to these disparities and formulate targeted interventions to address them effectively.

The escalation of research in this field reflects a collective commitment to confront the challenges posed by the pandemic head-on. As the world grapples with the evolving nature of the crisis, scholars and practitioners alike are driven by a shared sense of urgency to generate knowledge that can inform evidence-based responses and mitigate the impact on vulnerable populations. Motivated by the pressing need to bridge the knowledge gap surrounding the pandemic's effects on SSA, this book originated from a Symposium Series dedicated to fostering interdisciplinary dialogue and collaboration among researchers, policymakers, and healthcare providers. By bringing together diverse perspectives and expertise, the symposium aimed to catalyze innovative solutions to the complex challenges facing the region.

What makes *Africa's Knowledge Bridge* unusual and worth reading lies in its nuanced exploration of the pandemic's impacts from various angles, ranging from mental health implications to vaccine-related insights and prevailing beliefs and perceptions. By shedding light on these interconnected issues, this book offers a holistic understanding of the pandemic's impact on SSA and presents actionable recommendations for addressing key challenges.

This book is designed to appeal to a wide audience, including researchers, policymakers, healthcare providers, and public health practitioners with an interest in understanding and mitigating the impact of COVID-19 in SSA and in tackling future outbreaks. Furthermore, it serves as a valuable resource for academics, students, and anyone seeking to deepen their understanding of the pandemic's effects on vulnerable populations.

By reading Africa's Knowledge Bridge, the reader will benefit from a comprehensive analysis of the COVID-19 pandemic's impact on SSA, gaining insights into the critical challenges faced by the region and the strategies needed to address them effectively. From informing evidence-based interventions to guiding future research directions, this book serves as a beacon of knowledge and a call to action in the ongoing fight against the pandemic in Sub-Saharan Africa.

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We also acknowledge the support of Professor Chika Anyanwu who joined as a presenter in one of our community information forums on infodemics during COVID-19 pandemic. chika.anyanwu@gmail.com

Acknowledgment of the Traditional Owners of Western Sydney University Land

Western Sydney University acknowledges the custodians of the lands in which we meet, work, learn and socialise. We pay respect to the peoples of the Darug, Tharawal, Eora and Wiradjuri nations where are campuses are located. We acknowledge that the teaching, learning and research undertaken across our campuses continues the teaching, learning and research that has occurred on these lands for tens of thousands of years. We acknowledge and pay our respect to the Elders past, present and emerging.

Source: 'Matta: Meeting place' by Jason and Trevor Dalmarri

Co-created by the team of WSU School of Business, Parramatta, this artwork represents the lands and communities upon which the Parramatta City campus is built. The word Parramatta comes from the Aboriginal word 'Baramada or Burramatta'. The Burramatta people (Burra meaning place and Matta meaning the eels) belong to the Dhurug people, who lived in this food-rich area before the time of the white invasion.

The story to this artwork is the land you work on today, showing the diversity of the area and paying respects to the past.

The “Matta” roamed along these rivers and grew large along the banks of the Burramatta river and in abundance. The green and blue waterways run through the artwork as they moved ever so gracefully up and down the inlets. The artwork shows the bubbles, the current, and the plentiful fish running through what today is known as Parramatta.

The shoreline depicts the edge of the land as the waters head out to Sydney Harbour and the ocean.

The colourful sections represent all the towns surrounding Burramatta. inside those towns are circles belonging to multicultural families now living on Dhurug country. The dot lines and tracks were once walking lines of the Dhurug people, now turned into roads, routes, and railway lines.

These lands occupy the growth of the town now called Parramatta in honour of the first Australians. Western Sydney University acknowledges the Dhurug nation as the traditional owners of the lands we work and live on today.

Introduction

The tumultuous year of 2020 bore witness to the global threat posed by the novel coronavirus disease (COVID-19) as it swept across the world, leaving nowhere untouched. Remarkably, the response in Africa was met with a degree of underestimation, resulting in the continent emerging as the least vaccinated region globally. Drawing upon past experiences with SARS and Ebola, it becomes evident that misconceptions and a climate of panic have contributed to a population reluctant to adhere to recommended preventive measures. This underscores the pressing need for comprehensive engagement with both healthcare and non-healthcare professionals in monitoring and enforcing pandemic control measures.

The spectre of 'inequity' has long haunted Africa, extending beyond the realms of the COVID-19 pandemic and permeating the distribution of vaccines, ultimately revealing the inadequacies of the global COVID-19 vaccine rollout within the continent. This complex scenario has driven African researchers to formulate effective strategies aimed at fortifying the continent's response to present and future public health crises.

In the wake of the COVID-19 outbreak, healthcare professionals, scientists and researchers in Africa have rallied together, embarking on a relentless pursuit to pinpoint target populations for tailored policies and interventions during this and subsequent pandemics. This book serves as a compendium of cross-sectional survey findings. Our work illuminates the multifaceted dimensions of knowledge, attitudes and practices (KAP) pertaining to public health measures, chloroquine hydrochloride treatment uptake and COVID-19 vaccination acceptance among Africans, including healthcare workers and non-healthcare workers.

The comprehensive studies documented within the book underscore the gravity of false information surrounding COVID-19, which has perpetuated a climate of vaccine hesitancy, further underscoring the pivotal role of health education and targeted policy reforms in tackling this mounting challenge. Moreover, insights from a cross-sectional matched sample study reveal the critical link between marital status, misconceptions and risk perception among pregnant women, ultimately emphasising the necessity of understanding and motivating vaccination acceptance to catalyse effective public health initiatives.

Comprising 17 rigorously peer-reviewed journal articles, the book transcends conventional discourse, offering profound insights into the intricacies of the impact of COVID-19 on the African continent. It meanwhile champions the lessons learned and presents a roadmap for future collaborative research initiatives by the African Translational Research Group (ATReG).

Through this achievement, the group was able to obtain a Tertiary Education Trust Fund (TetFund) grant from the Nigerian government, and the first paper from this grant is presented in the last chapter of this book.

The first article provides a brief history of the emergence of the group, formation of the team, and challenges, strategies, achievements and dynamics in implementing research collaboration for the coronavirus disease (COVID-19) by the African Translational Research Group (ATReG). It also outlines the lessons learnt and future opportunities for global collaborative research. The following chapter provides context for the knowledge, attitude and perception of COVID-19 among healthcare and non-health workers in Sub-Sahara Africa (SSA) and identifies the sub-populations to target for appropriate intervention in future pandemics in SSA. Throughout the book we discuss topics including pregnancy, diabetes, misinformation and mental health impacts of the pandemic; we encourage you to take the time to dive into the book to enrich your knowledge.

About this book

The aim of this book is to provide a one-stop repository for first-hand evidence on COVID, eliminating concerns about payments and subscriptions for people in developing countries. This activity is aligned with *SDG3-Good Health and Well-Being*, *SDG4 – Quality Education*, *SDG9-Industry, Innovation and Infrastructure*, *SDG10-Reduced Inequality*, and *SDG17-Partnerships for the Goals*.

Book reference: Osuagwu, UL, Agho, KE, Ekpenyong, BN, Mashige, KP, & Ishaya, T editors. Africa's Knowledge Bridge: Empowering Global Access to Research Resources in a COVID World [Internet]. Kingswood: Western Open Books; 2024 [cited YYYY MMM DD]. Available from: https://westernsydney.pressbooks.pub/africasknowledgebridge

Dataset reference: Osuagwu, Levi; Miner, Chundung Asabe; Bhattarai, Dipesh; Mashige, Khathutshelo Percy; Oloruntoba, Richard; Abu, Emmanuel Kwasi; Ekpenyong, Bernadine N; Timothy, Chikasirimobi Goodhope; Goson, Piwuna Christopher; Ovenseri-Ogbomo, Godwin O; Langsi, Raymond; Charwe, Deborah Donald; Agho, Kingsley Emwinyore (2024): African Translational Research Group COVID-19 survey data 1: Cross-sectional data across 15 sub-Saharan (SSA) countries during the pandemic. Western Sydney University. https://doi.org/10.26183/npmh-qx30

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NOTES

List of Abbreviations

ANDO	Association of Nigerian Dispensing Opticians
ANOVA	Analysis Of Variance
AOR	Adjusted Odds Ratio
CI	Confidence Interval
COVID-19	Coronavirus SARS-CoV2
ECPs	Eye Care Practitioners
EPPM	Extended Parallel Process Model
EVD	Ebola Virus Disease
FCT	Federal Capital Territory
FHCW	Frontline Health Care Worker
GIS	Geographic Information System
HADS	Hospital Anxiety and Depression Scale
HCWs	Health Care Workers
NOA	Nigerian Optometric Association
NONA	Nigeria Ophthalmic Nurses Association
OR	Odds Ratio
OSN	Ophthalmological Society of Nigeria
PTSD	Post-Traumatic Stress Disorder
SPRP	Strategic Preparedness and Response Plans
SSA	Sub–Saharan Africa
WHO	World Health Organization

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[2] https://www.caul.edu.au/programs-projects/enabling-modern-curriculum/oer-collective

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References	Aimed to ensure diversity in references (this may be easier in some disciplines than others)	NA
References	Less formal, in-text mentions of specific researchers or studies have been made as diverse as possible	NA

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We hope that by being transparent on our current books, we can begin the process of making sure accessibility is top of mind for all authors, adopters, students and contributors of all kinds on all our open-text projects. As such, we welcome any feedback from students, instructors or others who encounter the book and identify an issue that needs resolving.

[4] https://d3bxy9euw4e147.cloudfront.net/oscms-prod/media/documents/OpenStax_Representation_and_Diversity_Development_Guidelines.pdf

[5] https://d3bxy9euw4e147.cloudfront.net/oscms-prod/media/documents/OpenStax_Representation_and_Diversity_Development_Guidelines.pdf; https://www.rice.edu/

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Accessibility checklist

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1. International research collaboration during the pandemic: Team formation, challenges, strategies and achievements of the African Translational Research Group (ATReG)

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Background

This paper discusses team formation, operational challenges, strategies, achievements, and dynamics in the implementation of research for the coronavirus disease-2019 (COVID-19), by the African Translational Research Group (ATReG), as well as the lessons learnt and future opportunities for global collaborative research.

Methods

In-depth virtual interviews were conducted with consenting members of ATReG. Questions were designed to provide rich, deep, and insightful subjective opinions, and lived experiences and perspectives of the group members on formation, challenges, and strategies and achievements. Data was transcribed and analysed thematically, and the results were presented with important quotations cited.

Findings

The ATReG consisted of English (n=13) and French (n=1) speaking sub-Saharan African (SSA) researchers who specialise in public health, epidemiology, optometry, information technology, supply chain management, psychiatry, community health, general medical practice, nutrition and biostatistics. Most members reported the informal but well-coordinated structure of the group. Formed during the pandemic, all meetings were held online, and some members have never met each other in person. The group collected data from Africans and published ten peer reviewed articles on COVID-19, presented in international conferences and were awarded a national competitive funding in Nigeria which contributed to career progressions and promotions of the members. There have been numerous challenges in sustaining the collaboration and maintaining productivity including meeting deadlines and obtaining funding for research activities. However, these challenges have been addressed through a collaborative problem-solving approach. The need for operational and methodological flexibility, central coordination and funding sources are essential for the group sustainability.

Conclusion

The ATReG's objective of providing useful data on COVID-19 in SSA was achieved. In such a multi-disciplinary collaborative team, the experiences and challenges can be a model for researchers intending future collaborative groups. There remain numerous important areas for research which the ATReG will continue to pursue.

Keywords: *Multidisciplinary; Research collaboration; COVID-19 pandemic; Sub-Sahara Africa*

Introduction

In April of 2020 as the COVID-19 pandemic raged, five public health researchers of African heritage agreed to collaboratively undertake timely translational public health research concerning COVID-19 in African countries. Two members of the

group have affiliation to an Australian University public health department, while three members were affiliated to various public health and medical departments at South African and Nigerian universities. Within a period of eight months, the international research collaboration grew by invitation to a membership of 14 African researchers working in various universities and research institutions spanning Australia, Cameroun, Ghana, Kenya, Nigeria, Saudi Arabia, South Africa, Tanzania, and the United Kingdom. The group adopted the name 'African Translational Research Group (ATReG)'.

The consensus goal of this international, multicultural, multi-lingual and multidisciplinary collaborative research team was to: work as a collaborative group of African researchers by bringing in expertise from their various disciplines, resources and knowledge of their country's culture and language with respect to research and data collection, in mitigating the effects of the pandemic particularly in African countries. The team sought to provide evidence-based information that could be used to drive decision-making and health policy thereby, reducing the impact of the pandemic and its control measures. It also sought to undertake knowledge exchange activities between African researchers in the Diaspora and those in the African countries based on the peculiarities found in the different settings. The pandemic was a great opportunity for such cross-sector partnership which have been shown to help create and deliver value in response to health emergencies, like the COVID-19 pandemic, and in turn help with adaptive learning (Arslan, Golgeci, Khan, Al-Tabbaa, & Hurmelinna-Laukkanen, 2020; Vervoort, Ma, & Luc, 2021). A review of the emergency response in the United States demonstrated that the involvement of stakeholders where partnerships for resources, expertise and knowledge are built between state and non-state actors from different sectors, but functioning in a non-hierarchical manner, produced better outcomes. (Demiroz, Fatih & Kapucu, Naim. 2015; Yu Z, Xu, & Yu, L, 2022).

Furthermore, this collaborative team could drive empirical research from an African perspective and report on the outcomes of such research in a range of academic and non-academic outlets such as international journals, conferences, health policy outlets, and the general media. ATReG also aimed to engage with public health and COVID-19 policymakers. In doing so, the team sought to achieve its aim of translating research findings to be of use to academicians, laypersons and policy makers in making decisions towards control of the epidemic. This aligns with the goal of translation research to "translate (move) basic science discoveries more quickly and efficiently into practice". It does this by promoting multidisciplinary collaboration, incorporating the desires of the public and identifying and supporting adoption of best medical and health practices (Rubio et al 2010; Li & Yu, 2022). The formation of the team, the challenges it overcame and the recorded achievements were significant and timely giving the ongoing global challenges of the pandemic, particularly in sub-Saharan African (SSA) countries. In a health policy article that explored multilateral collaboration between countries during infectious disease outbreaks, the authors (Jit et al., 2021) suggested that responding to future global infectious disease threats and other health emergencies will require the creation of stronger mechanisms for multilateral collaboration before they arise(Jit et al., 2021). This should be done through cooperation agreements driven by major research funders and harmonising research findings to avoid duplication.

Overview synthesis of the literature on international research collaboration

Research collaboration between individuals, groups, departments, institutions, regions, and countries is a growing activity that has attracted the attention of researchers from several fields including those in natural sciences, medicine, communication technology, and software engineering (Fry, Cai, Zhang, & Wagner, 2020; Kwiek, 2021). With a diverse expansion of the literature on research collaboration, there have been several studies in this domain (Bozeman & Boardman, 2014; Kwiek, 2021). Previous publications have identified several clusters of research collaborations, ranging from inter-individual research collaboration (Nyström, Karltun, Keller, & Andersson Gäre, 2018) to inter-departmental and inter-institutional collaborations(Hedges et al., 2021). Driven by increasing global economic competition and rapid technological changes, more countries consider cross-country collaboration in science and technology a critical way to foster and maintain global innovation and economic competitiveness (Glänzel, 2001). A country with more cross-country collaborative linkages is able to leverage the domestic capabilities and exploit foreign investments in research and development (R&D) and commercialisation opportunities(Wagner, 2009). Thus, international research collaboration is perceived as a dominant driving force for promoting scientific and technological advancement(Wang, Rodan, Fruin, & Xu, 2014), industrial innovation, and economic growth(Sharma & Thomas, 2008). Furthermore, in scientific and technological research domains, the growing scale of research projects and complexity, particularly in projects that are set up to address important global challenges (e.g., COVID-19, energy crisis and climate change), are often beyond the capabilities of individual countries, hence significant interest in international research collaboration activities is necessary (D'ippolito & Rüling, 2019). The literature on international research collaboration is on a steady increase, while some studies have examined the factors that trigger cross- country research collaboration (Plotnikova & Rake, 2014), others have explored international research collaboration in higher education (Milman, 2021; Taras et al., 2013), its structures and team dynamics (Bagshaw, Lepp, & Zorn, 2007; Garg & Padhi, 2001). It is also important to understand who researchers choose to collaborate with (Iglič, Doreian, Kronegger, & Ferligoj, 2017) including industry or university research collaborations (Mascarenhas, Ferreira, & Marques, 2018), as well as the effects of such international research collaborations (Ernberg, 2019). The dramatic growth of international research collaborative studies in recent times, makes this paper necessary and conducive to a nuanced understanding of our particular research domain, the difficult context of the pandemic in which this collaboration was hastily formed, and how trust was developed very quickly resulting in several successful research outcomes (Berger, Doherty, Rudol, & Wzorek, 2021; Yu, Shen, & Khazanchi, 2021; Zakaria & Yusof, 2020). The unique characteristics of the inter-individual international research collaboration make this study different from that of other domestic research collaborations. A robust understanding of the field of international research collaboration in any discipline is necessary. The geographic, linguistic, political, cultural distances or gaps are more significant than those in other kinds of research collaboration (Chen, Zhang, & Fu, 2019; Cheng et al., 2016; Fu & Li, 2016). Moreover, the capabilities and motivations

for international research collaboration may affect the patterns, effects, and outcomes of international research collaboration. Such differences are pronounced when research collaboration expands to individual researchers in several countries across Africa, UK, and Australia. Therefore, the patterns, team dynamics, processes and effects of such inter-individual international research collaboration demonstrates unique features that are yet to be analysed in other international research collaboration studies. To fill this research gap, a case study was conducted based on collaborative team processes and dynamics in the implementation of COVID-19 related empirical research in sub-Saharan African (SSA) countries during the lockdowns that were enforced in many African countries, as well as lessons learnt that could be adopted by researchers seeking to collaborate anywhere in the world.

Methodology and interview analysis strategies

Interview guide and consent

The interview guide was developed by an independent researcher – an expert in qualitative research who was not a member of the group at the time. The guide was based on the information provided on the activities of the group. This was reviewed and pre-tested before the actual interview was conducted. A written and/or verbal informed consent was obtained from participating members before the commencement of the interview, basic biographical data of the members was asked followed by questions focused on the composition, strategies, success stories and achievements of the groups, as well as the challenges and recommendations. Approval for this study was obtained from the Humanities and Social Sciences Research Ethics Committee (approval#: HSSREC 00002504/2021) of the University of KwaZulu-Natal, Durban, South Africa. The study adhered to the principles of the 1967 Helsinki declaration (as modified in Fortaleza 2013) for research involving human subjects. The confidentiality of participant responses was assured, and anonymity maintained.

Samples and interview

The narration of the team formation, working strategies, achievements and lessons from this international research collaboration was obtained through an in-depth interview conducted among members of ATReG. The members were in nine different countries namely, Australia, Cameroon, Ghana, Kenya, Nigeria, Saudi Arabia, South Africa, United Kingdom and Tanzania. All members of the group except for one who declined interview were purposively sampled in this research. The interviews were conducted virtually either via Zoom video conferencing applications or scheduled telephone calls, depending on member's preference, and at a convenient time for the respective respondents. With the consent of the respondent, the interviews were audio-recorded, and notes taken by a note taker. In total, 13 interviews were conducted; each interview lasted about an hour thirty minutes to two hours.

Data analysis

A thematic analysis of the data was conducted in six phases as suggested by Braun & Clarke (2006). Phase 1 was the familiarization with the data where the recording was listened to by two independent researchers and thereafter, the interviews were transcribed verbatim using the Otter.ai transcription application and complemented manually using both the tape recordings and the notes taken during the interview. The

transcripts were read thoroughly and comprehensively to generate initial codes (phase 2) and subsequently, themes and subthemes were generated using the inductive and deductive approaches (phase 3) (Elo & Kyngäs, 2008). The sub-themes were reviewed for accurate representation and checked to ensure they fit the main themes and objective of the study. Those that did not fit, were eventually discarded before the final analysis (phase 4). The final themes and sub-themes were labelled, and the data analysed using Excel (phase 5). Finally, the results were produced, and the reports presented using the various themes and important quotes (phase 6).

Findings

Characteristics of the Research Team

In total, 13 interviews were conducted, one member declined to participate for lack of time, resulting in a response rate of 92.9%. Each interview lasted about an hour 30 minutes to 2 hours. The respondents were aged between 39 and 62 years, mostly men (10, 76.9%), majority were from English speaking countries in SSA (11, 84.6%), had postgraduate qualifications in various fields (Figure 1) and two were full Professors, one in health-related specialty (Optometry) and the other in computer science.

Analysis of the interview transcripts revealed three main themes, which are shown in Table 1: (1) membership/group composition and roles (2) organisational structure and coordination/strategies and (3) success stories, achievements and challenges related to international research collaborations on Africa during the pandemic.

Thematic responses

Table 1 shows the different themes and sub-themes that emerged from the interview. At the time of this study, the group had published 10 peer reviewed jounal articles in respected public health outlets. The group also published two policy articles in the Australian and African editions of the Conversation. Also, ATReG made presentations at two separate international conferences. The group also published translated research in three newspaper articles, one in Ghana and two in Nigeria and successfully obtained a highly competitive research grant award from the Nigerian Tertiary Education Trust Fund (TETFUND). According to the respondents, the social factors responsible for the research successes of ATReG included strong social relationships and ties between members, mutual tolerance and mutual respect, having a team ethos, a strong central coordinator, and strong trust in each other's ability.

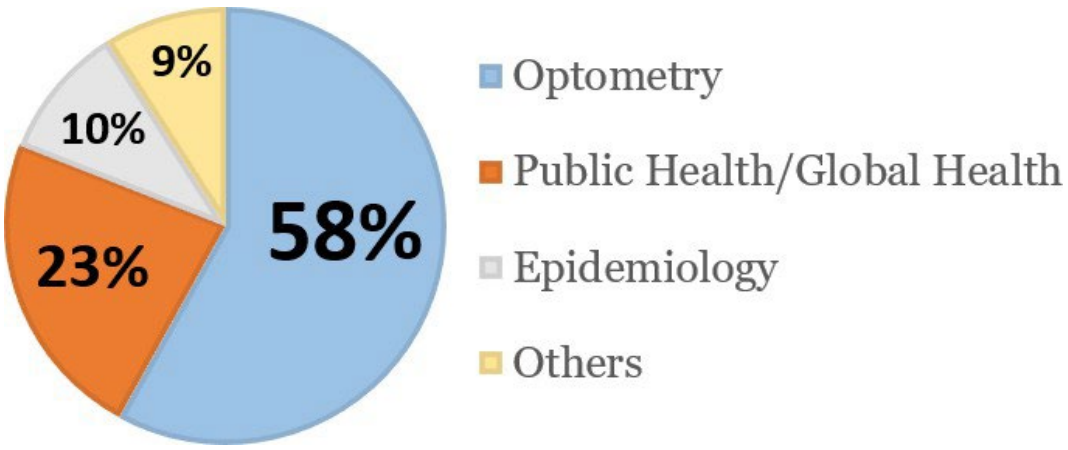

Figure 1. Areas of specializations of the research group members. The categories included computer science, human nutrition, supply chain management, psychiatry.

Table 1. Analysis of responses of group members by the themes and sub-themes that emerged from the interview.

Themes	Sub-Themes	Results	Participants Quotes
Composition/ organization/ roles	Membership What constituted membership? Organization structure/ coordination Roles in the group	Majority of the members joined the group by invitation from someone known to them in the group. This was closely followed by those who were contacted by a member because of their research background. For the majority, being an African researcher was what constituted membership, but others said there was no criteria for being a member because people were either invited by their friends or recommended by someone else. All the members agreed there was no formal structure but there was some form of informal structure. A member of the group mostly coordinated the activities of the group with some assistance from others. Majority said there were no specific roles but that they were assigned roles based on needs. There were a few specific roles like those of statistical analysis.	So there was a need to expand and reach out to other African countries, I was invited by my teacher It was my head of department that recommended my name for that team But the initial idea was to try and drive research from an African perspective Research for Africa, for Africans, in Africa and by Africa Constituents of very high intellectual people at different level The person who initiated this group, has done a tremendous job in coordinating and leading Yes there are no specific roles, but depending, particularly statistical aspect of it, and the interpretation of those statistical responses It's based on your strengths, because we are always asked what can you do
Success stories/ achievements	Achievements Reasons for the achievements	Most members considered the biggest achievement of the group to be the number of publications within a short period and also the successful collaboration in the group. A few others considered the group biggest achievement as the grant received while other members indicated that career progression and promotion as a result of the activities of the group was the biggest achievement When asked about the factors responsible for the achievements in the group, the majority said it was because of the high level of commitment from the members while a significant number said the simplicity of the members was the reason for the achievement. This was followed by those who said the manner of communication, which is perceived to be good, prompt and respectful was the reason for the achievement that was recorded in the group.	Publication that we've had and actually opening up the way to interregional, intercontinental inter-country research I think, is that ability to bring people from different backgrounds, people from different categories. Being able to put in a proposal that attracted some research funds. Commitment, the people know what they are about, focus, and they are ready to work. Their simplicity, their hard work, they are focused on what we were to achieve There's good communication
Challenges and recommendations	Challenges Recommendations	Lack of funding was the biggest challenge mentioned by the majority of the members as a draw back for the group. A few other members said the lack of a formal organizational structure and the meeting times, which was usually Saturdays, was a challenge because it was not convenient but they had to attend due to their commitment to the group while others saw the focus of the group on one research area without diversification as a draw back. Most members recommended a formal structure should be put in place moving forward to help with the coordination of the activities. Identifying a funding source was also mentioned by most members as what they would recommend moving forward or what they would do differently if they have to set up a group like this in the future.	We have challenges in terms of funding, I think going forward, it's important that we look at, you know, the support of institutions. I think what I see is that we are limited to certain types of research, for now we have not been diversified as that, but we also need to be diversified. There should be some sort of formal structure, even if it's not as formal as is done in other groups, there has to be structures, Structure going forward, Yeah I would want to have funding before I start, we need to identify source of income for publications

Discussion

The working principles and several achievements of the group were identified and reported under three important themes. The themes, which included, group composition and working strategies, successes and achievements of the group, the group's challenges and future recommendations moving forward, are discussed below.

Group composition and working strategies

Group members are from different SSA countries and were invited to join the group either by someone known to them who was already in the group or through referral from a member of their institution who was not part of the group, because of their research background. Members included researchers, clinicians or programme officers and spoke mainly English and French, which connotes the concept of collaboration that describes the involvement of people from different contexts and experiences or perspectives coming together for a purpose (Nyström et al., 2018).

Inter-individual collaborative research is becoming popular amongst scholars with advancement in information and communication technology and globalisation in research agenda (Carayol & Roux, 2007). Inter-individual collaborative research is also growing to increase research productivity and attract higher numbers of citations (Katz & Martin, 1997). Coordination is often needed in collaborative research to ensure smooth running, commitment, and performance by the diverse partners (Bansal et al., 2019). Different collaborating groups adopt different approaches such as having a formal structure or an informal structure like the type presented in this study. ATReG was set up without a formal organisational structure but has effectively functioned with successes through an informal coordination by one of the conveners of the group. The coordination mechanisms used were frequent online meetings, WhatsApp messaging, emails, and phone calls. On the contrary, Nyström et al. (2018) found that projects were more successful if they use more coordination mechanisms compared to those that use fewer coordinating mechanisms.

Depending on the approach chosen in research collaboration, partners can be involved from the stage of the design, data collection, analysis, report, or manuscript writing to the final dissemination. Roles were mostly assigned to members based their area of strength and voluntariness. There are no permanent roles in the collaborating team except for a couple of scholars with aptitude for and skills in statistical analysis. There was however active and collective participation by members of the group from conceptualization of topics, research design, to the design of data collection instruments, actual data collection, analysis and reporting through a rigorous review process during their regular meetings. This approach has also been successful in other international collaborations involving researchers from diverse cultures who were at different career stages in North American, European, Middle Eastern, and East Asian universities (Dusdal & Powell, 2021). Numerous factors influence collaborative research, and they are usually driven by funding organizations. The group was established on the premise of wanting to promote collaborative research in Africa by Africans and this was captured in a respondent's statement; *"But the initial idea was to try and drive research from an African perspective", "It is a Research, for Africa, in Africa and by Africans".*

Success stories/ achievements

Although the initial objective of the group was to conduct research with the focus on COVID-19, this later expanded to other research areas. The group achieved successes by the numerous peer reviewed publications, including COVID-19 myths in Sub Saharan Africa (Osuagwu et al., 2021; Ovenseri-Ogbomo et al., 2020) which was part of a World Health Organization sponsored series, Risk perception of COVID-19 among SSA (Abu et al., 2021), and compliance to public health practices during the pandemic (Nwaeze et al., 2021) within the eighteen months period; and successful award of a competitive national grant from the Federal Government of Nigeria. These were considered as the greatest achievements by many in the group because both the grant and the publications have accelerated their career progression and academic promotion to higher levels. It has also elevated their research, academic and professional careers profiles above those of their peers. Some members reported that they got promoted to Associate Professorship and others mentioned that they were assigned higher responsibilities, and became more visible in their institutions and other professional groups as a result of the publications and conference presentations. The social relationships formed, and networking opportunities were also viewed as more valuable achievements of the collaborative team than the publications and grants by some members, considering that the group was formed during the COVID-19 lockdown, a period of increased isolation and loneliness (Wu, 2020).

As documented by other research collaboration teams, successful international research collaboration is the result of synergy and commitment among diverse partners, where every partner is willing to work and contribute positively to the group, in addition to the effective coordination of the group's activities (Cummings & Kiesler, 2005). The most reported motivation in this collaborative research were the groups' diverse competencies, level of commitment, simplicity, respect for one another and hard work. Good communication is an important concern raised in inter- cultural/inter-country and inter-disciplinary collaborative research, and in this study, participants appreciated the good communication and high level of respect. They considered these to be motivating factors for their active involvement and high performance.

Challenges and recommendations

Figure 2 presents a summary of the challenges of ATreG. Although the research collaboration was among Africans for African health and COVID-19 policymakers, there were some challenges posed by the differences in time zones since some members of ATReG were residing outside of Africa at the time of the collaboration, which made virtual meetings, the most convenient option. Even though the meeting times were not convenient for some members, they made regular sacrifices to attend the meetings due to the commitment. With diverse membership and multiple activities, it was expected that bottlenecks and challenges would be encountered. Respondents felt research activities were tasking and meeting deadlines were overwhelming. The process of designing and writing manuscripts and grant proposals were perceived as time consuming and challenging as was also noted in another study (Martin, 2010).

Some other challenges that were reported by members which are peculiar to most collaborating groups were financial

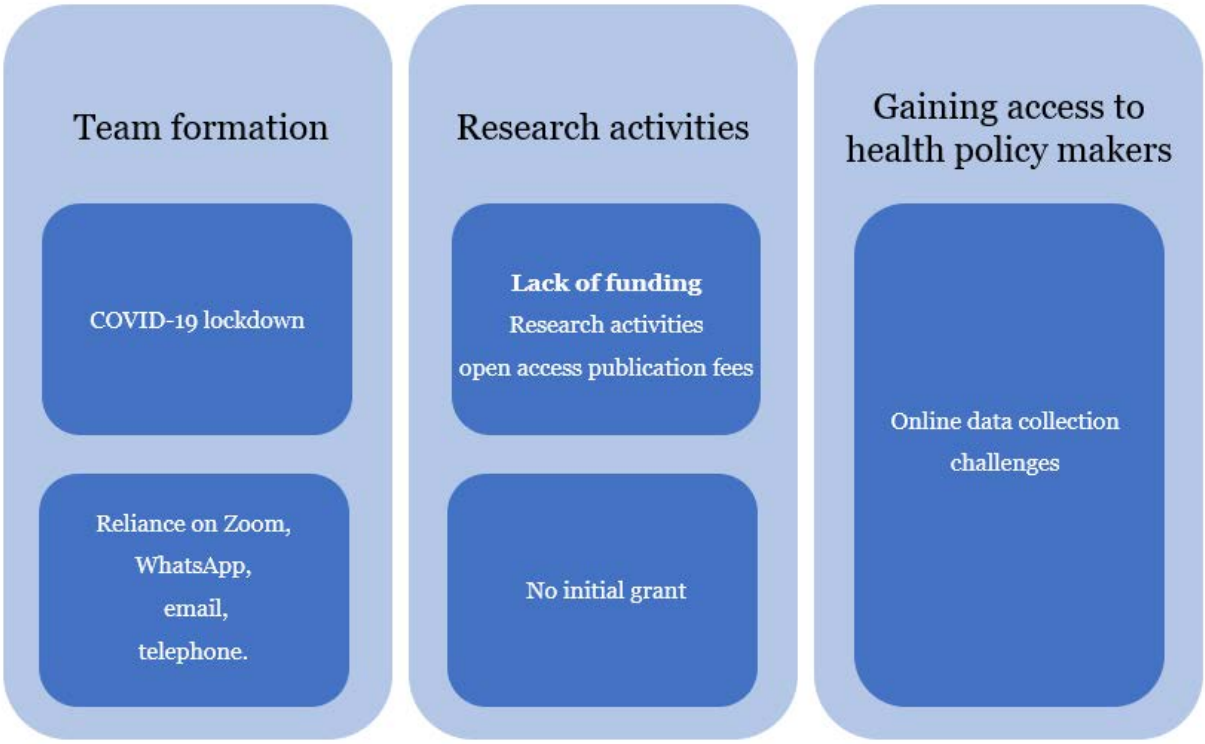

Figure 2. *Challenges to team formation and research activities.*

constrains in funding research activities, and a lack of formal structure. There were also issues with payment of open access publication fees which the respondents thought could be overcome by identifying a funding source subsequently for future activities and sustainability of the group. Although the group has managed well without a formal structure or source of funding, respondents felt there is a need for a formal coordinating structure believing it will help achieve better productivity and ease up the workload on few individuals especially as the scope and mandate of the group is expanding.

Conclusions

This study revealed that international inter-disciplinary health research collaboration among African researchers during the pandemic could result in great achievements in publications and contribute to career progression and academic promotion for its members, even though they never met in person. There were challenges with data collection, which were mostly done online, as well as the intermittent financial challenges in funding research activities and publications. Collaborative research is a model for researchers and a critical way to foster and maintain global innovation and research successes, particularly around public health. However, there is the paramount need to have a central coordination to drive projects, frequently pull all team members together while ensuring that team members are working collectively and cohesively as a team through intensive and effective communications and coordination with team members online. Furthermore, there were lessons that emerged from the complexity of the context of the collaboration. These include the transnational, transcultural nature, and subsequent reliance on online tools such as Zoom and WhatsApp for communications, over the period, and the collaboration of researchers at different career stages (senior scholars, mid-career researchers (MCR) and early career researchers (ECR)) and in different part of the globe with

researchers based in African institutions who speak French and/or English language with no conflict, grievance or group breakdown. The collaboration also involved knowledge exchange between researcher's resident in Africa and those in the diaspora through presentations and discussions during meetings. Learning from the successes and challenges in such a large cross-cultural collaborative team can be replicated any researcher in any discipline at any level of career and experience. We reported on the need to develop swift trust of team members even when one hardly knows the other and the fact that all team members need to take on a mature, tolerant, and respectful stance towards others, their opinions, and perspectives.

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2. Knowledge, Attitudes, and Perception of COVID-19 Among Health Care and Non-Health Care Workers in Sub-Sahara Africa: A Web-based Survey

Running title: Health and Non-health workers' COVID-19 related KAP

Abstract

Due to the current COVID-19 pandemic and associated high mortality in Sub-Saharan Africa (SSA), there is panic amongst healthcare workers (HCWs) because of the higher risk of being infected. This study compared knowledge, attitude and perception (KAP) towards COVID-19 between HCWs and non- healthcare care workers (NHCWs) and examined common associated factors. A web-based cross-sectional study on 1871 participants (HCWs=430, NHCWs=1441) was conducted over a period when lockdown measures were in place in the four SSA regions. Data were obtained using a validated self-administered questionnaire disseminated through an online survey platform. KAP mean scores were calculated and summarized using t-test for NHCWs and HCWs. Multivariate linear regression analyses was conducted to assess the unadjusted (B) and adjusted coefficients (β) at 95% confidence interval (CI). The mean KAP scores were slightly higher among HCWs than non-HCWs, but not statistically significant. Worried about COVID-19 was the only common factor associated with KAP between the two groups. Knowledge of COVID-19 was associated with attitude and perception between the two groups. Other significant factors associated with KAP were: the SSA region, age 29-38 years (β= 0.32, 95%CI: 0.04, 0.60 for knowledge in NHCWs), education, (β = -0.43, 95%CI -0.81, -0.04 and β= -0.95, 95%CI -1.69, -0.22, for knowledge in NHCWs and HCWs, respectively), practice of self-isolation (β=0.71, 95%CI 0.41, 1.02 for attitude in NHCWs and HCWs (β= 0.97, 95%CI 0.45, 1.49), and home quarantine due to COVID-19, in both groups. Policymakers and health care providers should consider these factors when targeting interventions during COVID-19 and other future pandemics.

Keywords: frontline workers, COVID-19, pandemic, lockdown, knowledge, risk perception.

Introduction

The global population is threatened by the raging pandemic caused by novel coronavirus disease (COVID-19), which started in Hubei Province of the People's Republic of China in 2019.[1-4] The disease spreads among humans through respiratory droplets of symptomatic and asymptomatic patients,[5] with the classic respiratory symptoms of fever, cough and fatigue.[6-11] As at 4th August 2020, the Africa Centre of Disease Control (CDC), confirmed over 17.9m cases of COVID-19 and over 687,011 deaths across the African regions, with Southern Africa reporting the highest burden of the infection and Central Africa reporting the least.[12] Like most developed countries, many countries in SSA are now in the second and third epidemic phases,[12] suggesting the need to strengthen the public health control measures put in place by SSA government to contain the spread of the outbreak.

To mitigate the impact of the disease, the respective SSA governments implemented various recommended public health strategies such as bans on public gatherings, travel bans, social distancing, use of facemasks and others.[2, 13-15] However, compliance with these measures were variable, largely dictated by economic and other factors.[16] With no antiviral treatment or vaccine recommended explicitly for COVID-19 at the time,[17, 18] management of severe hospitalized cases consisted of ensuring appropriate infection control and supportive care.[14] A confused comprehension of an emerging disease combined with inadequate expert knowledge can lead to fear and chaos, further aggravating the pandemic.[19] Past experience with outbreaks such as SARS and Ebola showed that misconceptions and excessive panic in the public led to the resistance to comply with suggested preventive measures and contributed to the rapid spread of the diseases.[20, 21] These experiences underscore the vital role of engaging with both healthcare and non-healthcare professionals and the importance of monitoring their knowledge and compliance with the pandemic control measures.

In sub-Saharan Africa, the people's perception of their health is rated among the lowest in the world. This may be connected with the low prioritization of health and health care by the respective governments in the four regions.[22] According to WHO (2012), improving health care services delivery and disease control in Africa goes beyond increased financing and policy but also encompasses community perceptions and perspectives. As active players in the pandemic response, the healthcare worker is extremely strained.[1, 23-26] Since COVID-19 is caused by a novel coronavirus, there is a dearth of accurate information available to healthcare workers and non-healthcare alike. Level of knowledge has a direct effect on an individual's perception of susceptibility to disease and compliance with preventive protocols that could result in delayed treatment and a rapid spread of infection.[27-29] Hence, it is crucial to understand people's attitude, their perceived risk of contracting the disease

and compliance towards to mitigation practices to effectively communicate and frame key messages in response to the emerging disease.[30]

Country-specific studies on knowledge, attitude and perception (KAP) of COVID-19 control measures among the general population[31-35] and among HCWs[17, 36-39] have been reported within and outside Africa. However, no study has compared the KAP of COVID-19 among HCWs and NHCWs in SSA. Understanding related factors affecting and influencing people's decision to undertake precautionary behaviour may help decision-makers respond appropriately to promote individual or community health in a pandemic situation. Comparing knowledge, attitude and risk perception between HCWs and NHCWs will also help to tailor health education messages to each specific group rather than a generic message that does not consider the difference between the two groups of people. Therefore, the aim of this study was to assess the differences in KAP scores as well as compliance with COVID-19 public health control measures, between HCWs and NHCWs in SSA, and to determine the common associated factors.

Materials and Methods

From 18th April to 16th May 2020 corresponding to the lockdown period in the four SSA regions, this web-based cross-sectional survey was conducted among respondents from Cameroon (Central Africa), Ghana, Nigeria (Western Africa), Kenya, Tanzania (East Africa) and South Africa (Southern Africa). All of these countries have reported cases of COVID-19 in the recent pandemic, according to the World Health Organization (WHO). The survey was only available in English language and an e-link of the questionnaire was posted on social media platforms (Facebook and WhatsApp) which were commonly used by the locals in the participating countries, and was sent via emails by the researchers to broaden the scope of the survey. Participants in the survey received no incentives.

Sample size determination

The survey assumed a proportion of 50% because there was no previous studies on from SSA that has examined factors associated with 2019-nCoV in HCW and NHCWs, with 95% confidence and 2.5% margin of error. Using an online calculator, we assumed a sample size of approximately 1921, including 20% non-response rate. However, 1871 (97.4%) participants responded to the desired questions.

Consent and Ethical Consideration

The participants responded with a 'yes' or 'no' to a question designed to obtain voluntary online consent to express their willingness to attend the study via survey monkey. Human Research Ethics Committee of the Cross-River State Ministry of Health in Nigeria (Human ethics approval number: CRSMOH/HRP/HREC/2020/117) approved this study. The study adhered to the tenets of the Declaration of Helsinki. To participate in this study, respondents had to be 18 years and above. Participation was voluntary and anonymous.

Questionnaire

The survey tool for the COVID-19 knowledge questionnaire was developed

based on the guidelines from the World Health Organization (WHO) for clinical and community management of COVID-19[40]. The questionnaire was adapted with some modifications to suit this study's objective namely to explore the knowledge of healthcare and non- healthcare workers about the nature and origin of COVID-19 and their attitude and perception towards the mitigation strategies to control the spread of the novel coronavirus.

Prior to the launching of the survey, a pilot study was conducted to ensure clarity and understanding and to determine the duration for completing the questionnaire. Participants (n=10) who took part in the pilot were not part of the research team and did not participate in the final survey as well. This was a self-administered 58-item questionnaire divided into four sections (A) demographic characteristics (B) knowledge (C) attitude and (D) risk perception. Demographic variables included age, gender, marital status, education, employment, occupation, the number living in the household, and religion.

Dependent variables

The three dependent variables were knowledge, attitude towards COVID-19 and risk perception for contracting the disease, which were taken as continuous variables. Twelve items on the questionnaire assessed the respondent's knowledge of COVID- 19, most of which required a 'yes' or 'no' response. Each question used a binary scale. The score for each ranged from 'yes' (score '1') to 'no' (score '0'). The knowledge score ranged from 0–12 points and these items have been shown to have an acceptable internal consistency[41]. The survey tool for the COVID-19 knowledge questionnaire was developed based on the guidelines from the World Health Organization[42] for clinical and community management of COVID-19. There were 15 items in the survey (each used a Likert scale with five levels) that assessed perception of risk for contracting COVID-19. The scores for each item ranged from 0 (lowest) to 4 (highest). The risk perception score ranged from 0–60 points and the Cronbach's alpha coefficients of the items were 0.74 indicating satisfactory internal consistency. The COVID-19 attitude items included "whether they have gone to any crowded place such as religious events?" "if they wore a mask when leaving home?", and "if in recent days, they have been washing their hands with soap for at least 20 seconds each time". Each question used a Likert scale with five levels with scores for each item ranging from 0 (lowest) to 4 (highest). The total scores ranged from 0-24 points, and the Cronbach's alpha coefficient of attitude items was an average of 0.73, indicating acceptable internal consistency.

Independent variables

The independent variables were as follows: The demographic characteristics included age, country of origin, country of residence, sex, religion, educational, marital and occupational status, number of people living together in the household. Attitude towards COVID-19 included compliance to mitigation practices to minimize the spread of the virus such as, domestic self-isolation and quarantine measures. The risk perception variables included questions on, how they felt about the quarantine, whether participants think they were at risk of becoming infected, at risk of dying from the infection, if they were worried about contracting COVID-19, and participants' feeling towards self-isolation (Table 1). Questions on knowledge and attitude towards COVID-19 were included when each variable was not the dependent variable in the analysis.

Table 1. Demographic Characteristics and Knowledge, Attitude, and Risk Perception Scores Among HCWs and Non-HCWs in Sub-Saharan Africa

Variables			Knowledge		Attitude		Perception	
	Non-HCW n	HCW n	Non-HCW Mean (SD)	HCW Mean (SD)	Non-HCW Mean (SD)	HCW Mean (SD)	Non-HCW Mean (SD)	HCW Mean (SD)
Demographic characteristics								
Region	1441	430	7.20(2.18)	7.16(2.25)	13.64(5.25)	13.80(5.14)	20.56(7.81)	21.27(7.92)
West Africa	788	280	7.14(2.27)	7.21(2.13)	13.16(5.24)	13.49(5.00)	20.36(7.90)	21.59(7.68)
East Africa	164	37	7.09(2.32)	6.73(2.78)	13.97(5.63)	13.38(6.07)	20.73(8.07)	19.78(9.57)
Central Africa	191	48	7.31(2.22)	7.33(2.33)	14.35(5.72)	15.21(5.11)	20.41(8.28)	21.23(8.59)
Southern Africa	298	65	7.34(1.81)	7.08(2.36)	14.28(4.62)	14.37(6.09)	21.11(7.11)	20.80(7.48)
Age category (years)	1433	428	7.26(2.10)**	7.20(2.21)	13.76(5.13)**	13.82(5.10)	20.75(7.62)*	21.29(7.84)
18 to 28	561	175	7.01(2.42)	7.13(2.40)	13.25(5.58)	13.60(5.63)	19.95(8.15)	20.54(8.15)
29 to 38	391	109	7.44(1.87)	7.26(2.07)	14.16(4.97)	14.61(4.24)	20.99(7.26)	22.83(6.78)
39 to 48	310	91	7.34(1.97)	7.14(2.26)	13.69(5.08)	13.29(5.13)	21.27(7.58)	20.56(8.37)
49+	171	53	7.50(1.51)	7.38(1.75)	14.63(3.74)	13.87(4.74)	21.91(6.35)	21.89(7.60)
Sex	1434	429	7.25(2.11)	7.20(2.21)	13.73(5.15)	13.84(5.09)	20.72(7.64)	21.27(7.85)
Male	788	240	7.29(2.09)	7.30(2.04)	13.76(4.85)	13.80(4.48)	21.03(7.40)	21.41(7.48)
Female	646	189	7.21(2.13)	7.07(2.41)	13.70(5.50)	13.88(5.41)	20.35(7.92)	21.10(8.31)
Marital status	1438	429	7.25(2.11)*	7.20(2.21)	13.74(5.15)	13.83(5.09)	20.74(7.65)	21.30(7.84)
Married	636	186	7.40(1.85)	7.30(1.96)	13.96(4.90)	13.87(4.71)	21.05(7.28)	21.43(7.39)
Not married	802	243	7.13(2.29)	7.12(2.38)	13.56(5.34)	13.80(5.38)	20.49(7.93)	21.21(8.18)
Highest level of education	1439	430	7.26(2.09)	7.20(2.21)	13.76(5.12)	13.83(5.09)	20.77(7.61)	21.28(7.84)
Postgraduate degree (master's/PhD)	487	118	7.46(1.72)***	7.50*(1.56)	14.14(4.53)*	14.79(3.71)	21.16(6.74)**	22.19(6.60)*
Bachelor's degree	763	248	7.28(2.08)	7.20(2.23)	13.76(5.15)	13.65(5.22)	20.99(7.70)	21.38(7.90)
Secondary/primary	189	64	6.66(2.81)	6.64(2.92)	12.77(6.12)	12.80(6.41)	18.84(8.99)	19.19(9.34)
Employment status	1442	430	7.25(2.12)*	7.20(2.21)	13.73(5.15)	13.83(5.09)	20.72(7.66)	21.28(7.84)
Employed	957	275	7.33(2.00)	7.29(2.02)	13.98(5.01)	14.04(4.68)	20.92(7.44)	21.68(7.53)
Unemployed	485	155	7.09(2.32)	7.03(2.50)	13.24(5.40)	13.47(5.75)	20.34(8.07)	20.57(8.36)
Religion	1437	430	7.25(2.11)	7.20(2.21)	13.74(5.14)	13.83(5.09)	20.75(7.64)	21.28(7.84)
Christianity	1267	385	7.26(2.09)	7.23(2.19)	13.75(5.14)	13.95(5.06)	20.73(7.66)	21.22(7.77)
Others	170	45	7.17(2.25)	6.96(2.34)	13.74(5.14)	12.82(5.28)	20.88(7.47)	21.76(8.53)
Do you live alone during COVID-19?	1439	429	7.25(2.10)	7.20(2.21)	13.76(5.13)	13.83(5.09)	20.72(7.63)	21.28(7.85)
No	1168	355	7.29(2.06)	7.19(2.19)	13.79(5.05)	13.74(5.13)	20.76(7.53)	21.06(7.72)
Yes	271	74	7.10(2.30)	7.22(2.32)	13.62(5.46)	14.22(4.91)	20.56(8.05)	22.30(8.43)
Number living together in 1 household	1313	362	7.20(2.19)	7.15(2.32)	13.70(5.25)	13.68(5.22)	20.67(7.77)	21.06(7.97)
<3	375	110	7.18(2.25)	7.24(2.24)	13.51(5.25)	14.02(5.07)	20.66(7.68)	21.17(7.54)
4 to 6	663	200	7.17(2.19)	7.08(2.44)	13.77(5.30)	13.38(5.30)	20.54(7.79)	20.95(8.58)
6+	275	52	7.31(2.11)	7.29(1.99)	13.80(5.16)	14.12(5.29)	21.00(7.86)	21.25(6.40)
Attitude toward COVID-19								
Self-isolation	1300	388	7.76(0.92)	7.76(1.01)	15.33(2.51)***	15.36(2.46)***	22.63(4.81)	23.28(4.92)
No	899	267	7.76(0.91)	7.74(1.07)	14.98(2.41)	14.93(2.28)	22.62(4.65)	23.13(5.02)
Yes	401	121	7.77(0.93)	7.79(0.86)	16.11(2.56)	16.33(2.58)	22.66(5.16)	23.62(4.70)
Home quarantined due to COVID-19	1298	387	7.76(0.92)	7.75(1.00)	15.34(2.49)***	15.39(2.43)***	22.63(4.81)	23.28(4.93)
No	794	233	7.78(0.96)	7.75(1.02)	14.92(2.40)	14.90(2.25)	22.56(4.73)	23.33(5.03)
Yes	504	154	7.74(0.84)	7.75(0.97)	16.02(2.48)	16.12(2.51)	22.75(4.95)	23.21(4.77)
Risk perception								
How worried are you because of COVID-19?	1471	433	7.20(2.19)***	7.17(2.24)***	13.64(5.26)***	13.81(5.13)***	20.56(7.80)***	21.26(7.90)***
Very worried	410	127	7.70(0.84)	7.80(0.84)	15.49(2.88)	15.49(2.71)	25.93(4.39)	26.29(4.10)
Somehow worried	496	140	7.84(0.93)	7.66(1.19)	14.66(3.19)	14.46(3.64)	20.38(3.37)	20.66(3.50)
Not at all	565	166	6.27(3.13)	6.28(3.17)	11.41(6.99)	11.98(6.79)	16.81(9.98)	17.92(10.45)
Feeling about self-isolation								
Bored	1181	359	7.19(2.23)	7.15(2.23)	13.59(5.29)	13.88(5.11)	20.53(7.88)	21.27(7.98)
No	343	112	7.22(2.23)	7.10(2.33)	13.71(5.26)	13.59(5.43)	20.72(7.69)	20.63(8.39)
Yes	838	247	7.18(2.24)	7.18(2.19)	13.54(5.31)	14.02(4.96)	20.45(7.95)	21.57(7.78)
Frustrated	1165	350	7.18(2.25)	7.15(2.25)	13.60(5.34)	13.89(5.16)	20.50(7.96)	21.30(8.05)
No	550	187	7.24(2.16)	7.14(2.17)	13.68(5.23)	13.94(5.08)	20.58(7.77)	20.88(7.84)
Yes	615	163	7.13(2.33)	7.15(2.35)	13.53(5.45)	13.85(5.25)	20.42(8.12)	21.79(8.27)
Angry	1128	334	7.20(2.23)	7.19(2.21)	13.59(5.32)	13.93(5.15)	20.47(7.90)	21.36(8.03)
No	862	279	7.20(2.23)	7.19(2.25)	13.57(5.32)	13.96(5.17)	20.54(7.94)	21.33(7.98)
Yes	266	55	7.18(2.23)	7.22(1.99)	13.65(5.34)	13.73(5.10)	20.25(7.78)	21.51(8.38)
Anxious	1153	353	7.19(2.22)	7.16(2.25)	13.57(5.33)	13.91(5.15)	20.49(7.93)	21.31(8.02)
No	480	134	7.33(2.04)	6.99(2.30)	13.85(4.98)	13.34(5.54)	20.85(7.42)	20.54(8.45)
Yes	673	219	7.10(2.34)	7.26(2.21)	13.37 (5.57)	14.26(4.87)	20.22(8.27)	21.79(7.74)

Note: P values are paired t test results of comparison of variables within groups. *P<.05, **P<.005, ***P<.0005.
Abbreviations: HCW, healthcare worker; non-HCWs, non-healthcare workers; SD, standard deviation.

Data analysis

Data analysis was performed using Stata version 14.1 (Stata Corp. College Station United States of America). KAP by independent variables were summarized using t-test for two categorical groups and one-way analysis of variance (ANOVA) for more than two categorical groups.

Univariate linear regression analyses were conducted to assess the unadjusted coefficients (B) with 95% confidence intervals among HCWs and NHCWs. The adjusted coefficients (β) with 95% confidence intervals obtained from the multiple linear regression model were used to measure the factors associated with KAP among HCWs and non-HCWs.

For the multiple linear regression a nalyses, a four-staged modelling technique was conducted. In the first stage (Model 1) included regions and demographic factors and manual process backward stepwise elimination process was conducted and those with P< 0.05 were retained. The factors associated in Model 1 were added to Model 2, which was attitude towards COVID-19. The variables would influence action to reduce the spread of the infection and this was then followed by similar backward stepwise elimination procedure. The significant factors retained in Model 2 were included in Model 3, which was feeling about isolation during COVID - 19 lockdown. This was because they would help in identifying individuals who could develop mental health issue during the lockdown. Manual process backward stepwise elimination process identified the associated factors in Model 3. The fourth and final model included addition of knowledge and attitude scores to Model 3, which were added because knowledge is strongly related to attitude and practice while knowledge and attitude has been reported to be associated with practice[43].

Results

Figure 1 presents the mean scores and their 95% confidence intervals for KAP among respondents who were NHCWs and HCWs. The mean score for knowledge (7.2 out of 12 points) and *attitudes* (13.7 out of 24 points) of *COVID–19* were relatively high with low risk perception (20.7 out of 60 points) for contracting the disease. In figure 1, there was no significant difference between both groups for KAP scores.

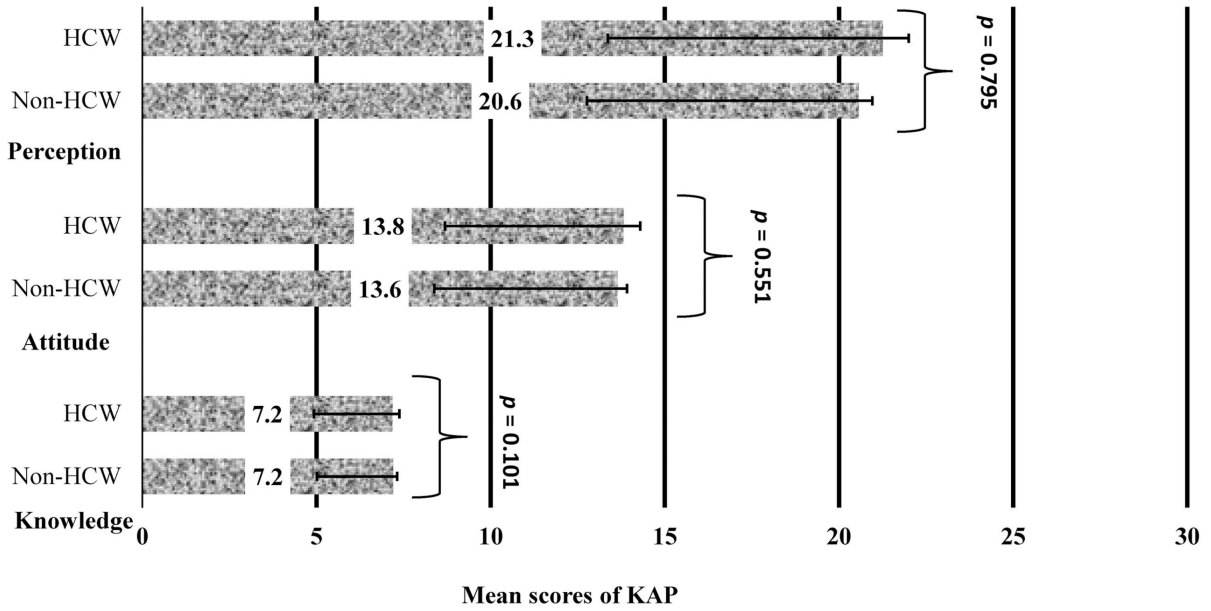

Figure 1. *Mean scores for knowledge, attitudes, and perceptions of COVID-19 among HCWs and non-HCWs in sub-Saharan Africa. Error bars are standard deviations. P values are results of comparison between both groups. Abbreviations: HCW, healthcare worker; KAP, knowledge, attitudes, and perceptions; non-HCW, non- healthcare worker.*

Descriptive statistics

Majority of the respondents were NHCWs (77.0%, mostly teachers, managers and administrators; Supplementary Table S1) and 23.0% were HCWs. The breakdown of the responses are shown in Table 1 including the results of comparative analysis for the mean KAP scores. Most of the participants were single, men, aged between 18 and 38 years old, were from West Africa, and had completed University education or its equivalent, at the time of this study. 66.4% of HCWs and 64.0% of NHCWs were employed. About 40% of NHCWs and HCWs stated they voluntarily quarantined themselves during the lockdown period. Regarding their concern on the spread of the 2019-nCoV virus, about 62% of NHCWs and HCWs were worried about contracting the infection.

There were significant differences in mean scores between the age groups for NHCWs and between educational status, worried about contracting the infection, practised self-isolation and self-quarantined during the lockdown in both HCWs and NHCWs (see Table 1 for details).

Unadjusted coefficients of COVID-19 related knowledge, attitude and perception of risk of contracting the infection

The unadjusted coefficient for factors associated with COVID-19 related knowledge, attitude and perception are presented in the Supplementary material (S2). Among HCWs and NHCWs, older age was significantly associated with all three-outcomes. In HCWs and NHCWs, Southern and Central Africans had significantly higher attitude scores, those with secondary/primary education, not worried about contracting the infection reported a lower attitude scores. NHCWs who were unemployed had lower knowledge and attitude scores. In HCWs and NHCWs, knowledge and attitude were significantly associated with risk perception (see S2 for further details).

Factors associated with KAP during COVID-19 among HCWs and NHCWs

Table 2 shows the factors associated with KAP of COVID-19 in HCWs and NHCWs, after adjusting for the potential cofounders. Region of origin (Southern and Central Africa), age group (29-38 years) were significantly associated with high knowledge but lower education (primary/secondary) and not worried about COVID-19 were associated with low knowledge of COVID-19 among NHCWs. For HCWs, lower education (primary/secondary) and not worried about COVID-19, were associated with low knowledge of COVID-19. Compared to Western Africans, HCWs and non-HCWs from other SSA regions reported higher attitude scores towards COVID-19 (Table 2). Other factors associated with positive attitude towards COVID-19 mitigation practices were practice of self-isolation among NHCWs (β= 0.71, 95%CI 0.41, 1.02) and HCWs (β= 0.97, 95%CI 0.45, 1.49), self-quarantine among NHCWs (β= 0.83, 95%CI 0.54, 1.12) and HCWs (β= 1.01, 95%CI 0.51, 1.50) during the lockdown. High knowledge scores were associated with positive attitude for NHCWs (β=0.26, 95%CI 0.12, 0.41) and HCWs (β= 0.34, 95%CI 0.11, 0.57). Negative attitude towards COVID-19 mitigation practices was observed among HCWs who completed Bachelor education (β= -0.56, 95%CI -1.08, -0.03) and those and those who expressed some worry about contracting the infection (β= -0.58, 95%CI -1.13, -0.02).

There were significant associations between risk perception and knowledge of COVID-19 (β= 1.28, 95%CI 1.13, 1.43 for NHCWs and β= 0.96, 95%CI 0.65, 1.27 for HCWs) and attitude (β=0.61, 95CI 0.55, 0.67 for NHCWs). Those who were either somewhat worried or not worried at all had a lower risk perception of contracting the infection. NHCWs from Central Africa (β= -0.94, 95%CI -1.67, -0.20) had a lower risk perception than West Africans.

Table 2. Factors Associated with Knowledge, Attitudes, and Perceptions of COVID-19 Among HCWs and Non-HCWs

Variables	Knowledge		Attitude		Perception	
	Non-HCW *β*(95% CI)	HCW *β* (95% CI)	Non-HCW *β* (95% CI)	HCW *β* (95% CI)	Non-HCW *β*(95% CI)	HCW *β*(95% CI)
Demographic characteristics						
Region (West Africa)	Reference		Reference	Reference	Reference	
East Africa	.06 (-0.28 to 0.39)		1.05 (0.63 to 1.47)	.92 (0.09 to 1.76)	-.44 (-1.22 to 0.35)	
Central Africa	.36 (0.04 to 0.67)		1.36 (0.96 to 1.75)	1.61 (0.88 to 2.34)	-.94 (-1.67 to -0.20)	
Southern Africa	.32 (0.06 to 0.59)		.51 (0.18 to 0.84)	1.00 (0.37 to 1.64)	-.48 (-1.10 to 0.14)	
Age category in years (18 to 28 years)	Reference					
29 to 38	.32 (0.04 to 0.60)					
39 to 48	.13 (-0.19 to 0.44)					
49+	.31 (-0.08 to 0.69)					
Highest level of education (postgraduate degree)	Reference	Reference		Reference		
Bachelor's degree	-.02 (-0.28 to 0.23)	-.38 (-0.90 to 0.13)		-.56 (-1.08 to -0.03)		
Secondary/primary	-.43 (-0.81 to -0.04)	-.95 (-1.69 to -0.22)		-.42 (-1.18 to 0.34)		
Attitude toward COVID-19						
Self-isolation (No)			Reference	Reference		
Yes			.71 (0.41 to 1.02)	.97 (0.45 to 1.49)		
Home quarantined due to COVID-19 (No)			Reference	Reference		
Yes			.83 (0.54 to 1.12)	1.01 (0.51 to 1.50)		
Risk perception						
How worried are you about COVID-19? (Very worried)	Reference	Reference	Reference	Reference	Reference	Reference
Somehow worried	.18 (-0.08 to 0.44)	-.18 (-0.76 to 0.40)	-.65 (-0.96 to -0.33)	-.58 (-1.13 to -0.02)	-5.29 (-5.91 to -4.67)	-4.76 (-5.95 to -3.58)
Not at all	-1.27 (-1.53 to -1.01)	-1.43 (-1.98 to -0.88)	-.35 (-0.68 to-0.03)	.04 (-0.51 to 0.60)	-4.86 (-5.49 to -4.23)	-4.39 (-5.58 to -3.20)
Feeling about self-isolation						
Frustrated (No)		Reference				
Yes		-.00 (-0.45 to 0.45)				
Knowledge score †			.26 (0.12 to 0.41)	.34 (0.11 to 0.57)	1.28 (1.13 to 1.43)	.96 (0.65 to 1.27)
Attitude score †					.61 (0.55 to 0.67)	

†=continuous variable. Bolded are significant variables.
Abbreviations: CI, confidence interval; HCW, healthcare workers; non-HCWs, non-healthcare workers.

Discussion

The study found comparable KAP scores among NHCWs and HCWs in SSA. However, the SSA region of origin, age of respondents, level of education, and how worried they were about contracting COVID-19, were associated with knowledge of COVID-19 among NHCWs. On the other hand, level of education, worry about COVID-19 and feeling of frustration about self-isolation were associated with knowledge of COVID-19 among HCWs. There was a significant association between positive attitude towards COVID-19 practices and the SSA region of origin, practice of self-isolation and home quarantine as well as knowledge of COVID-19, among HCWs and NHCWs. In addition, lower risk perception for contracting COVID-19 was reported among NHCWs who lived in Central Africa and among HCWs and NHCWs who were somewhat worried or not worried about contracting COVID-19. Past studies showed that the overall incidence of the COVID-19 pandemic was disproportionately higher among HCWs than the general population[44]. Inadequate training for HCWs on the control measures for this novel respiratory borne infectious disease has been cited for the increased risk among HCWs[45]. Following the initiation of emergency responses, HCWs found it difficult to make time for systematic training and practice, leaving them with a lack of relevant knowledge about the disease. This may have contributed to the lack of significant difference in the overall KAP scores between HCWs and NHCWs in this study. Although, it is expected that HCWs would exhibit better knowledge about the disease than NHCWs, no study has provided a statistical comparison of knowledge scores between the groups. A web-based descriptive study of university hospital staff including healthcare workers and administrative staff, in northern Italy, found an overall good knowledge on 2019-nCoV control measures in both groups (71.6% for HCWs and 61.2% for administrative staff), and noted the need to promote effective control measures and correct preventive behaviours at the individual level[46]. In other studies, greater knowledge of COVID-19 by HCWs correlated with their greater confidence to fight the pandemic[37, 47] and their more positive attitudes[48]. The participants in this study (HCWs and NHCWs) responded to the same questionnaire. However, in another study where different questionnaires were administered to the HCWs and the general public, similar scores for knowledge and perception was found between the groups[36], but there was a difference in their knowledge of COVID-19 treatment. The predominant sources of information differed between the groups, and the study did not assess their sources of information.

In this study, we found significant association between the knowledge of COVID-19 and being worried about contracting COVID-19, after adjusting for the confounding variables. HCWs and NHCWs who were not worried about contracting the infection, had lower knowledge of COVID-19 compared to those who were very worried about the disease. This finding suggests that, although HCWs may be knowledgeable about the disease, they may not be protected from the mental health effects, which are now being documented among health workers due to the pandemic[4, 49, 50]. It may actually be a risk factor as they have information about the disease but are not favourably disposed to the measures that need to be put in place to prevent the spread of the disease[51]. This was seen in the SARs outbreak where HCWs were found to have increased emotional distress that was associated with quarantine and isolation, among other factors[52].

NHCWs who lived in Central and Southern African countries showed higher knowledge scores than those from the West African countries. This finding is consistent with a cross-sectional study carried out in five health communities in a Central African country (Cameroon) which showed that 65.7% of respondents had high knowledge[53]. In this study, positive attitude towards COVID-19 was also associated with living in the East, Central and Southern African regions for NHCWs, which was similar to the high KAP scores found among community drivers who participated in an online cross sectional study conducted in Uganda in East Africa during the COVID-19 pandemic[54]. Our findings of higher risk perception scores among West African respondents than the others, was supported by the findings of high risk perception of COVID-19 among Ghanaian adults, who participated in an electronic based cross-sectional survey[55].

Another finding of this study was the more positive attitude towards COVID-19 practices reported by HCWs who lived in the East, Central and Southern African countries. This is consistent with the positive attitude towards COVID-19 prevention practices found among HCWs in Uganda East Africa[39]. Similar findings of positive attitude has been reported in Nigeria, West Africa, with some unacceptable practices in wearing of facemask during the COVID-19 pandemic among the HCWs[56]. SSA is a mix of persons of different tribes, cultures and beliefs and racial disparities in attitude towards COVID-19 have been documented[57]. During the Ebola epidemic in 2015 that swept the region, negative attitude was observed among West Africans, and this was influenced by misconceptions and perceived changes to culture. These same factors may be at play here in this current pandemic. The fact that educational background was consistently associated with lower attitude scores towards COVID-19 and other health matters[57-60] has implications for control measures, as behavioural change health communication should be designed to target those with lower levels of education in the SSA population.

In this study, educational background was significantly associated with the KAP scores among NHCWs possibly, because HCWs were already the well-educated group in this study due to the requirements of their profession. As shown in the socio-demographics only 3.4% of the HCWs had less than a bachelor's degree, hence significant differences would not be visible here. Additionally, NHCWs who practiced self-quarantine during the lockdown had more positive attitude than the HCWs. Unlike the public, many health workers were expected to report at their work stations during the pandemic hence may not self-quarantine unless asked to do so from exposure at the workplace and may result in them having a poorer attitude. NHCWs who were unemployed had poor attitude towards COVID-19 practices which may reflect the existing inequities in the labour market and the chronic stress and uncertainty created by unemployment that are believed to have been exacerbated by the COVID-19 pandemic.[61, 60]

Worry is an affective, emotional response to a threat and can predict protective behaviours and attitudes independent of the risk severity[62]. Social isolation and loneliness are linked to both poor mental and physical health, such that isolation brings about feelings of anxiety, worry and depression. We found that being worried about contracting the infection led to poor attitude towards the public health measures put in place to contain the spread of the disease, among HCWs and NHCWs. There

were significant associations between knowledge about COVID-19 and the perception of high risk for contracting the infection among both HCWs and NHCWs in this study. Similar to a previous study[63], NHCWs who felt at risk of being infected by the disease showed positive attitude towards the preventive measures. A study on HCWs[64] also found that despite the high positive attitude of the respondents, their risk perception for susceptibility to contracting the disease was also high. This may be explained by to the report that HCWs were afraid of infecting their family members, stigmatized, lacked the necessary *personal protective* equipment, had to deal with a public that is not committed to the preventive measures coupled with the poor ventilation and overcrowding at the workplace[64].

This study has some limitations. The cross-sectional design of this study made it impossible to determine causation. Given the inability to physically access respondents due to the pandemic, the survey tool was sent out to prospective respondents electronically using social media platforms and emails. This method of soliciting respondents may have inadvertently excluded some potential participants whose opinion may have differed, such as those who without internet access, and people living in rural areas where internet penetration remains relatively low[65]. However, the use of an internet-based methodology was the only reliable means to disseminate information at the time of this study. Furthermore, the survey was presented in the English language and those from non-English speaking countries in SSA may not have participated. Notwithstanding these limitations, this was the first study from the SSA region to provide insight into the factors that influence KAP among NHCWs and HCWs as well as information about compliance with the public health control measures in this pandemic. The study used a robust analysis to control for potential confounders during the analysis in order to reduce the issue of bias.

Conclusion

In summary, although there was no significant difference in KAP among HCWs and non-HCWs, the study showed essential elements of variation between HCWs and non- HCWs. HCWs who felt frustrated about self-isolation during the lockdown period had significantly higher COVID-19 related knowledge than non-HCWs. For non-HCWs, employment status was associated with the level of COVID-19 related knowledge but this association was not observed among HCWs. The level of knowledge and attitude towards COVID-19 played significant roles in the respondents' perceived risk of COVID-19 transmission. The findings of this study, indicate the importance of strengthening public health knowledge of workers in SSA towards COVID-19. Priority should be given to HCWs and unemployed non-HCWs. This approach would change the response of the target group to public health control measure and ultimately may lead to containment of the pandemic.

Notes

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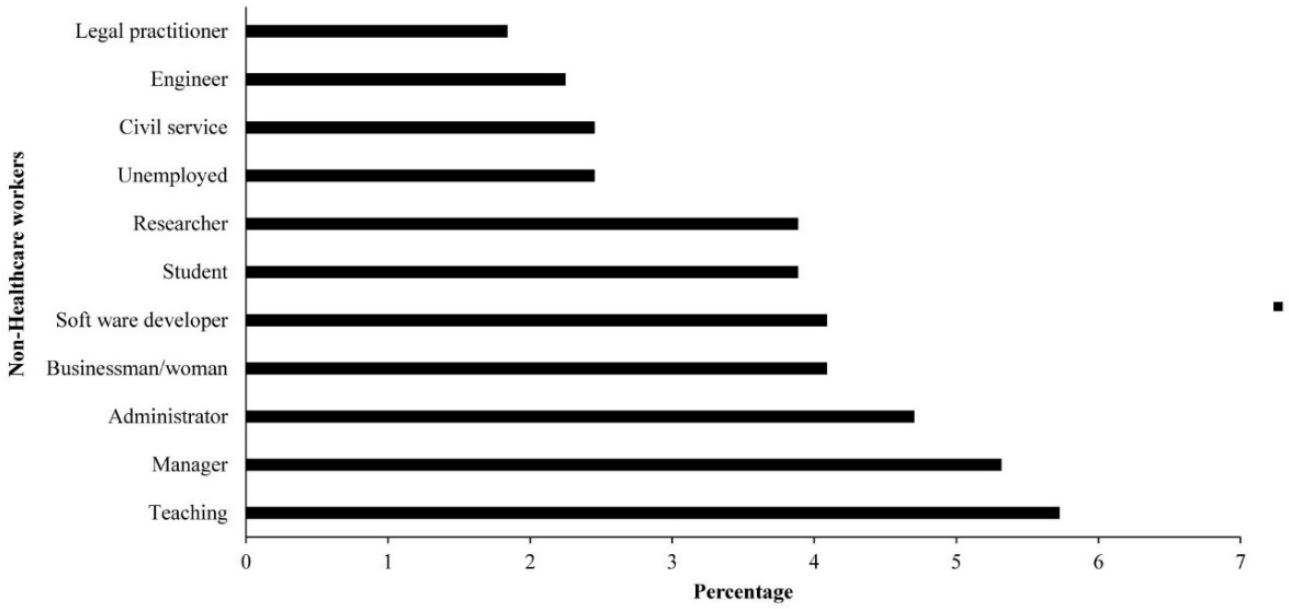
Supplementary Materials

§ S1. Breakdown of the non-Healthcare workers' by Profession (n=489). The rest of the participants in this group reported other professions (n=244, 49.9%)



S2.Unadjusted coefficients (B) and their 95% confidence intervals (CI) for knowledge, attitude and perception of risk for contracting COVID-19 in Sub-Saharan Africa.

Variables	Knowledge		Attitude		Perception	
	NHCW	HCW	NHCW	HCW	NHCW	HCW
Demography	B (95%CI)	B (95%CI)	B (95%CI)	B (95%CI)	B (95%CI)	B (95%CI)
Region (West Africa)	**Reference**	**Reference**	**Reference**	**Reference**	**Reference**	**Reference**
East Africa	-0.05 [-0.42, 0.31]	-0.48 [-1.25, 0.29]	0.81 [-0.07, 1.69]	-0.11 [-1.87, 1.65]	0.37 [-0.94, 1.69]	-1.80 [-4.53, 0.93]
Central Africa	0.18 [-0.17, 0.52]	0.12 [-0.57, 0.81]	1.18 [0.35, 2.01]	1.72 [0.15, 3.30]	0.05[-1.19, 1.29]	-0.36 [-2.79, 2.08]
Southern Africa	0.20 [-0.09, 0.49]	-0.13 [-0.74, -0.47]	1.11 [0.41, 1.81]	0.88 [-0.50, 2.27]	0.75 [-0.29, 1.80]	-0.79 [-2.93, 1.36]
Age category (18 – 28 years)	**Reference**	**Reference**	**Reference**	**Reference**	**Reference**	**Reference**
29-38	0.43 [0.16, 0.70]	0.13 [-0.41, 0.66]	0.91 [0.25, 1.57]	1.01 [-0.21, 2.24]	1.04 [0.06, 2.02]	2.30 [0.43, 4.17]
39-48	0.32 [0.03, 0.61]	0.01 [-0.55, 0.57]	0.42 [-0.27, 1.15]	-0.31 [-0.61, 0.98]	1.33 [0.27, 2.38]	0.02 [-1.96, 2.01]
49+years	0.48 [0.13, 0.84]	0.25 [-0.44, 0.93]	1.38 [0.50, 2.25]	0.27 [-1.30, 1.83]	1.96 [0.66, 3.26]	1.35 [-1.06, 3.76]
Sex (Males)	**Reference**	**Reference**	**Reference**	**Reference**	**Reference**	**Reference**
Females	-0.08 [-0.30, 0.14]	-0.23 [-0.65, 0.20]	-0.06 [-0.60, 0.47]	0.07 [-0.90, 1.05]	0.68 [-1.47, 0.12]	-0.31 [-1.82, 1.19]
Marital Status (Married)	**Reference**	**Reference**	**Reference**	**Reference**	**Reference**	**Reference**
Not married	-0.27 [-0.49, -0.05]	-0.18 [-0.60, 0.25]	-0.40 [-0.93, 0.14]	-0.07 [-1.04, 0.91]	-0.56 [-1.36, 0.23]	-0.22 [-1.73, 1.28]
Highest level of Education (Masters /PhD)	**Reference**	**Reference**	**Reference**	**Reference**	**Reference**	**Reference**
Bachelor's degree	-0.18 [-0.42, 0.55]	-0.30 [-0.78, 0.18]	-0.38 [-0.96, 0.20]	-1.14 [-2.25, -0.03]	-0.17 [-1.03, 0.69]	-0.81 [-2.53, 0.90]
Secondary/Primary	-0.81 [-1.16, -0.45]	-0.86 [-1.53, -0.19]	-1.37 [-2.23, -0.52]	-1.99 [-3.53, -0.45]	-2.32 [-3.60,-1.05]	-3.01 [-5.39, -0.63]
Employment status (Employed)	**Reference**	**Reference**	**Reference**	**Reference**	**Reference**	**Reference**
Unemployed	-0.24 [-0.47, -0.004]	-0.26 [-0.69, 0.18]	-0.74 [-1.30, -0.18]	-0.57 [-1.57, 0.44]	-0.57 [-1.41, 0.26]'	-1.11 [-2.66, 0.43]
Religion (Christianity)	**Reference**	**Reference**	**Reference**	**Reference**	**Reference**	**Reference**
Others	-0.09 [-0.43, 0.24]	-0.27 [-0.95, 0.41]	-0.00 [-0.83, 0.82	-1.13 [-2.70, 0.45]	0.15 [-1.08, 1.37]	0.53 [-1.90, 2.96]
Household factors						

[#] S2. Continued

Variables	Knowledge		Attitude		Perception	
	NHCW	HCW	NHCW	HCW	NHCW	HCW
Do you live alone during COVID-19 (No)	**Reference**	**Reference**	**Reference**	**Reference**	**Reference**	**Reference**
Yes	-0.19 [-0.46, 0.09]	0.02 [-0.53, 0.57]	-0.16 [-0.84, 0.51]	0.47 [-0.81, 1.75]	-0.19 [-1.20, 0.82]	1.23 [-0.74, 3.20]
Number living together (<3 people)	**Reference**	**Reference**	**Reference**	**Reference**	**Reference**	**Reference**
4-6 people	-0.02 [-0.29, 0.26]	-0.16 [-0.70, 0.38]	0.26 [-0.40, 0.93]	-0.64 [-1.86, 0.58]	-0.12 [-1.10, 0.87]	-0.22 [-2.09, 1.64]'
6+ people	0.13 [-0.22, 0.47]	0.05 [-0.72, 0.82]	0.29 [-0.53, 1.11]	0.10 [-1.63, 1.83]	0.34 [-0.87, 1.55]	0.08 [-2.57, 2.72]
Attitude towards COVID-19						
Self-Isolation (No)	**Reference**	**Reference**	**Reference**	**Reference**	**Reference**	**Reference**
Yes	0.01 [-0.10, 0.12]	0.06 [-0.16, 0.27]	1.13 [0.84, 1.41]	1.41 [0.89, 1.92]	0.04 [-0.53, 0.60]	0.49 [-0.57, 1.55]
Home quarantined due to COVID-19 (No)	**Reference**	**Reference**	**Reference**	**Reference**	**Reference**	**Reference**
Yes	-0.04 [-0.14, 0.07]	0.01 [-0.20, 0.21]	1.10 [0.83, 1.37]	1.23 [0.75, 1.71]	0.18 [-0.35, 0.72]	-0.13 [-1.13, 0.88]
Risk Perception						
Worried about COVID-19 (Very worried)	**Reference**	**Reference**	**Reference**	**Reference**	**Reference**	**Reference**
Somehow worried	0.13 [-0.14, 0.40]	-0.14 [-0.65, 0.37]	-0.82 [-1.47, -0.18]	-1.02 [-2.21, 0.16]	-5.55 [-6.45, -4.65]'	-5.63 [-7.35, -3.92]'
Not at all	-1.43 [-0.17, -1.17]	-1.52 [-2.01, -1.02]	-4.07 [-4.71, -3.44]	-3.51 [-4.64, -2.37]	-9.12 [-9.99, -8.24]	-8.38 [-10.03, -6.72]
Feeling about self-isolation						
Bored (No)	**Reference**	**Reference**	**Reference**	**Reference**	**Reference**	**Reference**
Yes	-0.03 [-0.31, 0.25]	0.08 [-0.42, 0.58]	-0.18 [-0.84, 0.49]	0.43 [-0.72, 1.57]	-0.27 [-1.26, 0.72]	0.94 [-0.84, 2.73]
Frustrated (No)	**Reference**	**Reference**	**Reference**	**Reference**	**Reference**	**Reference**
Yes	-0.11 [-0.37, 0.15]	0.00 [-0.47, 0.48]	-0.15 [-0.77, 0.47]	-0.09 [-1.18, 1.00]	-0.16 [-1.07, 0.76]	0.91 [-0.78, 2.61]
Angry (No)	**Reference**	**Reference**	**Reference**	**Reference**	**Reference**	**Reference**
Yes	-0.02 [-0.33, 0.28]	0.03 [-0.61, 0.67]	0.08 [-0.65, 0.81]	-0.24 [-1.73, 1.26]	-0.29 [-1.38, 0.80]	0.18 [-2.15, 2.52]
Anxious (No)	**Reference**	**Reference**	**Reference**	**Reference**	**Reference**	**Reference**
Yes	-0.22 [-0.48, 0.37]	0.28 [-0.20, 0.76]	-0.47 [-1.10, 0.15]	0.92 [-0.19, 2.03]	-0.63 [-1.56, 0.30]	1.25 [-0.48, 2.98]
Knowledge score†	-	-	-	-	2.40 [2.27, 2.54]	2.32 [2.07, 2.57]
Attitude score†	-	-	-	-	1.05 [0.99, 1.10]	1.11 [1.01, 1.21]
†=continuous variable. HCW=Health care workers; Non-HCWs =non-healthcare workers						

Version of Record (VoR)

Ekpenyong, B., Abu, E. K., Langsi, R., Osuagwu, U. L., Oloruntoba, R., Ovenseri-Ogbomo, G. O., ... Agho, K. E. (2022). Public awareness and perception towards COVID-19 in sub-saharan African countries during the lockdown. Health Promotion Perspectives, 12(2), 200-211. https://doi.org/10.34172/hpp.2022.25

3. Public awareness and perception towards COVID-19 in Sub-Saharan African countries during the lockdown

Abstract

Introduction: The COVID-19 outbreak has caused a universal health crisis resulting in significant morbidities and mortalities particularly among high-risk groups. This study sought to determine regional factors associated with knowledge and attitude towards COVID-19 mitigation practices and risk perception (KAP) of contracting the disease in Sub-Saharan African (SSA) countries.

Methodology: A cross-sectional anonymous online study was conducted among 1970 participants between April and May 2020, during the lockdown in many SSA countries. Recruitment of participants was via WhatsApp, Facebook and emails using authors' networks. The outcome variables were KAP of COVID-19 and analysis of variance (ANOVA) with post hoc test was run to assess the level of KAP by four regions in SSA. Simple and multiple linear regression (MLR) analyses were performed to examine factors associated with the outcome measures in the four SSA regions.

Results: Mean knowledge (*P*= 0.707) and risk perception (*P*= 0.904) scores by four regions in SSA did not differ significantly. However, the mean attitude score was higher among West Africans compared with Southern (*P*= 0.019) and Central Africans (*P*= 0.003). MLR analysis revealed that among those living in West (adjusted coefficient β =-0.83 95%CI: -1.19, -0.48) and Southern Africa (β = -0.91 95%CI: -1.42, -0.40), having a primary or secondary education was associated with a decrease in knowledge scores while not being worried about COVID-19 decreased risk perception scores across the four SSA regions(West [β = –6.57, 95%CI: –7.53, –5.62], East [β = -6.24: 95%CI -8.34,-4.15], Central [β = -6.51 95%CI-8.70, -4.31], and Southern Africa [β =-6.06: 95%CI -7.51, -4.60]). Except among Southern Africans, participants who practiced self-isolation had positive attitude towards COVID-19.

Conclusion: Future research on health education regarding COVID-19 or a future related pandemic in SSA should target people with lower education, those who don't self-isolate, those living in Southern and Western Africa and not worried about contracting COVID-19.

Key words: Coronavirus; Africa; pandemic; awareness; risk perception; attitude.

Running Title: Public awareness and perception towards COVID-19

Introduction

Upon the emergence of the Coronavirus disease (COVID-19), there has been severe disruptions to both human and economic activities across the world.[1] Several mitigation measures and guidelines to limit the spread of the virus were put in place by governments.[2-4] With COVID-19 vaccines being rolled out globally,[5,6] some of these restrictive practices have been relaxed including the resumption of international travels.[7] There are also fears that some countries may be confronted with new COVID-19 waves.[8] Case fatality rate for COVID-19 varies across countries, and is currently less than 3% globally, with Africa having a case fatality rate of 2.31%.[9]

The low incidence of COVID-19 case severity and mortality in Africa has been attributed to the co-existence of malaria in this region.[10] A recent systematic review[10] found a low incidence of COVID-19 in malaria-endemic regions supporting the suggestion that COVID-19 poor prognosis may be prevented by malaria. Although Africa appeared to have been spared by the infection partly due to its relatively young population (more than 60% are under the age of 25), recent increases in numbers of COVID-19 deaths, were the highest rate of increase in all WHO regions,[9] occurring in South Africa, Ethiopia, and in Kenya[9] heightening concerns already expressed by scientists[11] in the midst of a weakened health care system.[12] This calls for increased regional surveillance as the region cannot cope with the extra burden from the pandemic.

Since the outbreak of the COVID-19 pandemic, scientists, researchers, and health professionals across the globe with varied expertise have carried out surveys on knowledge, attitudes and practice (KAP) amongst the general population.[13-19] While some studies have focused on knowledge and perceptions of health workers on COVID-19,[14,18,20,21] others have focused on African countries,[15,16,22,23] and one study included a limited number of countries (South Africa, Kenya, and Nigeria).[5] Kaura and Gupta found that awareness of the pandemic was high across the countries studied with 94% of all respondents being aware of the current outbreak, while 34% perceived it as a global infection.

Previous studies[15,16,22,23] that have examined COVID -19 in Africa, particularly in SSA countries only established some basic concepts about knowledge and perception levels on the pandemic in single countries. In addition, some studies[20,21] considered only non-health care workers, and their conclusions may not be generalized to the wider SSA population. Understanding the knowledge, attitude and risk perception on a wider regional scale is important in guiding government policies geared towards reinforcing COVID-19 preventive measures. It also encourages best practices amongst the general SSA population as well as amongst healthcare workers. This study also investigated lifestyle modifications as a result of the pandemic. The findings of this study will help bridge the research gap from previous studies by including seven African countries representing the four regions of Africa, south of the Sahara.

Materials and Methods

A cross-sectional survey was carried out during the lockdown period using a Survey monkey in seven African countries with reported COVID-19 cases. The study population consisted of Sub-Saharan Africans who were 18 years and older. The seven countries included Nigeria, Ghana, Cameroon, Kenya, Tanzania, Uganda, and South Africa. An e-link to a self-administered online survey was disseminated via emails, Facebook and WhatsApp, which were frequently used by the residents within the participating countries. As noted previously,[24-26] online surveys can be administered at a lower cost and higher speed than other forms of interviews, they are more interactive, visual, flexible and do not require that interviewers be present. In addition, people who are busy and would systematically disregard partaking in telephone surveys are willing to answer questions when posted on their computer screens.[27] This was considered the best option to obtain this important information during the lockdown period, where face to face interview was not possible. Participants were allowed a one-month period to complete the survey. Participation was completely voluntary and there were no special incentives or inducements made available to participants by the researchers. Participation was open to only Africans of age 18 years and older, living in or outside of Africa.

Dependent or outcome variables

This validated self-administered online questionnaire survey tool was initially developed and utilized for similar COVID-19 studies in the past.[14-16,28] The questionnaire was based on the World Health Organization guidelines for clinical and community management of COVID-19.[29] Participants were tested using 58 items categorized into: socio-demographics, knowledge, attitude towards COVID-19 preventive practices and risk perception sections. Details of the survey are described elsewhere.[16] The survey was pilot-tested among few people who did not participate in the final survey. Appropriate modification and additional questions were added based on the results of the pilot study. The outcome variables in this study were KAP of COVID-19 among SSA respondents, and the items are described below.

Knowledge about COVID-19 virus was assessed by 12 items, most of which required a 'yes (scored as 1)' or 'no (scored as 0)' response and the maximum score was 12 points. Attitude towards the preventive practices put in place during the pandemic was assessed by 11 items including "whether they have gone to any crowded place including religious events?" "If they wore a mask when leaving home?", and "if in recent days, they have maintained good hand washing hygiene using hand sanitizers or washed their hands with soap for at least 20 seconds each time". Each question used a Likert scale with five levels with scores ranging from 0 (lowest) to 4 (highest) and the maximum score being 24 points. The risk perception of COVID-19 was tested using 16 items in a Likert scale with five levels. Each item score ranged from 0 (lowest) to 4 (highest) and the maximum score was 20 points. The variables included questions on, how they felt about the quarantine, whether participants think they were at risk of becoming infected, at risk of dying from the infection.

The Cronbach's alpha coefficients for the knowledge, risk perception and attitude towards the preventive practice scales were 0.78, 0.74, and 0.73, respectively indicating that the internal consistency of each scale was satisfactory.

Independent variables

The independent variables included the socio-demographics of the participants such as age (categorized as 18-28, 29-38, 29-48 and 49+years based on distribution), region of origin (West, East, Southern and Central Africa), religion (Christian and others), educational (Postgraduate degree [masters and PhD], Bachelor/undergraduate University degree, primary/secondary school), marital (married/de facto and not married [widowed, divorced, separated, and single]), employment, occupational status (working in healthcare and non-healthcare sectors) and household factors (how many people lived together and whether they lived alone or not).

Questions on knowledge, perceived risk of infection and attitude towards COVID-19 preventive practices were included when each variable was not listed as the dependent variable in the analysis (see Table S1 for the items).

Statistical Analysis

Analyses were performed on survey data using *Stata* version 14.1 (Stata Corp. College Station, Texas, USA). Descriptive statistics were used to summarize continuous data including the number of observations used in the calculation (*n*), mean, standard deviation (SD). Categorical data were presented as counts and percentages of each category. Preliminary analysis revealed that the mean and median were similar, and the skewness and kurtosis were close to zero and hence, a one-way analysis of variance (ANOVA) was used to establish whether there were any statistically significant differences between the means of KAP scores by region and followed by pairwise comparisons using Tukey's post-hoc test. For each region, simple linear regression model was run to assess the unadjusted Coefficients. All confounding variables with a *P*-value < 0.20 were retained and used to build a multiple linear regression (MLR) model. A manual stepwise backwards model was performed to assess the adjusted estimates for the independent variables and to predict the factors associated with scores of KAP towards COVID-19. Breusch-Pagan test was used to check the homogeneity of variance (homoskedasticity**)** and multicollinearity using Variance Inflation Factors (VIF) and the VIF < 4 was considered appropriate[30]. A *P*-value < 0.05 was considered statistically significant.

The study had ethical approval from the Human Research Ethics Committee of the Cross-River State Ministry of Health in Nigeria (Human ethics approval number: CRSMOH/HRP/HREC/2020/117) and adhered to the tenets of the Declaration of Helsinki. Informed consent was also obtained by asking participants to respond either 'yes' or 'no' to a question asking if they voluntarily wished to participate in the study. Consent was obtained after a detailed explanation of the nature and purpose of the study was provided to all participants in an online preamble. To participate in this study, respondents had to be 18 years and older.

Results

Characteristics of the sample population

Table 1 presents the demographic characteristics of the respondents. There were 1970 respondents including 1062 (55%) males who participated in the study. About fifty-six percent (n=1,108) of the respondents were from West Africa and more than 2/3rd had completed university education.

KAP scores of the different SSA regions

Figures 1, 2 and 3 presents the mean and 95% confidence intervals, respectively of knowledge (7.2 0.2), attitude (13.9 0.7) and perception (22.3 0.5) scores of SSA respondents towards COVID-19. A one-way ANOVA found no significant differences in mean scores for knowledge (p=0.707, Figure 1) and perception (p=0.896, Figure 2) between respondents from the Eastern, Western, Central and Southern Africa. However, there was a significant difference in attitude scores between SSA regions (p<0.001) and furthermore, multiple comparison test indicated that West Africans had significantly poorer attitude towards COVID-19 preventive practices compared to Central (p=0.003) and Southern Africans (p=0.019).

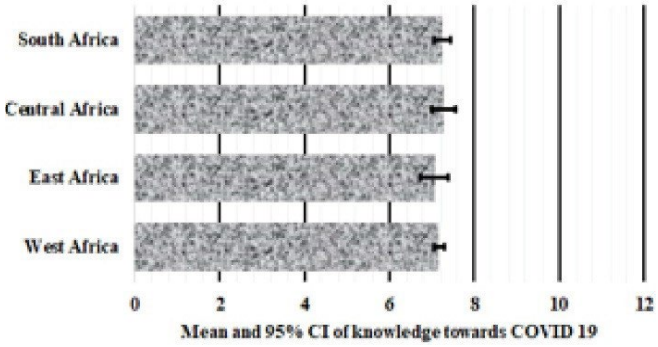


Figure 1. Mean and 95% confidence intervals (CI) of knowledge towards COVID-19 in Sub-Saharan African countries

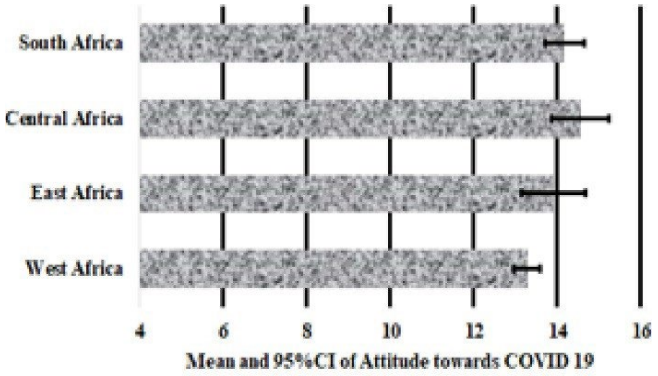


Figure 2. Mean and 95% confidence intervals (CI) of attitude towards COVID-19 in Sub- Saharan African countries

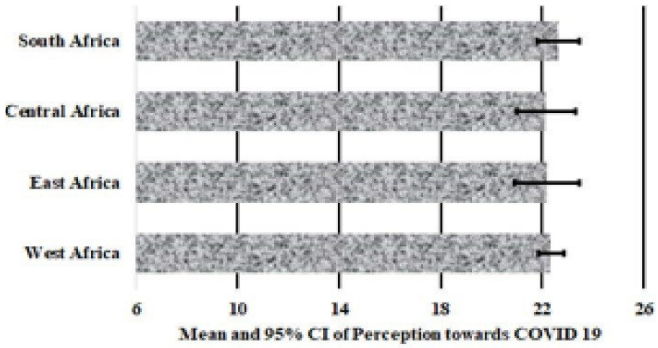


Figure 3. Mean and 95% confidence intervals (CI) of perception towards COVID-19 in Sub-Saharan African countries

Table 1. Descriptive statistics of the respondents' demographics in Sub-Sahara Africa (SSA)

Variables	West Africa	East Africa	Centra Africa	Southern Africa
N (%)	**1,108 (56.2)**	**210 (10.7)**	**251 (12.7)**	**401 (20.4)**
Demography				
Age, mean (SD)	34.4 (11.6)	36.2 (11.3)	29.9 (10.5)	34.0 (11.8)
Age category in years	1086 (100)	205	245	391
18-28	402 (37.0)	61 (29.8)	137 (55.9)	165 (42.2)
29-38	300 (27.6)	65 (31.7)	51 (20.8)	101 (25.8)
39-48	254 (23.4)	42 (20.5)	41 (16.7)	74 (18.9)
49+	130 (12.0)	37 (18.1)	16 (6.5)	51 (13.0)
Sex	1089	207	244	390
Males	632 (58.0)	123 (59.4)	110 (45.1)	197 (50.5)
Females	457 (42.0)	84 (40.6)	134 (54.9)	193 (49.5)
Marital Status	1092		245	391
Married	504 (46.2)	105 (51.0)	74 (30.2)	158 (40.4)
Not married	588 (53.9)	101 (49.0)	171 (69.8)	233 (59.6)
Highest level of education	1095	205	245	391
Postgraduate Degree (Masters /PhD)	373 (34.0)	58 (28.3)	70 (28.6)	119 (30.4)
Bachelor's degree	497 (45.4)	107 (52.0)	112 (45.7)	189 (48.3)
Secondary/Primary	255 (20.6)	40 (19.5)	63 (25.7)	83 (21.2)
Employment status	1095	205	245	393
Employed	740 (67.6)	139 (67.8)	132 (53.9)	258 (65.6)
Unemployed	355 (32.4)	66 (32.2)	113 (46.1)	135 (34.4)
Religion	1093	206	243	392
Christianity	952 (87.1)	186 (90.3)	215 (88.5)	356 (90.8)
Others	141 (12.9)	20 (9.7)	28 (11.5)	36 (9.2)
Occupation	1068	202	239	363
Non-health care sector	595 (55.7)	141 (69.8)	102 (42.7)	172 (47.4)
Health care sector	473 (44.3)	61 (30.2)	137 (57.3)	191 (52.6)
Do you live alone during COVID-19?	1092	206	244	392
No	891 (81.6)	169 (82.0)	195 (79.9)	317 (80.9)
Yes	201 (18.4)	37 (18.0)	49 (20.1)	75 (19.1)
Number living together	867	209	248	397
<3 people	280 (32.3)	63 (30.1)	51 (20.6)	102 (25.7)
4-6 people	427 (49.2)	109 (52.2)	120 (48.4)	233 (58.7)
6+ people	160 (18.5)	37 (17.7)	77 (31.0)	62 (15.6)
Are you currently or have you been in self-isolation because of COVID-19?	982	182	221	363
No	680 (69.3)	128 (70.3)	154 (69.7)	238 (65.6)
Yes	302 (30.8)	54 (29.7)	67 (30.3)	125 (34.4)
Have been home quarantined due to Covid-19	979	181	221	364
No	599 (61.2)	110 (60.8)	143 (64.7)	213 (58.5)
Yes	380 (38.8)	71 (39.2)	78 (35.3)	151 (41.5)
How much worried are you about COVID-19	1108	210	251	401
Very worried	301 (27.2)	64 (30.5)	71 (28.3)	124 (30.9)
somehow worried	394 (35.6)	57 (27.1)	76 (30.3)	127 (31.7)
not at all	413 (37.3)	89 (42.4)	104 (41.4)	150 (37.4)
How do you feel about the self-isolation?				
Anxious	870	173	193	299
No	373 (42.9)	70 (40.5)	53 (27.5)	136 (43.2)
Yes	497 (57.1)	103 (59.5)	140 (72.5)	179 (56.8)
Bored	908	172	195	310
No	243 (26.8)	64 (37.2)	37 (19.0)	117 (37.7)
Yes	665 (73.2)	108 (62.8)	158 (81.0)	193 (62.3)
Frustrated	878	172	198	313
No	467 (53.2)	72 (41.9)	81 (40.9)	136 (43.5)
Yes	411 (46.8)	100 (58.1)	117 (59.1)	177 (56.5)
Angry	852	166	188	315
No	685 (80.4)	126 (75.9)	119 (63.3)	238 (79.6)
Yes	167 (19.6)	40 (24.1)	69 (36.7)	61 (20.4)

Note: For each variable, number of responses (denominator) were shown.

Factors associated with knowledge of COVID-19 transmission in Sub-Saharan Africa

The unadjusted and adjusted coefficients of factors associated with COVID-19 related knowledge is presented in Table 2. The findings showed that among respondents from the West, East and Southern Africa, age was associated with COVID-19-related knowledge. Respondents who were aged 29-38 years from West Africa and those aged 49 years and above from East and Southern Africa had significantly higher knowledge about COVID-19 compared to those aged 18 – 28 years. By contrast, lower knowledge of COVID-19 was observed among Western and Southern African respondents who were single and less educated. Across all SSA regions, respondents that were not worried about contracting the infection showed significantly lower knowledge compared to those who were very worried about contracting the infection. However, after adjustment for confounders, it was revealed that older people living in Central (39-48years, β =1.14 95%CI 0.26, 2.02) and East (49+years: β =1.09 95% CI 0.16, 2.02) Africa and Central Africans with higher education (β =1.05 95%CI 0.22, 1.87) were more knowledgeable compared to other respondents (Table 2). Compared to Western Africans, HCWs and non-HCWs from other SSA regions reported higher attitude scores towards COVID-19 (Table 2). Other factors associated with positive attitude towards COVID-19 mitigation practices were practice of self-isolation among NHCWs (β= 0.71, 95%CI 0.41, 1.02) and HCWs (β= 0.97, 95%CI 0.45, 1.49), self-quarantine among NHCWs (β= 0.83, 95%CI 0.54, 1.12) and HCWs (β= 1.01, 95%CI 0.51, 1.50) during the lockdown. High knowledge scores were associated with positive attitude for NHCWs (β=0.26, 95%CI 0.12, 0.41) and HCWs (β= 0.34, 95%CI 0.11, 0.57). Negative attitude towards COVID-19 mitigation practices was observed among HCWs who completed Bachelor education (β= -0.56, 95%CI -1.08, -0.03) and those and those who expressed some worry about contracting the infection (β= -0.58, 95%CI -1.13, -0.02).

There were significant associations between risk perception and knowledge of COVID-19 (β= 1.28, 95%CI 1.13, 1.43 for NHCWs and β= 0.96, 95%CI 0.65, 1.27 for HCWs) and attitude (β=0.61, 95CI 0.55, 0.67 for NHCWs). Those who were either somewhat worried or not worried at all had a lower risk perception of contracting the infection. NHCWs from Central Africa (β= -0.94, 95%CI -1.67, -0.20) had a lower risk perception than West Africans.

Factors associated with attitude towards coronavirus (COVID-19) preventive practices in Sub-Saharan African Regions

Table 3 presents the unadjusted and adjusted coefficients for attitude towards COVID-19 preventive measures during the pandemic. Before adjusting for confounders, positive attitude towards COVID-19 preventive practices during the pandemic was associated with older age such that respondents living in West Africa aged 29-38 years and 49+ years and those aged 29-38 years from East Africa had more positive attitudes towards COVID-19 preventive practices compared to those aged 18-28 years. After adjusting for confounders, positive attitude was significantly associated with the practice of self-isolation while negative attitude was associated with being somewhat worried or not at all worried about getting the infection among Africans except East Africans.

Table 2. Unadjusted and adjusted coefficients (95% confidence intervals, CI) of factors associated with knowledge of COVID-19 during the pandemic among Sub-Sahara African respondents

Variables	Unadjusted Coefficient (B) (95%CI)				Adjusted Coefficient (?) (95%CI)			
	West Africa	East Africa	Central Africa	Southern Africa	West Africa	East Africa	Central Africa	Southern Africa
Demography								
Age category in years								
18-28	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
29-38	0.49 (0.17, 0.82)	0.61 (-0.19, 1.41)	0.30 (-0.38, 0.99)	0.06 (-0.41, 0.53)	–	0.61 (-0.19, 1.41)	0.78 (-0.01, 1.56)	
39-48	0.29 (-0.05, 0.63)	0.53 (-0.37, 1.43)	0.56 (-0.18, 1.31)	-0.05 (-0.56, 0.47)	–	0.53 (-0.37, 1.43)	1.14 (0.26, 2.02)	
49+	0.22 (-0.21, 0.65)	1.09 (0.16, 2.02)	0.46 (-0.65, 1.56)	0.63 (0.03, 1.22)	–	1.09 (0.16, 2.02)	1.27 (-0.01, 2.56)	
Sex								
Males	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
Females	-0.25 (-0.51, 0.02)	0.11 (-0.54, 0.76)	0.29 (-0.25, 0.83)	0.01 (-0.36, 0.39)	–	–	–	–
Marital Status								
Married	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
Not married	-0.36 (-0.62, -0.10)	-0.26 (-0.90, 0.38)	-0.13 (-0.71, 0.45)	-0.13 (-0.52, 0.25)	–	–	–	–
Highest level of Education								
Postgraduate Degree (Masters/PhD)	Ref	Ref	Ref	Ref	Ref	Ref	Ref	
Bachelor's degree	-0.24 (-0.53, 0.05)	-0.05 (-0.78, 0.69)	0.3 (-0.34, 0.94)	-0.30 (-0.72, 0.12)	-0.25 (-0.53, 0.05)	–	1.05 (0.22, 1.87)	-0.30 (-0.72, 0.12)
Secondary/Primary	-0.83 (-1.19, -0.48)	-0.32 (-1.25, 0.61)	0.07 (-0.66, 0.80)	-0.91 (-1.42, -0.40)	-0.83 (-1.19, -0.48)	–	0.81 (-0.08, 1.70)	-0.91 (-1.42, -0.40)
Employment status								
Employed	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
Unemployed	-0.26 (-0.54, 0.02)	-0.40 (-1.08, 0.27)	-0.12 (-0.65, 0.42)	-0.31 (-0.71, 0.09)	–	–	–	–
Religion								
Christianity	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
Others	-0.21 (-0.60, 0.17)	-0.45 (-1.53, 0.64)	0.66 (-0.18, 1.50)	0.10 (-0.55, 0.75)	–	–	–	–
Occupation								
Non-health care sector	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
Health care sector	0.07 (-0.23, 0.38)	-0.36 (-1.22, 0.50)	0.02 (-0.70,0.73)	-0.26 (-0.78, 0.26)				
Number living together								
3 people	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
4-6 people	-0.15 (-0.49, 0.19)	-0.00 (-0.74, 0.74)	-0.25 (-0.99, 0.48)	-0.16 (-0.63, 0.31)	–	–	–	–
6+ people	0.11 (-0.33, 0.54)	0.35 (-0.62, 1.32)	-0.15 (-0.94,0.65)	-0.14 (-0.79, 0.50)	–	–	–	–
Are you currently or have you been in self-isolation because of COVID-19?								
No	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
Yes	0.07 (-0.06, 0.19)	0.07 (-0.17, 0.31)	-0.07 (-0.41, 0.26)	0.01 (-0.17, 0.19)	–	–	–	–
Home quarantined due to Covid-19								
No	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
Yes	0.08 (-0.04, 0.20)	-0.07 (-0.29, 0.16)	-0.04 (-0.36, 0.28)	-0.13 (-0.31, 0.04)	–	–	–	–
Do you live alone during COVID-19?								
No	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
Yes	-0.30 (-0.63, 0.03)	-0.63 (-1.44, 0.19)	0.43 (-0.24, 1.10)	0.29 (-0.20, 0.77)	–	–	–	–
How much worried are you about COVID-19?								
Very worried	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
somehow worried	-0.02 (-0.33, 0.29)	-0.03 (-0.84, 0.77)	0.36 (-0.33, 1.05)	0.08 (-0.40, 0.56)	–	–	–	–
not at all	-1.54 (-1.85, -1.23)	-1.60 (-2.32, -0.87)	-1.32 (-1.97, -0.68)	-1.23 (-1.70, -0.77)	–	–	–	–

Table 2. Continued

Variables	Unadjusted Coefficient (B) (95%CI)				Adjusted Coefficient (?) (95%CI)			
	West Africa	East Africa	Central Africa	Southern Africa	West Africa	East Africa	Central Africa	Southern Africa
How do you feel about the self-isolation?								
Anxious								
No	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
Yes	-0.10 (-0.41, 0.20)	-0.08 (-0.79, 0.63)	-0.03 (-1.02,0.41)	-0.04 (-0.52, 0.44)				
Bored								
No	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
Yes	-0.06 (-0.39, 0.27)	-0.19 (-0.92, 0.53)	0.31 (-0.51, 1.12)	0.19 (-0.30, 0.68)	–	–	–	–
Frustrated								
No	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
Yes	0.03 (-0.27, 0.33)	-0.67 (-1.40, 0.05)	-0.05 (-0.68, 0.58)	0.04 (-0.45,0.53)	–	–	–	–
Angry								
No	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
Yes	0.02 (-0.37, 0.40)	-0.49 (-1.32, 0.34)	-0.23 (-0.86, 0.40)	0.37 (-0.24, 0 .98)	–	–	–	–

0.00 = Reference; CIs excluding 0.00 are significant variables.
For each region, a linear regression model was conducted with knowledge of COVID-19 mean score as the outcome variable, however, only the significant variables after adjusting for potential confounders were presented.

Table 3. Unadjusted and adjusted coefficients (95% confidence intervals, CI) of factors associated with attitude towards Coronavirus (COVID-19) preventive practices during the pandemic among Sub-Sahara African respondents

Variables	Unadjusted Coefficient B (95%CI)				Adjusted Coefficient β (95%CI)			
	West Africa	East Africa	Central Africa	Southern Africa	West Africa	East Africa	Central Africa	Southern Africa
Age category in years								
18-28	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
29-38	1.59 (0.83, 2.35)	1.99 (0.04, 3.94)	0.65 (-1.08, 2.38)	-0.89 (-2.04, 0.26)	0.64 (0.18, 1.09)	–	–	–
39-48	0.70 (-0.09, 1.50)	0.69 (-1.51, 2.88)	-0.04 (-1.91, 1.84)	0.29 (-.98, 1.56)	0.35 (-0.16, 0.85)	–	–	–
49+	1.17 (0.16,2.17)	1.82 (-0.46, 4.10)	0.97 (-1.81, 3.76)	0.78 (-0.67, 2.24)	0.53 (-0.04, 1.11)	–	–	–
Sex								
Males	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
Females	-0.19 (-0.81, 0.42)	0.19 (-1.38, 1.77)	-0.20 (-1.55, 1.16)	0.34 (-0.58, 1.27)	–	–	–	–
Marital Status								
Married	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
Not married	-0.90 (-1.51,-0.30)	-0.11 (-1.66, 1.44)	0.25 (-1.21, 1.72)	0.33 (-0.61, 1.27)	–	–	–	–
Highest level of Education								
Postgraduate Degree (Masters/PhD)	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
Bachelor's degree	-0.99 (-1.67,-0.31)	-0.11 (-1.91, 1.69)	0.89 (-0.71, 2.49)	-0.08 (-1.13, 0.97)	–	–	–	–
Secondary/ Primary	-1.66 (-2.50, -0.82)	-0.45 (-2.71, 1.83)	0.54 (-1.28, 2.37)	-1.55 (-2.83, -0.26)	–	–	–	–
Employment status								
Employed	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
Unemployed	-0.90 (-1.55, -0.26)	-1.10 (-2.74, 0.53)	-0.53 (-1.87, 0.82)	-0.65 (-1.63, 0.33)	-0.60 (-1.04, -0.16)	–	–	–
Religion								
Christianity	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
Others	-0.39 (-1.29, 0.51)	-1.34 (-3.95, 1.28)	1.14 (-0.97, 3.26)	0.76 (-0.83, 2.36)	–	–	–	–
Occupation								
Non-health care sector	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
Health care sector	0.32 (-0.39, 1.03)	-0.63 (-2.68, 1.42)	0.86 (-0.92, 2.65)	0.09 (-1.17, 1.36)	–	–	–	–
Number living together								
<3 people	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
4-6 people	-0.02 (-0.79, 0 .76)	-0.57 (-2.35, 1.21)	-0.29 (-2.11, 1.54)	-0.32 (-1.46, 0.81)	–	–	–	–
6+ people	0.10 (-0.90, 1.10)	0.96 (-1.37, 3.29)	-0.46 (-2.43, 1.51)	-0.57 (-2.11, 0.97)	–	–	–	–
Attitude								
Are you currently or have you been in self-isolation because of COVID-19?								
No	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
Yes	1.15 (0.82, 1.48)	1.60 (0.86, 2.33)	1.68 (0.97, 2.40)	0.74 (0.26, 1.23)	0.81 (0.45,1.16)	1.68 (0.91, 2.44)	0.86 (0.04, 1.67)	–
Home quarantined due to Covid-19								
No	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
Yes	1.17 (0.86, 1.47)	1.25 (0.58, 1.92)	1.94 (1.27, 2.61)	0.73 (0.27, 1.20)	1.09 (0.75, 1.43)	–	1.53 (0.75, 2.31)	0.78 (0.32, 1.24)
Do you live alone during COVID-19?								
No	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
Yes	-0.30 (-1.08, 0.48)	-1.54 (-3.52, 0.45)	0.90 (-0.76, 2.56)	0.59 (-0.59, 1.77)	–	–	–	–
How much worried are you about COVID-19?								
Very worried	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
Somehow worried	-0.77 (-1.49,-0.04)	-0.06 (-1.99, 1.86)	-0.73 (-2.44, 0.98)	-1.33 (-2.47, -0.19)	-0.51 (-0.86, -0.15)	–	-0.73 (-2.44, 0.98)	-1.33 (-2.47, -0.20)
Not at all	-3.93 (-4.65,-3.21)	-4.02 (-5.75, -2.28)	-4.19 (-5.78, -2.60)	-3.76 (-4.85, -2.66)	-0.19 (-0.56, 0.19)	–	-4.2 (-5.78,-2.60)	-3.76 (-4.85, -2.66)

Table 3. Continued

Variables	Unadjusted Coefficient B (95%CI)				Adjusted Coefficient β (95%CI)			
	West Africa	East Africa	Central Africa	Southern Africa	West Africa	East Africa	Central Africa	Southern Africa
How do you feel about the self-isolation?								
Anxious								
No	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
Yes	-0.00 (-0.71, 0.70)	0.13 (-1.58, 1.85)	-1.07 (-2.86, 0.73)	-0.69 (-1.82, 0.44)	–	–	–	–
Bored								
No	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
Yes	0.24 (-0.52, 1.01)	-0.43 (-2.18, 1.32)	-1.15 (-3.18, 0.87)	0.09 (-1.03, 1.22)	–	–	–	–
Frustrated								
No	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
Yes	0.14 (-0.56, 0.83)	-1.73 (-3.48, 0.01)	-0.61 (-2.17, 0.97)	-0.51 (-1.63, 0.61)	–	0.71 (0.02, 1.40)	–	–
Angry								
No	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
Yes	0.23 (-0.66, 1.12)	-0.87 (-2.89, 1.16)	-1.14 (-2.79, 0.49)	-1.15 (-2.80, 0.49)	–	–	–	–
Knowledge	1.62 (1.52, 1.71)	1.80 (1.59, 2.02)	1.65 (1.42, 1.88)	1.65 (1.42, 1.88)	0.35 (0.19, 0.51)	-0.39 (-0.82, 0.05)	0.39 (0.12, 0.66)	0.27 (-0.01, 0.54)

0.00 = Reference; CIs excluding 0.00 are statistically significant variables.

For each region, a linear regression model was conducted with mean score for attitude towards preventive practices during the pandemic as the outcome variable.

However, only the significant variables after adjusting for potential confounders were presented.

Factors associated with perceived risk of contracting COVID-19 in Sub-Saharan African Regions

The factors associated with respondents' perceived risk of contracting COVID-19 in SSA are presented in Table 4. The unadjusted results indicated that age differences were associated with the perception of the pandemic in the West and East African sub- regions. Participants within ages 29 -38 years from West and East Africa and those aged 49 years and older from East Africa had significantly higher perception scores compared to those aged 18 -28 years. Again, health care sector workers living in West Africa had higher perception than their non-health care sector counterparts (β =1.09; 95%CI 0.26, 1.92). On the other hand, lower perception of the infection was significantly linked to lower education and females in West Africa and East Africa respondents who were unhappy for being required to undergo self-quarantine of COVID-19 by their governments.

In addition, perceived low risk of contracting COVID-19 was observed amongst individuals living in SSA (Central, East, South and West) who were somehow worried or not worried at all about getting infected with the disease. After correcting for the confounding variables, we found that health care workers and respondents from West Africa, showed high perceived risk of contracting the infection whereas those who were somehow worried or not worried of getting infected had low risk perception of contracting the disease (Table 3). In addition, knowledge of COVID-19 was positively associated with perceived high risk of contracting the infection among SSA respondents.

Table 4. Unadjusted and adjusted coefficients (95% confidence intervals, CI) of factors associated with perceived risk of contracting Coronavirus (COVID-19) during the pandemic among Sub-Sahara African respondents

Variables	Unadjusted (B) Coefficient (95%CI)				Adjusted (β) Coefficient (95%CI)			
	West Africa	East Africa	Central Africa	Southern Africa	West Africa	East Africa	Central Africa	Southern Africa
Demography								
Age category in years								
18-28	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
29-38	1.43 (0.13, 2.74)	3.68 (0.45, 6.90)	2.57 (-0.38, 5.52)	0.16 (-1.84, 2.16)	–	–	–	–
39-48	1.21 (-0.15, 2.58)	1.90 (-1.73, 5.52)	0.46 (-2.74, 3.66)	1.41 (-0.81, 3.62)	–	–	–	–
49+	1.56 (-0.16, 3.29)	4.64 (0.88, 8.41)	0.64 (-4.10, 5.40)	0.93 (-1.61, 3.46)	–	–	–	–
Sex								
Males	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
Females	-1.27 (-2.31, -0.22)	0.61 (-2.00, 3.23)	0.18 (-2.14, 2.50)	-0.04 (-1.65, 1.56)	–	–	–	–
Marital Status								
Married	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
Not married	-0.54 (-1.58, 0.50)	-0.97 (-3.54, 1.61)	0.84 (-1.66, 3.35)	0.96 (-2.59, 0.67)	–	–	–	–
Highest level of Education								
Postgraduate Degree (Masters/PhD)	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
Bachelor's degree	-1.28 (-2.45, -0.11)	0.83 (-2.17, 3.82)	0.90 (-1.85, 3.64)	0.68 (-1.15, 2.50)	–	–	–	–
Secondary/Primary	-1.96 (-3.40, -0.52)	-0.08 (-3.85, 3.69)	1.09 (-2.04, 4.21)	-1.50 (-3.73, 0.73)	–	–	–	–
Employment status								
Employed	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
Unemployed	-0.79 (-1.90, 0.31)	-1.81 (-4.54, 0.92)	0.25 (-2.06, 2.55)	-1.41 (-3.10, 0.28)	–	–	–	–
Religion								
Christianity	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
Others	-0.23 (-1.78, 1.31)â€	-0.62 (-4.98, 3.73)	2.10 (-1.52, 5.71)	2.21 (-0.55, 4.96)	–	–	–	–
Occupation								
Non-health care sector	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
Health care sector	1.46 (0.26, 2.66)	1.24 (-4.61, 2.13)	0.94 (-2.06, 3.95)	-0.51 (-2.70, 1.69)â€	1.09 (0.26, 1.92)	–	–	–
Number living together								
<3 people	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
4-6 people	0.04 (-1.28, 1.35)	0.98 (-1.97, 3.92)	-2.38 (-5.44, 0.69)	-0.61 (-2.57, 1.34)	–	–	–	–
6+ people	0.82 (-0.88, 2.52)	2.46 (-1.40, 6.32)	-3.02 (-6.33, 0.28)	-0.26 (-2.91, 2.39)	–	–	–	–

Table 4. Continued

Variables	Unadjusted (B) Coefficient (95%CI)				Adjusted (β) Coefficient (95%CI)			
	West Africa	East Africa	Central Africa	Southern Africa	West Africa	East Africa	Central Africa	Southern Africa
Are you currently or have you been in self-isolation because of COVID-19?								
No	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
Yes	0.22 (-0.55, 0.99)	-0.19 (-2.09, 1.71)	1.22 (-0.72, 3.17)	-0.06 (-1.30, 1.18)	–	–	–	–
Home quarantined due to COVID-19?								
No	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
Yes	0.29 (-0.44, 1.02)	-1.93 (-3.70, -0.17)	1.81 (-0.05, 3.67)	-0.53 (-1.73, 0.66)	–	–	–	–
Do you live alone during COVID-19?								
No	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
Yes	0.49 (-0.85, 1.82)	-1.10 (-4.41, 2.22)	0.95 (-1.92, 3.82)	-0.53 (-2.58, 1.52)	–	–	–	–
How much worried are you about COVID-19?								
Very worried	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
somehow worried	-10.2 (-11.37, -9.05)	-6.64 (-9.65, -3.63)	-5.46 (-8.23, -2.68)	-6.19 (-8.04, -4.34)	-6.34 (-7.27, -5.41)	-6.56 (-8.79, -4.34)	-6.28 (-8.57,-4.00)	-6.37 (-7.84,-4.91)
not at all	-6.40 (-7.57, -5.23)	-10.27 (-12.98, -7.56)	-9.53 (-12.13, -6.95)	-8.98 (-10.76, -7.21)	-6.57 (-7.53, -5.62)	-6.24 (-8.34, -4.15)	-6.51 (-8.70, -4.31)	-6.06 (-7.51, -4.60)
How do you feel about the self-isolation?								
Anxious								
No	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
Yes	0.07 (-1.13, 1.27)	0.87 (-1.97, 3.72)	-2.60 (-5.60, 0.40)	-0.83 (-2.82, 1.16)	–	–	–	–
Bored								
No	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
Yes	0.40 (-0.89, 1.70)	-1.66 (-4.55, 1.24)	-1.38 (-4.81, 2.06)	0.42 (-1.58, 2.43)	–	–	–	–
Frustrated								
No	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
Yes	0.73 (-0.45, 1.91)	-2.26 (-5.18, 0.66)	-1.89 (-4.57, 0.79)	-0.16 (-2.14, 1.83)	–	–	–	–
Angry								
No	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
Yes	-0.24 (-1.75, 1.27)	-3.40 (-6.72, -0.08)	-0.23 (-3.02, 2.56)	-0.01 (-2.48, 2.47)	–	–	–	–
Knowledge	2.57 (2.39, 2.75)	2.75 (2.36, 3.14)	2.46 (2.04, 2.88)	2.57 (2.25, 2.88)	2.35 (2.18, 2.52)	2.53 (2.15, 2.91)	2.29 (1.88, 2.70)	2.38 (2.08, 2.68)

0.00 = Reference; CIs excluding 0.00 are statistically significant variable.

For each region, a linear regression model was conducted with mean score for risk perception scores for contracting COVID-19 as the outcome variable. However, only the significant variables after adjusting for potential confounders were presented

Discussion

This study found that the mean percentage for knowledge, perception and attitude were 58.3%, 28.3% and 54.2%, respectively. This study also revealed that more than half of the respondents in SSA had adequate knowledge about COVID-19 and the preventive measures against it. Older age, higher educational achievement (i.e. bachelor's degree or more) and being married were associated with high knowledge of COVID-19. However, these were not homogenous across the sub-regions of SSA. Older respondents from Central and Eastern Africa, those from Central Africa who had bachelor's degree and felt at risk of being infected had good COVID-19 related knowledge while West African respondents who were employed in the health sector had a higher perceived risk of the disease. SSA respondents older than 38 years, those that practiced self-isolation, or self-quarantined in the Central and Southern Africa during the pandemic and knowledgeable West Africans had positive attitude towards COVID-19 preventive practices.

Our study indicated that three out of every five people surveyed in SSA had good knowledge of COVID-19 which was similar to previous cross-sectional studies conducted in China[14,17,18,31] which found high knowledge of COVID-19 among the study participants. In this study, two-thirds of the respondents had at least a bachelor's degree and this may have contributed to the high COVID-19 related knowledge. Although this level of education may not reflect the level of education in the region (UNESCO reported the highest rates of education exclusion in sub-Sahara Africa),[32] it is expected that educated people are more inclined to participate in online surveys.[31] Older people had higher educational qualifications and were more knowledgeable about COVID-19 than the younger age group after adjusting for potential cofounders. This was evident among East and Central African respondents. The COVID-19 pandemic has caused millions of infections and thousands of deaths in Africa and the world in general despite the strict preventive and control public health measures introduced. Similarly, other studies have also reported a positive association between higher educational level and higher knowledge of COVID-19 in the general population[15,19] and among health care professionals.[21] The possible reason for this association could be attributed to the fact that people who are more educated are more informed and as such are more likely to update their knowledge of disease using various media. However, some previous studies found significant association between younger age and COVID-19 related knowledge.[14,18]

In this study, COVID-19 related knowledge was higher among those who stated that they were worried about contracting the infection compared to those who were not worried at all. This is in line with the report that worried individuals were more likely to seek advice or information about a disease during a pandemic.[33] As the understanding of the epidemiology of COVID-19 evolved, human-to-human transmission was confirmed with the potential for asymptomatic transmission as well.[34] COVID-19 is transmitted very rapidly such that each patient can spread the virus to two other patients.[35] This highlights the importance of continuous public education and competency, not only to decrease transmission but to limit anxiety among SSAs, which will result in better compliance, to the mitigation practices put in place by the respective governments. Most of the respondents in this study were worried about contracting the infection (about 60%).

There was a significant difference in respondents' attitude towards COVID-19 preventive practices among SSA regions. Although most of the respondents had a generally positive attitude, those from central and southern African countries had greater recognition of the importance of self-quarantine during the pandemic. In the SSA countries where the attitude towards COVID-19 preventive practices were lower (Western and Eastern Africa), there were lower knowledge scores, which was also influenced by their perception of the disease in this study. Other possible barriers against the control measures put in place by governments that could influence attitude include economic factors, poor or non-existent government palliative plan, lack of strict enforcement of the compulsory lockdown, prohibitive cost of face masks and hand sanitizers.[36]

The perceived risk of contracting the infection was not statistically different across the four SSA regions, but this was significantly influenced by the knowledge of the disease. This explains why perception of the risk of COVID-19 was higher among health workers in West African region but lower among respondents across the four regions who said they were not worried about the COVID-19 disease. The danger based on such insights is that SSA governments might fail to attain the goal of reaching the peak of transmissions and entering the 'Waning Transmission Phase' of the pandemic at the end of the lockdown. It is difficult to say if the public health measures are yielding desired results going by the data and other interventions such as the number of testings being undertaken. The exact degree and scale of testing is however, beyond the scope of this study.

Public health information campaign may also target misinformation on social media as this could affect perception due to misinterpretation of their risk of the health problem. Adjusting these measures without adequate scientific evidence may risk resurgence of COVID-19 cases and jeopardize the efforts of governments and the health of the population. Studies on similar episodes in the past have shown that people's knowledge, attitude towards COVID-19 preventive practices and perceptions about a condition affects their compliance with public health preventive measures.[33,36-38]

Limitations and strengths

As with most internet-based surveys, the data may be skewed towards using a convenient sample such that only individuals with access to internet and regularly use the social media platforms may have participated in the survey. This may have led to the preponderance of young and educated participants in this study. However, due to the lockdown, this was the only reliable means of disseminating the survey information and online surveys have been shown to have numerous strengths compared to other interview models.[27] Furthermore, by deploying the questionnaire in the English language only, the study may have excluded the non-English speaking residents in SSA such as the French-speaking people from the Central and West African region. Another limitation of this study was that the lockdown might have limited the participation of respondents, especially in East African countries (Kenya, Uganda and Tanzania) where the citizens were restrained from giving out information regarding the pandemic as was observed by a member of the research team representing those regions. We did not receive assistance with any online company to distribute the survey, which may also have affected the reach of the survey. The results of this study should be interpreted with caution as non-response is

not known because we do not know who has received an invitation to participate. In addition, as this was a cross-sectional study and findings may be due chance, the estimates reported may have overestimated or underestimated the level of KAP of COVID-19 in SSA. Despite these limitations, the study has many strengths. Firstly, this is the first study to provide evidence of KAP across different sub-regions of SSA. Secondly, the study tested the hypothesis with robust strategies for controlling confounders at the analysis stage of the research.

Conclusion

In conclusion, this study found that the respondents across the four SSA regions have adequate knowledge of COVID-19 with positive attitude towards COVID-19 preventive practices. Future research on health education regarding COVID-19 or future related pandemic in SSA should target people with lower education, those who don't self- isolate, those living in Southern and Western Africa who are not worried about contracting COVID-19. These are important to improve attitude and perceptions of SSAs towards this disease. These findings will help influence decision making by government officials, policy makers and public health workers to direct resources and educational campaigns to target the appropriate personnel.

Ethical Consideration

The study was approved by the Human Research Ethics Committee of the Cross-River State Ministry of Health in Nigeria (Human ethics approval number: CRSMOH/HRP/ HREC/2020/117)

Conflict of Interest

The authors declare that they have no conflict of interest.

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4. Misinformation of COVID-19 in Sub-Saharan Africa: Evidence from online Cross-Sectional Survey

Running title: Misinformation of COVID-19 in Sub-Sahara Africa

Open access fee for this article was covered by World Health Organization (WHO) during the pandemic.

Abstract

Globally, misinformation about the coronavirus disease (COVID-19) constitute a significant threat to public health because they could inadvertently exacerbate public health challenges by promoting the spread of the infection. This cross sectional study used convenience-sampling technique to examine factors associated with misinformation of COVID-19 in Sub-Sahara African (SSA) using an online cross- sectional survey. An e-link of the self-administered questionnaire was distributed to 1,969 participants through social media platforms and authors' email networks. A pilot study informed the misinformation to be included. The four common misinformation were 'COVID-19 was designed to reduce world population', 'holding one's breath for 10 seconds is a sign of not having COVID-19′, 'drinking hot water flushes down COVID-19' and 'COVID-19 has little effect(s) on Blacks than Whites'. The participants' responses were classified as 'Agree', 'Neutral' and 'Disagree'. A multinomial logistic regression was used to examine associated factors. The proportion of respondents who thought that 'COVID-19 was designed to reduce world population', 'holding one's breath for 10 seconds is a sign of not having COVID-19′, 'drinking hot water flushes down COVID-19' and 'COVID-19 has little effect(s) on Blacks than Whites' were 19.3%, 22.2%, 27.8% and 13.9%, respectively. Multivariate analysis revealed that those who thought COVID-19 was not likely to continue in their countries reported higher odds for the 4 misinformation about COVID-19. Other significant factors associated with belief in the misinformation were: Age (older respondents), employment (unemployed); gender (females), education (secondary/primary) and knowledge of main clinical symptoms of COVID-19. Strategies to reduce the spread of false information on COVID-19 and other future pandemic should target these subpopulations especially those with limited education. This will also enhance compliance with the public health measures.

Keywords: infodemic, COVID-19, sub-Saharan Africa, belief, myth

Introduction

There remains a great deal that is not known about the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), and this limited scientific information has contributed to a slew of misinformation (1, 2). As the outbreak of the COVID-19 which started in Wuhan province of China in December of 2019 (3), spread rapidly across the world, so did the conversation about the disease (4). Similar to other challenges (e.g., global warming), the impact of the COVID-19 pandemic depends on the actions of individual citizens and, therefore, the quality of the information to which people are exposed. Notably, social media has been flooded with information regarding the origin and implications of coronavirus(4, 5). Unfortunately, a lot of information about the pandemic, its symptoms, transmission methods and response mechanisms have been unreliable (6-9). As a result, audiences have been treated to misinformation and misconceptions through propaganda and fake news that needs to be addressed.

Despite creating awareness and providing adequate information to the public through telecommunication (radio, television advertisements, public health messages by prominent celebrities and national leaders) and distributing pamphlets/signboards at public places about infection control measures and mode of spread of the infection, the misinformation around the disease remain. While some of these misinformation may be harmless, others can be potentially dangerous and could have implications for compliance with non-pharmaceutical preventive strategies prescribed for the control of the novel coronavirus (9, 10) and may affect the development and implementation of a possible treatment (11).

In this regard, the various health authorities [World Health Organization (WHO), African Centre for Disease Control and Prevention (CDC)] have listed some of the prevailing misinformation to increase awareness about the infection and have provided factual information about COVID-19 on their websites (7, 12, 13). Additionally, some of the claims made in terms of improvement or boosting of immunity against COVID-19 infection, are being challenged (7). All these have led to further confusion in the mind of the general population.

Our interest is in Sub-Sahara Africa countries where the pandemic arrived relatively late (8) and home to over one billion people (14% of the world's population). The first confirmed case of COVID-19 infection in Sub Saharan African (SSA) countries was in Nigeria, on the 28th February 2020. By 1st April 2020, 43 of the 46 SSA countries had reported confirmed cases of COVID-19(14). Contrary to predictions of the greater infection rates of COVID-19 in the region (15), SSA remains one of the least affected regions, and this could be attributed to the demonstrated solidarity and collective leadership in acting quickly. For example, African leaders' timely adaptation of preventive measures, the low international air traffic and lessons learnt from previous epidemics such as Ebola(16).

Considering the fragile healthcare systems, the catastrophic shortage of healthcare professionals(17), the drastic reduction (of 75%) in medical commodities and supplies following border closures and restrictions on exports(18), and financial resource limitations, the SSA region may still catch up with other regions of the world that are more affected by COVID-19(8). Vigilance is compulsory, and complacency should not be allowed while SSA needs to intensify its efforts to slow the spread of the pandemic

by providing evidence-based information on the disease using the channels trusted by the people (19, 20) to counter the misinformation of the public, which will lay the foundation for sustained recovery (21, 22). Identifying participatory ways of working will also be needed to put an end to the disease.

Studies have reported that belief in pseudoscience and myths about mental disorders was associated with a lower likelihood of health-seeking behaviour in the general population and medical professionals in India (21), and in a review study of 66 articles, myth was a barrier to receiving hepatitis C treatment (22). Also, many parents in northern Nigeria avoided polio immunizations for their children because of the myth that vaccinations cause infertility. Dispelling these types of myths may result in behaviour change that could improve the health-seeking behaviour of people (21). In addition, recognizing and confronting misinformation head-on may serve to increase both peoples' knowledge as well as their ability to accurately distinguish and remember both mythical and factual information (23).

In an experimental study of 1700 US adults, authors found that nudging people to think about accuracy nearly tripled the level of true discernment in participants' subsequent sharing intentions (24) and thus is a simple way to tackle sharing of false information. The purpose of this study is to provide analysis of the common misinformation about COVID-19 spreading across English speaking countries in SSA and the underlying implications regarding the realities of "social distancing" and "use of facemask' arising from such myths. The findings of this study will provide people with reliable information using valid scientifically backed answers, which they can use to counter the misinformation and misconceptions arising from myths in SSA.

Methodology

Ethical approval for the study was sought and obtained from the Human Research Ethics Committee of the *Blinded for Review* (BLINDED FOR REVIEW/HRP/HREC/ 2020/117). The study adhered to the tenets of the declaration of Helsinki regarding research involving human subjects, and informed consent was obtained from all participants prior to completing the survey. Participants were required to answer a 'yes' or 'no' to the consent question during survey completion to indicate their willingness to participate in this study. All those who agreed to voluntarily participate in the survey were included in the study. The confidentiality of participants was assured in that no identifying information was obtained from participants.

Survey questionnaire

The survey tool for the COVID-19 knowledge question was developed based on the guidelines from the World Health Organization (WHO) for clinical and community management of COVID-19. The questionnaire was adapted with some modifications to arrive at the type of information and misinformation, obtain information on the respondent's attitude towards the mitigation practices, and their potential impact on compliance with strategies to control the spread of the novel coronavirus and risk perception of contracting COVID-19.

Prior to launching of the survey, a pilot study was conducted to ensure clarity and understanding as well to determine the duration for completing the questionnaire. Participants (n=10) from different English speaking countries in SSA who took part in the pilot were not part of the research team and did not participate in the final survey as

well. The pilot also informed the misinformation to include in the final survey. This self-administered online questionnaire consisted of 36 items divided into four sections (demographic characteristics, knowledge, perception and practice). Supplementary Table 1 is a sample of the survey. All questions relating to demography were mandatory.

Recruitment

The participants were sub-Saharan African nationals from different African countries either living abroad or in their countries of origin including Ghana, Cameroun (only distributed to the English speaking regions), Nigeria, South Africa, Tanzania, Kenya, Uganda etc. The survey was only available in English language such that participants were mostly from English speaking countries in SSAs. To be eligible for participation, participants had to be 18 years and over, and should be able to provide online consent.

Survey distribution

This study was a cross-sectional survey that utilized a *convenience sampling* technique. An e-link of the structured synchronized questionnaire was posted on social media platforms (Facebook and WhatsApp) which were commonly used by the locals in the participating countries, and was sent via emails by the researchers to facilitate response. Participants were also encouraged to share the e-link with their African networks. The survey was online for four weeks (between April 18 and May 16, 2020) when most of the countries in SSA were under mandatory lockdown and restriction of movement. As it was not feasible to perform nationwide community-based sample survey during this period, the data were obtained electronically via survey monkey. Only participants who had access to the internet, were on the respective social media platforms and used them, may have participated.

The questionnaire included a brief overview of the context, purpose, procedures, nature of participation, privacy and confidentiality statements and notes to be filled out(25). To avoid multiple responses, participants were instructed not to complete the questionnaire twice if they had participated previously. All the eligible participants completing the survey when it was online were included in the study.

In order to further minimise bias, this online survey used a Likert scale with provisions for neutral responses, so that the answers were not influenced in one way or another. The participants did not receive any incentives, their responses were voluntary and anonymized. Testing for the internal validity of the survey items, the Cronbach's alpha coefficient score ranged from 0.70 to 0.74 indicating satisfactory consistency.

Outcome variables

There were four main outcome variables in this study, which were misinformation about COVID-19. The misinformation were those popular among online users in sub-Sahara African countries as informed by our initial pilot study. The questions included whether or not respondents thought that a) COVID-19 was designed to reduce the world population, b) COVID-19 has little effect(s) on Blacks than on Whites?, c) the ability to hold one's breath for 10 seconds, is a sign that they don't have COVID-19 and d) drinking hot water flushes down the virus.

Covariates

Demographic variables: This included age, gender, marital status, location, education, employment, occupation, religion.

Knowledge of common symptoms of COVID-19: These were included to account for the shifting knowledge about the disease in the analysis. Questions included whether or not the participants could identify the common symptoms of COVID-19 as listed by the WHO as the main clinical symptoms of the disease (fever, dry cough and fatigue)(26) at the time of this study and how these symptoms differ from the common cold symptoms.

Attitude towards COVID-19 variables: The variables were included because it will influence action to reduce the spread of the infection. They were obtained from survey items inquiring on the practice of self-isolation, home quarantine, number of people living together in the household.

Compliance to the precautionary public health measure variables: To understand respondents compliance to the precautionary measures put in place to mitigate the spread of COVID-19 during the lockdown, the respondents were asked: "whether they have gone to any crowded place, including religious events" "if they wore a mask when leaving home", and "if in recent days, they have been washing their hands with soap for at least 20 seconds each time or using hand sanitizers". Each question used a Likert scale with five levels. The scores for each item ranged from 0 (lowest) to 4 (highest). These questions were necessary to identify individuals who will violate the lockdown laws in protecting and preventing the spread of the virus.

Risk perception variables: The survey items for risk perception asked the respondents: if they thought they were 'at risk of becoming infected', 'at risk of dying from the infection', 'worried about contracting COVID-19', and if they thought 'the infection would continue in their country'. These were included because individuals who perceived the risk are more likely to reduce the spread of the virus.

Statistical analysis

Data cleaning, sorting, and processing were carried out before commencing the analyses. Tabulation was used to determine the prevalence and their corresponding 95% confidence intervals of the 4 misinformation variables of COVID-19 pandemic. Over one-third of respondents indicated 'neutral' and adding this category to either the 'agree' or the 'disagree' category, would bias the study findings (27) and the policy implication of this study. The responses to these 4 misinformation of COVID-19 were categorised as "Agreed (coded as '2'), "Neutral (coded as '1') or "Disagreed (coded as 'o'). Univariate and multivariate multinomial logistic regression were used to determine factors associated after controlling for individual confounding variables.

Multinomial logistic regression (MLR) using manual process stepwise backwards model was used in order to identify the factors associated with the 4 misinformation of COVID-19 pandemic. The results were presented as unadjusted (OR) and adjusted odds ratios (AOR) with their 95% confidence intervals (CI). All variables with statistical significance of $p \leq 0.05$ were retained in the final model as the adjusted odds ratios (AOR), and analyses were performed in Stata version 14.1 (Stata Corp, College Station, Texas, USA).

Results

Table 1 shows the detailed summary of the participant's characteristics in this study. Overall, there were a total of 1,969 participants (55.2% males and 44.8% females) who responded to this survey and their proportion by age were 39.0% for 18-28 years, 26.7% (29-38 years), 22.2% (39-48 years) and 12.1% (49+ years). A little over half of the respondents were from West Africa

(n=1,108, 56.3%) and few from East Africa (n = 209, 10.6%). More than two-third of the participants (79.2%) had at least a Bachelor degree while 20.8% had either a secondary or primary (basic) school education. While majority of the participants (>81%) correctly identified fever, dry cough and fatigue as the main clinical symptoms of the disease at the time of this study, their responses were split on whether participants with COVID-19 were less likely to experience the symptoms of common cold (50.7% versus 49.3%).

Prevalence of misinformation about COVID-19

Figure 1(a-d) presents the prevalence of the 4 misinformation regarding COVID-19 which are: "belief that drinking hot water flushes down the COVID-19", "belief that the infection has less effects on Blacks than on Whites", "belief that COVID-19 is designed to reduce the world population". The figures show that 28% of the respondents thought that drinking hot water flushes down the virus and this was followed by 22% who thought that the ability to hold one's breath for 10 seconds is a sign that the person does not have COVID-19 infection. Nineteen percent of the respondents believed that COVID-19 was designed to reduce the world population, while more than one-third of the respondents (38%) were unsure about these misinformation. On whether the participants thought that COVID-19 has little effect on Blacks than Whites, 14% upheld this belief and another 30% were undecided about this misinformation.

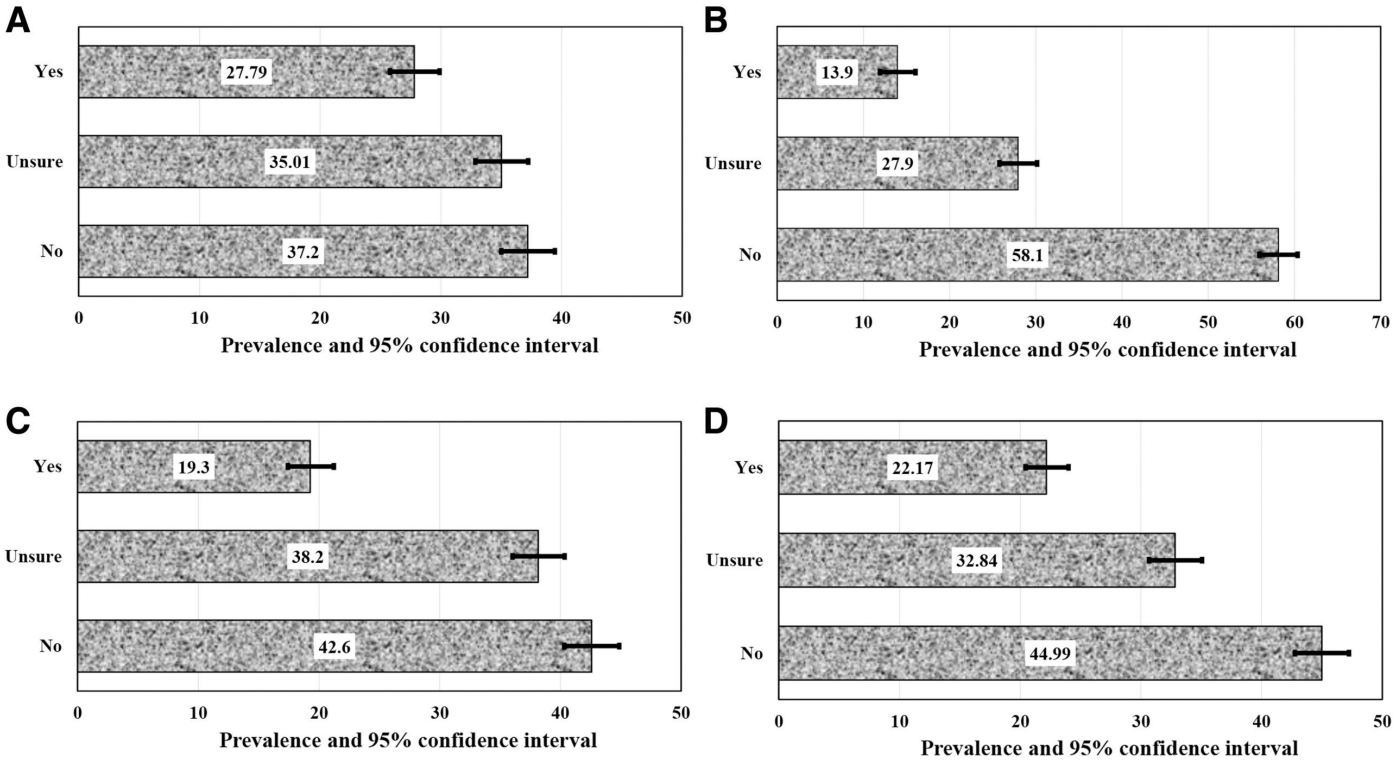

Figure 1. *Prevalence of belief in false statements related to COVID-19: (a) drinking hot water flushes down the virus; (b), COVID-19 has little effect on Blacks compared with Whites; (c) COVID-19 was designed to reduce world population; and (d) the ability to hold your breath for 10 seconds means you don't have COVID-19.*

Table 1. Demographic Characteristics of Survey Respondents

Variables	n (%)
Demography	
Region	
West Africa	1,108 (56.3)
East Africa	209 (10.6)
Central Africa	251 (12.7)
Southern Africa	401 (20.4)
Place of residence	
Locally (Africa)	1855 (92.5)
Diaspora	150 (7.5)
Age category (years)	
18-28	775 (39.0)
29-38	530 (26.7)
39-48	441 (22.2)
49+	242 (12.1)
Sex	
Male	1099 (55.2)
Female	892 (44.8)
Marital status	
Married	879 (44.1)
Unmarried	1116 (55.9)
Highest level of education	
Postgraduate degree (master's/PhD)	642 (32.2)
Bachelor's degree	939 (47.0)
Primary/secondary	416 (20.8)
Employment status	
Employed	1321 (66.0)
Unemployed	679 (34.0)
Religion	
Christian	1763 (88.4)
Others	232 (11.6)
Occupation	
Nonhealthcare sector	1471 (77.3)
Healthcare sector	433 (22.7)
Number of people living together in 1 household	
<3 people	506 (28.8)
4-6 people	908 (51.7)
6+ people	341 (19.4)
Knowledge of symptoms of COVID-19	
Fever	
No	36 (2.0)
Yes	1776 (98.0)
Fatigue	
No	324 (18.7)
Yes	1408 (81.3)
Dry cough	
No	324 (2.8)
Yes	1759 (97.2)
Sore throat	
No	215 (12.0)
Yes	1,580 (88.0)
Unlike cold symptoms	
No	907 (49.3)
Yes	931 (50.7)
Attitude toward COVID-19	
Self-isolation	
No	1237 (66.7)
Yes	564 (31.3)
Home quarantined due to COVID-19	
No	1091 (60.7)
Yes	707 (39.3)

Table 1. Continued

Variables	n (%)
Compliance during COVID-19 lockdown	
Gone to crowded places including religious events	
No	1097 (54.0)
Yes	935 (46.0)
Wore mask when going out	
No	485 (23.9)
Yes	1547 (76.1)
Practiced regular handwashing	
No	762 (37.5)
Yes	1270 (62.5)
COVID-19 risk perception	
Risk of becoming infected	
High	669 (37.2)
Low	1128 (62.8)
Risk of becoming severely infected	
High	466 (25.9)
Low	1333 (74.1)
Risk of dying from the infection	
High	349 (19.5)
Low	1445 (80.6)
How worried are you because of COVID-19?	
Worried	1037 (57.5)
Not worried	766 (42.5)
How likely do you think COVID-19 will continue in your country?	
Very likely	1152 (64.0)
Not very likely	649 (36.0)
Concern for self and family if COVID-19 continues	
Concerned	1667 (94.2)
Not concerned	102 (5.8)

Beliefs in 4 False Statements About COVID-19 – Unadjusted odd ratios of the 4 misinformation regarding COVID-19 in SSA

The unadjusted odd ratios (OR) and their 95% confidence intervals (CI) of the 4 misinformation regarding COVID-19 are presented in Supplementary Tables (S2, S3, S4 and S5, respectively). Table S2 shows that age (39-48 years), marital status, religion, level of education (bachelor degree), non-compliance with the public health measures, and level of perceived risk and continuity of the infection were significantly associated with the belief that drinking hot water flushes down COVID-19. The factors associated with the belief that COVID-19 has little effect(s) on Blacks than on Whites (Table S3) included age, region of residency (East Africa), employment status, marital status, religion, education level, non-compliance with the public health measures, and level of perceived risk of contracting COVID-19 infection. In addition to these variables, gender played a significant role in peoples belief on the misinformation that COVID-19 is designed to reduce the world population (Table S4). With regards to the factors associated with the belief that the ability to hold ones breath for 10 seconds means you do not have COVID-19 (Table S5), region of residency, and the level of perceived risk of contracting COVID-19 were the significant variables. These associated factors were further analysed after adjusting for the potential confounders.

Factors associated with the 4 misinformation regarding COVID-19 in SSA

Table 2 (a-d) shows the factors associated with the four misinformation variables of the pandemic. Analysis of the factors associated with belief in these misinformation is presented below.

a. Factors associated with the belief that drinking hot water flushes down the COVID-19 virus.

Table 2a revealed the factors associated with the belief that drinking hot water flushes down the COVID-19 virus. Older respondents, those who were unemployed and those who had a bachelor's degree was more likely to belief that drinking hot water flushes down the COVID-19 virus. The odds of believing that drinking hot water flushes down the COVID-19 was lower among participants who correctly identified fatigue (AOR=0.69, 95%CI [0.50, 0.96]) and higher among those who wrongly identified sore throat (AOR=1.71, 95%CI [1.15, 2.54]) as one of the main clinical symptoms of the disease at the time of this study. Non-compliance with the precautionary health measure urging people to avoid attending crowded places, including religious events, increased the odds of the belief that drinking hot water flushes down the COVID-19 virus (AOR=1.36, 95% CI [1.05, 1.77]). Those who perceived that the COVID-19 is not likely to continue in their countries were about 2 times more likely to agree with this misinformation compared to other respondents (AOR=1.90, 95% CI [1.45, 2.48]). Similar trend of significance was observed in the 'neutral' or 'no response' group. Respondents were more likely to be neutral to this misinformation if they were older, unemployed, non-Christians, bachelor degree holders, visited crowded places during the lockdown and thought that COVID-19 was not likely to continue in their countries after the lockdown.

b. Factors associated with the belief in COVID-19 that "the infection has less effects on Blacks than on Whites"

Table 2b also shows that East African respondents were more likely to agree with the misinformation that COVID-19 had less effects on Blacks than on Whites compared to Southern Africans (AOR = 2.07, 95% CI [1.36, 3.15]). The respondents who did not wash their hands or did not use hand sanitizer were more likely to agree with this misinformation. Similarly, the respondents who perceived that COVID-19 was not likely to continue in their country (AOR =2.53, 95% CI [1.87, 3.42]) had a higher likelihood of reporting Blacks are less affected. Similarly, a significant proportion of respondents who held a bachelor degree (AOR =1.43, 95% CI [1.11, 1.84]), non-Christians, respondents who visited crowded places during the lockdown and those who thought that COVID-19 will not continue in their respective countries, were more likely to stay neutral on the belief that COVID-19 has little effect(s) on Blacks than on Whites. Respondents who were unsure of the common clinical symptoms of the disease had a lower odds of belief in this misinformation.

c. Factors associated with the belief in COVID-19 misinformation that "COVID-19 is designed to reduce the world population."

Female respondents and those with lower education were more likely to agree that COVID-19 was designed to reduce the world population (see Table 2c for details). There were significant associations between belief in this misinformation and residents from the East African region. The respondents who did not perceive the continuing risk of the COVID-19 in their countries were more likely to agree to the statement (AOR =1.55, 95% CI [1.16, 2.07]). There was a similar trend of significance in the 'neutral' group concerning their belief on the misinformation. East Africans, those who were unemployed (AOR =1.54, 95%CI [1.12, 2.11]), visited crowded places or religious events (AOR =1.32, 95% CI [1.06, 1.66]) and those who thought the disease will not continue in their countries, were more likely to be neutral on the opinion that COVID-19 is designed to reduce the world population.

d. Factors associated with the belief in COVID-19 misinformation that "the ability to hold one's breath for 10 seconds means you do not have COVID-19."

As shown in Table 2d, Central and West African respondents were less likely to believe that holding one's breath for 10 seconds means that the person does not have COVID-19 compared to Southern Africans (AOR=0.59, 95%CI [0.37, 0.94]; AOR=0.72, 95%CI [0.52, 0.99]). Similarly, the respondents who were worried about contracting COVID-19 and that who did not perceive continuing risk of the COVID-19 in their countries, were more likely to agree and more likely to be indecisive with regards to this misinformation. The association between the household factors (living with 4 to 6 people) and respondents who neither agreed nor disagreed with the opinion that one's ability to hold his/her breath for 10 seconds means that they do not have COVID-19 was also significant (AOR=1.34 95%CI [1.01, 1.76]). Also, respondents who thought that COVID-19 will not continue in their respective countries were about two times more likely to stay neutral with regards to their belief in this misinformation when compared to those who thought that the disease will continue in their countries. Knowledge of the common clinical symptoms of COVID-19 was associated with a reduced risk particularly among those who were neutral to this misinformation.

Table 2. Multinomial Logistic Regression of Factors Associated with Misinformation Related to COVID-19

	Neutral		Agree	
Variables	AOR (95% CI)	P Value	AOR (95% CI)	P Value
a. Factors associated with belief in false statement 1: Drinking hot water flushes down the virus				
Demography				
Age category (years)				
18-28	1.00		1.00	
29-38	1.42 (0.99-2.03)	0.056	1.86 (1.25-2.77)	0.002
39-48	**2.22 (1.47-3.36)**	**<.001**	**3.61 (2.30-5.67)**	**<.001**
49+	**1.86 (1.16-3.00)**	**0.011**	**3.16 (1.90-5.26)**	**<.001**
Employment status				
Employed	1.00		1.00	
Unemployed	**1.62 (1.16-2.27)**	**0.005**	**1.72 (1.19-2.50)**	**0.004**
Religion				
Christian	1.00		1.00	
Others	0.64 (0.44-0.93)	0.02	0.67 (0.45-1.01)	0.053
Highest level of education				
Postgraduate degree (master's/PhD)	1.00		1.00	
Bachelor's degree	**1.83 (1.36-2.45)**	**<.001**	**1.84 (1.35-2.51)**	**<.001**
Primary/secondary	0.93 (0.58-1.49)	0.771	1.36 (0.83-2.22)	0.217
Knowledge of symptoms of COVID-19				
Fatigue				
No	1.00		1.00	
Yes	0.88 (0.64-1.19)	0.404	0.69 (0.50-0.96)	0.025
Sore throat				
No	1.00		1.00	
Yes	**1.60 (1.12-2.30)**	**0.01**	**1.71 (1.15-2.54)**	**0.008**
Compliance during COVID-19 lockdown				
Gone to crowded place including religious events				
No	1.00		1.00	
Yes	1.25 (0.98-1.60)	0.069	1.36 (1.05-1.77)	0.02
COVID-19 risk perception				
If COVID-19 continues, how concerned would you be that you or family would be directly affected?				
Concerned	1.00		1.00	
Not concerned	1.05 (0.64-1.73)	0.836	0.69 (0.39-1.24)	0.215
How likely do you think COVID-19 will continue in your country?				
Likely	1.00		1.00	
Not likely	**1.74 (1.35-2.24)**	**<.001**	**1.90 (1.45-2.48)**	**<.001**
b. Factors associated with belief in false statement 2: COVID-19 has little effect on Blacks compared with Whites				
Demography				
Subregion				
Southern Africa	1.00		1.00	
Central Africa	1.36 (0.93-1.97)	0.111	1.37 (0.85-2.22)	0.201
East Africa	1.30 (0.90-1.88)	0.165	2.07 (1.36-3.15)	0.001
West Africa	1.31 (0.98-1.73)	0.065	0.95 (0.63-1.42)	0.793
Religion				
Christian	1.00		1.00	
Others	0.63 (0.43-0.93)	0.02	0.61 (0.36-1.03)	0.065
Highest level of education				
Postgraduate degree (master's/PhD)	1.00		1.00	
Bachelor's degree	1.43 (1.11-1.84)	0.006	1.34 (0.96-1.87)	0.088
Primary/secondary	1.07 (0.72-1.59)	0.731	1.14 (0.69-1.89)	0.602
Knowledge of symptoms of COVID-19				
Fever				
No	1.00		1.00	
Yes	0.43 (0.20-0.92)	0.03	0.41 (0.16-1.05)	0.064
Compliance during COVID-19 lockdown				
Gone to crowded place including religious events				
No	1.00		1.00	
Yes	1.28 (1.01-1.61)	0.042	1.35 (0.99-1.82)	0.053
Handwashing/used hand sanitizer				
No	1.00		1.00	
Yes	**0.77 (0.60-0.98)**	**0.035**	**0.62 (0.45-0.84)**	**0.002**

Table 2. Continued

	Neutral		Agree	
Variables	AOR (95% CI)	P Value	AOR (95% CI)	P Value
COVID-19 risk perception				
How likely do you think COVID-19 will continue in your country?				
Likely	1.00		1.00	
Not likely	**1.88 (1.48-2.38)**	**<.001**	**2.53 (1.87-3.42)**	**<.001**
c. Factors associated with belief in false statement 3: COVID-19 was designed to reduce world population				
Demography				
Age category (years)				
18-28	1.00		1.00	
29-38	1.13 (0.81-1.57)	0.475	0.63 (0.42-0.94)	0.024
39-48	0.97 (0.67-1.42)	0.882	0.48 (0.30-0.79)	0.004
49+	0.86 (0.56-1.32)	0.489	0.43 (0.24-0.76)	0.004
Gender				
Male	1.00		1.00	
Female	1.11 (0.89-1.38)	0.368	1.54 (1.17-2.02)	0.002
Subregion				
Southern Africa	1.00		1.00	
Central Africa	1.16 (0.80-1.68)	0.44	1.45 (0.93-2.27)	0.104
East Africa	**1.55 (1.08-2.21)**	**0.017**	**1.68 (1.10-2.56)**	**0.016**
West Africa	0.99 (0.75-1.31)	0.964	0.85 (0.60-1.21)	0.375
Employment status				
Employed	1.00		1.00	
Unemployed	**1.54 (1.12-2.11)**	**0.008**	**1.85 (1.28-2.68)**	**0.001**
Highest level of education				
Postgraduate degree (master's/PhD)	1.00		1.00	
Bachelor's degree	1.43 (1.10-1.85)	0.007	1.69 (1.17-2.43)	0.005
Primary/secondary	1.07 (0.69-1.64)	0.771	1.30 (0.78-2.19)	0.317
Compliance during COVID-19 lockdown				
Gone to crowded place including religious events				
No	1.00		1.00	
Yes	1.32 (1.06-1.66)	0.015	1.18 (0.89-1.56)	0.259
COVID-19 risk perception				
How likely do you think COVID-19 will continue in your country?				
Likely	1.00		1.00	
Not likely	**2.00 (1.59-2.51)**	**<.001**	**1.55 (1.16-2.07)**	**0.003**
d. Factors associated with belief in false statement 4: The ability to hold your breath for 10 seconds means you don't have COVID-19				
Demography				
Subregion				
Southern Africa	1.00		1.00	
Central Africa	1.05 (0.72-1.52)	0.803	0.59 (0.37-0.94)	0.026
East Africa	1.20 (0.84-1.72)	0.32	1.09 (0.74-1.62)	0.655
West Africa	0.94 (0.70-1.27)	0.702	0.72 (0.52-0.99)	0.049
Number of people living together in 1 household				
<3 people	1.00		1.00	
4-6 people	1.34 (1.01-1.76)	0.04	1.23 (0.91-1.66)	0.186
6+	1.18 (0.84-1.65)	0.353	0.82 (0.56-1.23)	0.339
Knowledge of symptoms of COVID-19				
Unlike cold symptoms				
No	1.00		1.00	
Yes	0.77 (0.61-0.97)	0.026	0.85 (0.65-1.11)	0.226
COVID-19 risk perception				
How worried are you because of COVID-19?				
Worried	1.00		1.00	
Not worried	0.86 (0.68-1.10)	0.228	0.74 (0.56-0.97)	0.027
How likely do you think COVID-19 will continue in your country?				
Likely	1.00		1.00	
Not likely	**2.09 (1.63-2.68)**	**<.001**	**1.75 (1.32-2.31)**	**<.001**

Note: Variables set in bold are common factors associated with the belief or uncertainty in the false statements about COVID-19.
Abbreviations: AOR, adjusted odds ratio; CI, confidence interval.

Discussion

This study assessed four common misinformation and myths relating to the current COVID-19 pandemic and their determinants across English speaking countries in SSA. We found that about one in every five participants (21%) in this study believed the misinformation that drinking hot water flushes down COVID-19 and that one's ability to hold his/her breathe for 10 seconds is a sign that they do not have COVID-19. Some participants also believed that COVID-19 has relatively little effect(s) on Black people than White people, and that the disease was designed to reduce the world population. In addition, a reasonable proportion of the participants were unsure as to whether the misinformation were true. The common factors associated with belief in the misinformation were older age, females, East African origin and unemployment. In addition to these factors, those who were knowledgeable about the common clinical symptoms of COVID-19 had lower odds of belief in the misinformation. Participants who held any of these beliefs demonstrated low-risk perception for contracting the infection and poor attitude towards the WHO precautionary public health measures put in place to contain the spread of the infection in their countries.

The study showed that misinformation about COVID-19 pandemic were predominant among the older population in SSA particularly the English speaking countries in SSA, who are indeed the most at-risk population to develop severe complications due to the COVID-19 infection (28). This finding is corroborated by a recent study, which found that older adults are up to 7 times more likely to share fake news and dubious links than their younger counterparts (29). To more effectively target the spread of misinformation among older adults, there is need to look more closely at interpersonal relationships and digital literacy. In addition to the fact that older people are less likely to use social platforms than younger generations, they tend to have fewer people on the edges of their social spheres, and tend to trust the people they do know more (29).

In previous studies, belief in misinformation about COVID-19 was associated with a poor attitude towards the public health precautionary measures, which ultimately can lead to increased COVID-19 infections (30, 31), as well as lead to psychosocial, economic and ethical consequences (32). Respondents who were unemployed were more likely to believe in the misinformation about COVID-19, and as shown in a previous study, individuals with low incomes had a higher risk of mortality due to the COVID-19 infection (33). Therefore, it is imperative that public health efforts of combating COVID-19 should integrate targeted interventions to specific population sub-groups to ensure their effectiveness in a high-risk population. For instance, corroborating accountable mass media that disseminates socially and culturally acceptable preventives measures of COVD-19 not only can mitigate the misinformation but also can reduce the mental health impacts of COVID-19 among older population(34). Also, health communication that starts by fostering well-being and basic human psychological needs has the potential to cut through the infodemic and promote effective and sustainable behaviour change during a pandemic(35).

The finding that respondents from East Africa were more likely to agree with most of the misinformation of COVID-19 was not surprising. Despite imposing curfews, partial and full lockdowns, and enforcing physical distancing in Tanzania, President John Magufuli still believed that COVID-19

is the work of the devil. During the lockdown, he encouraged people to attend public worship in churches and mosques, insisting that 'prayer can defeat coronavirus disease'(36). On the other hand, Kenya, the closest neighbour to Tanzania, had earlier on introduced a national media and information literacy (MIL) policy into their national school curriculum, and took specific actions recently to apply these policies in order to combat COVID-19 disinformation. It is anticipated that MIL policies will help create a media literate population with capacity and skills for access to quality information, which the citizens need to make informed decisions within the new media and information environment(37). Although there are no evidence on the impact of introducing this initiative on misinformation spread during COVID-19, the Kenyan government through the support of UNESCO held several training targeting media practitioners, regulators and stakeholders during the pandemic. Training was conducted to improve the quality of journalism, and to provide trusted sources of information for the enhancement of MIL (37).

Non-compliance with the public health measures to mitigate the spread of COVID-19, such as avoiding crowds and practising good hand hygiene, was associated with belief in the misinformation of the pandemic. In the current COVID-19 crisis with the non- existence of the vaccine for all people, avoiding large gatherings, keeping good hand hygiene and use of facemask are the main public health directives in place to control the widespread of the outbreak. Public health initiatives to reduce the misinformation among the general population can prevent the violation of measures put in place to mitigate the spread of the pandemic. Social media could be an effective tool to promote health literacy among any targeted population using best evidence health literacy strategies, for instance the adaptation of plain language techniques(38). Mass campaigns using social media platforms with clear messages to encourage social distancing and wearing facemasks by the public health and local authorities can prevent the uncontrolled spread of the virus (39). While it is important to provide correct information about COVID-19, it is even more vital that such information are provided using trusted sources such as the government-owned broadcast media (40), use of celebrities(19) and trained community health advisors (20).

The belief that COVID-19 was deliberately developed and spread is common not only in the low-income countries (41) but also in the high-income countries like the USA and Australia (42, 43). A study conducted in the USA showed that around one-third of the respondents agreed to this misinformation (42). More than half of the participants in our study were either in agreement with a similar misinformation that COVID-19 was designed to reduce the world population or were undecided as to whether this information was true or false. Again, East Africans, females, the unemployed and people with a university degree were more likely to agree or remain undecided about this misinformation.

This study has some limitations. The survey was conducted using an online survey. It may not be a true reflection of the opinion of those living in rural areas where internet penetration remains relatively low (44). Since respondents are self-selected, there is no way to differentiate characteristics of respondents and non-respondents and it is difficult to completely prevent multiple responses of one person(45) even though respondents were instructed not to attempt the survey more than once.

Although the study may not have captured the opinion of the older people who are less likely to use internet compared to younger ones(45), this was the only reliable means to disseminate information at the time of this study and provided an innovative way to give real-time data on the current situation. However, studies have found an increase in the use of internet among the general population during the pandemic (46), and it is less likely that this may have significantly impacted the results presented. In addition, the reduced cost and the availability of the survey to a great number of people, at any time of the day as well as the data being processed in real-time make online surveys a preferred data collection tool at this period and setting. The survey was available only in English, and some respondents from French-speaking countries did not participate. The participation of respondents from East Africa may have been affected by the lockdown as citizens from Kenya and Tanzania were asked to refrain from giving out information regarding the pandemic, which may have resulted in the wide variation in the response rate per region. Another limitation of this study was the use of a 'neutral' option in the questionnaire without specifically defining what selecting this option indicates in the questionnaire. In a previous study, the authors found that the selection of the neutral option may be measuring different attitudes and that participants tend to over use this option in questionnaires. They also noted that providing respondents with the neutral option would minimise response bias (27). There were no incentives given to participants in this study, and no assistance was sought from online companies during the distribution of the survey, which may have affected the reach of the survey. Lastly, this study is limited by the fact that it did not examine the changing symptom profiles and knowledge about COVID-19 which has evolved over time. However, future research looking at the misinformation should consider the changing profile in knowledge of the disease and symptoms, and how that affect peoples' belief in the misinformation. Despite these limitations, this is the first study to provide robust and comprehensive evidence of the common misinformation of COVID-19 in English speaking countries in SSA region. Previous studies describing other misinformation did not explain how such beliefs are related with each other, and the factors associated and lack the robust statistical analysis to explore how such misinformation and other variables are related (47). In addition, efforts were made to minimise bias in this online survey.

Conclusion

The misinformation of COVID-19 is prevalent among East Africans and is associated with older age, females and those who are unemployed. There is a clear association between susceptibility to misinformation and knowledge about the clinical symptoms of COVID-19, low-risk perception of contracting the infection as well as a reduced likelihood to comply with public health measures. The study points to the obvious need to combat the infodemic of COVID-19 across English speaking countries of SSA by raising health and information literacy among SSA. It is widely suggested that raising the health literacy of the general population in the participating SSA countries is an effective approach to protect people from misinformation. Interventions to enhance compliance, and improve critical thinking and trust in science will be a promising avenue for future research. In addition to this, teaching the public health literacy, how to verify the source of information and other useful methods are necessary to combat

misinformation. SSA countries will benefit from engaging NGOs for greater penetration to the grassroots and the countries could go even further and convince people, by providing accurate information in local languages. A valid quality criterion would be a strategy (or a combination of strategies) that ensures effective health communication to improve public knowledge of the infection or change health behaviour, and such intervention should be associated with a measurable effect on health outcomes.

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5. Acceptance of COVID 19 vaccine among sub-Sahara African (SSA): a comparative study of residents and diaspora dwellers

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Abstract

The COVID-19 vaccines are being rolled out across all the Sub-Saharan Africa (SSA) countries, with countries setting targets for achieving full vaccination rates. The aim of this study was to compare the uptake of, resistance and hesitancy to the COVID-19 vaccine between SSA locally residents and in the diaspora. This was a cross-sectional study conducted using a web and

paper-based questionnaire to obtain relevant information on COVID-19 vaccine acceptance. The survey items included questions on demography, uptake and planned acceptance or non-acceptance of the COVID-19 vaccines among SSAs. Multinomial logistic regression was used to determine probabilities of outcomes for factors associated with COVID-19 vaccination resistance and hesitancy among SSA respondents residing within and outside Africa. Uptake of COVID-19 vaccines varied among the local (14.2%) and diaspora (25.3%) residents. There was more resistance to COVID-19 vaccine among locals (68.1%) and across the sociodemographic variables of sex [adjusted Relative Risk (ARR) =0.73, 95% CI; 0.58 – 0.93], primary/less [ARR =0.22, 95% CI; 0.12 – 0.40] and bachelor's degree [ARR =0.58, 95% CI; 0.43 – 0.77] educational levels, occupation [ARR =0.32, 95% CI; 0.25 – 0.40] and working status [ARR =1.40, 95%CI; 1.06 – 1.84]. COVID-19 vaccine hesitancy was almost similar between locals and diasporas (17.7% and 17.8% respectively) significant only among healthcare workers [ARR =0.46, 95% CI; 0.16 – 1.35] in the diaspora after adjusting for the variables. Similarly, knowledge and perception of COVID-19 vaccine among locals were substantial, but only perception was remarkable to resistance [ARR =0.86, 95% CI; 0.82 – 0.90] and hesitancy [ARR =0.85, 95% CI; 0.80 – 0.90] of the vaccine. Differences exist in the factors that influence COVID-19 vaccine acceptance between local SSA residents and those in the diaspora. Knowledge about COVID-19 vaccines affects the uptake, resistance, and hesitancy to the COVID-19 vaccine. Information campaigns focusing on the efficacy and safety of vaccines could lead to improved acceptance of COVID-19 vaccines.

Keywords: Vaccination; Acceptance; COVID-19; Hesitancy; Resistance; Sub-Sahara Africa; Locals; Diaspora

Running title: COVID-19 vaccine uptake, resistance, hesitancy

Introduction

The coronavirus disease (COVID-19) pandemic that started in December of 2019, initially reported in Wuhan, China, has continued despite preventative measures adopted worldwide under the guidance of the World Health Organization (WHO). Many countries have experienced their second, third and fourth waves in terms of cases and resultant deaths.[1- 4] The outbreak of the new Omicron variant in different countries [5-7] is of global concern,[8] as it threatens the return to normalcy and the ongoing COVID-19 vaccination programmes. Non-pharmaceutical interventions to minimise the spread of infections included travel restrictions, lockdowns, physical distancing, regular handwashing and wearing of face masks.[9-10] From the onset of the pandemic, scientists and pharmaceutical companies began the development of COVID-19 vaccines to offer protection against severe disease.[11]

The Pfizer/BioNTech, Moderna, AstraZeneca/Oxford, Johnson &Johnson, Sinopharm/ BIBP and India's Covishield,[12-13] vaccines are licensed for use across the globe. The utilisation of any vaccine can be influenced by system, client and provider factors,[14] but in particular, vaccine acceptance plays a huge role for clients and providers. Generally, the acceptance of any vaccine has been shown to be influenced by demographic factors, knowledge of the disease and the consequences of contracting it, perceptions of susceptibility, potential benefits of a health action and the occurrence of one or more cues to action.[11-17] Similar factors may influence COVID-19 vaccine acceptance.

The COVID-19 vaccines have shown to be efficient and safe,[18] however, their acceptance is a major barrier to the successful rollout plans in different countries including the SSA region. This is further exacerbated by the mistrust in the government demonstrated by residents in this region.[19] The WHO defines vaccine hesitancy as a 'delay in acceptance or refusal of safe vaccines despite availability of vaccine services'[20] It is also stated to be one of the top ten threats to global health.[21-22] Vaccine hesitancy is used to describe a phenomenon where individuals are unsure of getting vaccinated. Those who object to getting the vaccine are defined as vaccine resistant. [23]

The success of vaccines depends on achieving maximum coverage and thereby attaining herd immunity.[24] Vaccine acceptance is therefore crucial to the efforts currently made by public health experts of ensuring that the communities in every country are fully vaccinated. Studies have shown that there have been disparities in vaccine acceptance for other conditions, and factors such as age, race and ethnicity, social class, country and region of origin were associated with acceptance of vaccines.[25-26] Similar results were reported for COVID-19 vaccines.[27-28]

Persons in the diaspora are "national migrant communities living in interaction among themselves and with their country of origin".[29] Africans in the diaspora have been referred to by the African Union as "people of African origin living outside of the continent, irrespective of their citizenship and nationality, and who are willing to contribute to the development of the continent and the building of the African Union".[30] It is generally believed that being in the diaspora provides Africans with greater opportunities to become more enlightened and therefore adopt different approaches to decision making.[30] Furthermore, studies have shown that there is geographical and spatial variation in the uptake of vaccines.[31-32] In SSA, access to COVID-19 vaccines have improved, but the availability of vaccines and uptake remains substantially low compared with the rich European and North-American countries [33], and only 11% of the adult population in Africa are fully vaccinated as at January 2021.[34] Although there are significant differences in the vaccination programmes and their rollout between countries,[35-36] the fact that a previous study found similarities in the attitude and risk perception towards COVID-19 among Africans living locally and those in the diaspora (mostly living in Western countries) during the lockdown, [37] suggests there could be similarities in their acceptance of the COVID-19 vaccination. This study, therefore, sought to investigate the differences in the acceptance of COVID-19 vaccination of Sub-Sahara Africans living on the African continent and those in the diaspora. Although different studies exist that looked at COVID-19 vaccine acceptance, none had compared the same between locals and diaspora dwellers in SSA at the time of this study.

Results

Characteristics of the respondents

There was a total of 2545 SSA respondents [2391 locals (93.9%) and 154 in the diaspora (6.1%)]. Table 1 shows the frequency and percentage distribution of respondents according to their socio-demographic variables. The majority of the SSA local residents (67.8%) were younger than 38 years, while those in the diaspora were older. There were more females than males in both groups, and the majority were originally from West Africa (locals 55.6%, diaspora

Table 1: Characteristics (n=2545) of the study participants living in (Local) and outside of Africa (Diaspora).

Variables	Local 2391 (93.9%)	Diaspora 154 (6.1)	P-value^
Age group (years)			
18 - 28	898 (38.7)	23 (14.9)	<0.001
29 - 38	677 (29.1)	41 (26.6)	
39 - 48	450 (19.4)	46 (29.9)	
49 +	297 (12.8)	44 (28.6)	
Sex			
Males	1,264 (52.9)	112 (72.7)	<0.001
Females	1,127 (47.1)	42 (27.7)	
SSA region of origin*			
West Africa	1,330 (55.6)	107 (75.4)	<0.001
East Africa	116 (4.9)	6 (4.2)	
Central Africa	288 (12.1)	24 (16.9)	
Southern Africa	657 (27.5)	5 (3.5)	
Marital status			
Married	1,030 (43.1)	92 (59.7)	<0.001
Not married ‡	1,361 (56.9)	62 (40.3)	
Highest level of education			
Postgraduate degree (Masters/PhD)	668 (27.9)	82 (53.3)	<0.001
Bachelor's degree	1,237 (51.7)	61 (39.6)	
Secondary/High School	436 (18.2)	9 (5.8)	
Primary or Less	50 (2.1)	2 (1.3)	
Employment status			
Employed/ Self employed	1,733 (72.5)	139 (90.3)	<0.001
Unemployed/Retired	658 (27.5)	15 (9.7)	
Religion			
Christianity	2,140 (89.5)	138 (89.6)	0.966
Others	251 (10.5)	16 (10.4)	
Occupation			
Non-Healthcare	1,658 (69.3)	95 (61.7)	0.047
Healthcare	733 (30.7)	59 (38.3)	
Previous vaccination for any condition			
No	430 (18.0)	15 (9.7)	0.009
Yes	1,961 (82.0)	139 (90.3)	
Smoking Status			
Ex-smoker	142 (5.9)	18 (11.7)	0.014
Current smoker	168 (7.0)	8(5.2)	
Non smoker	2,081 (87.0)	128 (83.1)	
Risk factors: Any pre-existing condition §			
No	2,022 (84.6)	107 (69.5)	<0.001
Yes	369 (15.4)	47 (30.5)	

Data presented as frequencies (percentages)
^ chi-square test were used to obtained the P–value
* SSA Sub–Sahara Africa
‡ includes single, divorced, and widowed
§ includes the presence of any of the following conditions: cancer, diabetes, hypertension, asthma, kidney disease, any heart condition, sickle cell anemia

75.4%). More than half (56.9%) of the locals were not married, and 59.7% from the diaspora were married. Many locals had a bachelors' degree (56.9%), and most diaspora participants were postgraduate degree holders (53.3%). Most respondents from both groups were employed /self-employed were predominantly non-healthcare workers and were of the Christian faith. More than 80% of locals and above 90% of those in the diaspora had been previously vaccinated for one or two other conditions. More than two-thirds of the respondents indicated that they have never smoked. The proportion of respondents with preexisting conditions was high among locals (84.6%) and diaspora (69.5%).

Prevalence of uptake, resistance and hesitancy towards COVID-19 vaccine in SSA

Figure 1 presents the prevalence of vaccine uptake, resistance and hesitancy in both locals and those in the diaspora. The prevalence of COVID-19 vaccine uptake respondents was almost twice higher among the diaspora (25.3%) than among the locals (14.2%). Resistance to the COVID-19 vaccine was more common among the locals (68.1%) than those in the diaspora (55.2%). Hesitancy to COVID-19 vaccine was almost the same for both locals and resident in the diaspora (See Figure 1).

Distribution of vaccine uptake, resistance and hesitancy among local and diaspora residents

Table 2 shows the variations in the distribution of vaccine uptake, resistance and hesitancy across the demographic variables as well as their mean scores for knowledge, attitude and perception of risk of infection. Those aged between 39 – 48 years had the highest proportion of locals that were resistant to the vaccine (70.0%) while among those in the diaspora, the 18 – 28 years' age range had the highest proportion (73.9%). More males (70.2%) than females (65.7%) were resistant to taking the vaccine among the locals, whereas there was a preponderance of resistant females in the diaspora group (64.3%).

COVID-19 vaccine uptake was highest among Central African residents (20.1%) who lived locally but was highest among West Africans (29.9%) in the diaspora. The uptake of COVID-19 vaccine had the highest proportion among those with primary/less education [19 (38%)] while among those in the diaspora, uptake was highest in those having a Master's degree and higher [22 (26.8%)]. Resistance was substantial in those with Master's and higher degree respondents (70.7% for locals and 51.2% for those in the diaspora). For both healthcare and non-healthcare workers in both groups, the greatest proportions were resistant to taking the vaccine. The proportion of uptake, hesitancy and resistance towards COVID-19 vaccines varied with the employment status of the respondents, though the unemployed had the highest proportions of vaccine resistance in both groups (72.6% for locals and 60.0% for the diaspora). Christians represented the higher number of those who said they were hesitant to take the vaccine (18.6%) as compared with non-Christians in the diaspora (31.3%). Those who were ex-smokers had the highest proportion of those who were resistant among both the locals (69.0%) and those in the diaspora (72.2%). The uptake of the vaccine was also higher among those with pre-existing conditions in both local and diaspora respondents.

Higher mean scores for attitude and perception were observed among the COVID-19 vaccine uptake respondents for the local residents, while the mean knowledge score was highest for the hesitant group. Among the diasporas, the mean knowledge and perception scores were similarly highest in uptake respondents, but a higher score for attitude was observed in the hesitancy respondents (Table 2).

Unadjusted analysis of factors associated with COVID-19 vaccine uptake, resistance and hesitancy in SSA

Table 3 shows the unadjusted relative risk of factors associated with resistance and hesitancy towards COVID-19 vaccination among SSA respondents living locally and in the diaspora. Among the local residents, female sex was associated with the COVID-

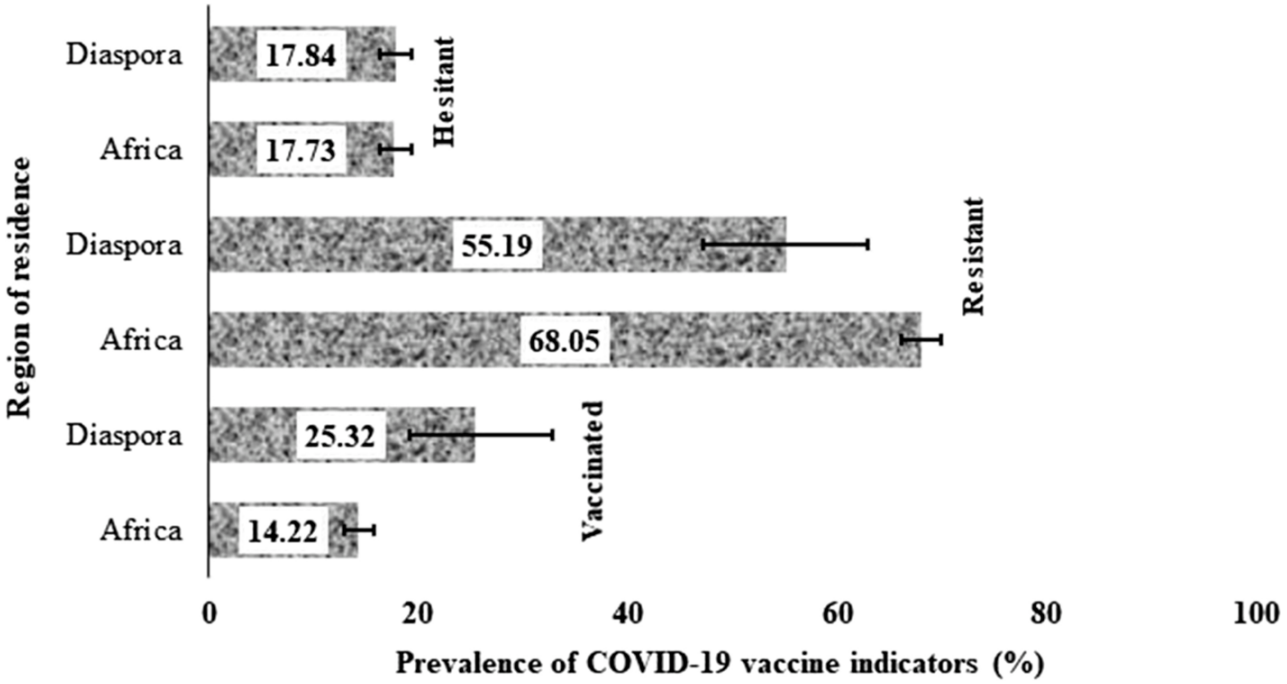

Figure 1: *Prevalence and 95% confidence intervals of vaccine uptake, resistance and hesitancy among SSAs living in (within) outside of Africa (diaspora).*

19 vaccine resistance [RR=0.73, 95% CI; 0.58 – 0.93]. East and Southern Africa local residents were significantly associated with COVID-19 vaccine resistance [RR=3.05, 95% CI; 1.31 – 7.08 and RR=1.49, 95% CI; 1.12 – 2.00 respectively] and hesitancy [RR=4.50, 95% CI; 1.83 – 11.02 and RR=1.54, 95% CI; 1.09 – 2.19 respectively]. Having primary or less education was also shown to be significantly associated with COVID-19 vaccine resistance [RR=0.22, 95% CI; 0.12 – 0.41] and hesitancy [RR=0.06, 95% CI; 0.01 – 0.25] among local residents. Unemployment was significantly associated with higher risk of vaccine resistance [RR=1.40, 95% CI; 1.06 – 1.84] among local residents. Being unmarried [RR=0.74, 95% CI; 0.58 – 0.95], and having a history of vaccination for other conditions were associated with lower risk of vaccine resistance [RR=0.39, 95% CI; 0.26 – 0.57] among locals. Also, those with high risk perception scores were significantly less likely to resist [RR=0.88, 95% CI; 0.84 – 0.92] or be hesitant [RR=0.90, 95% CI; 0.85 – 0.94] to the COVID-19 vaccines.

For those in diaspora, older age (>38years) [RR=0.13, 95% CI; 0.03 – 0.65], working in healthcare sector [RR=0.32, 95% CI; 0.25 – 0.40], having a more knowledge [0.82, 95% CI; 0.73 – 0.91] and better perception scores [RR=0.77, 95% CI; 0.66 – 0.90], were associated with lower risk of COVID-19 vaccine resistance, while not being married [RR=0.74, 95% CI; 0.58 – 0.95] had a higher risk of being resistant.

Adjusted analysis of factors associated with COVID-19 vaccine uptake, resistance and hesitancy in SSA

Table 4 presents the associated factors of COVID-19 vaccine resistance and hesitancy in this study. After controlling for potential confounders in the local resident group, East African respondents were more likely to be resistant [ARR= 3.33, 95% CI: 1.40 – 7.94] and hesitant [ARR= 4.64, 95% CI; 1.84 – 11.70] towards receiving COVID-19 vaccines while Central African respondents were less likely to be resistant [ARR= 0.46, 95% CI; 0.32 – 0.68] or hesitant [ARR= 0.44, 95%CI: 0.27 – 0.72] towards the vaccines. Having a bachelor's degree [ARR= 0.54, 95% CI; 0.38 – 0.76] or lower, being a health care worker [ARR= 0.24, 95% CI; 0.18 – 0.32], being previously vaccinated for any condition [ARR= 0.45, 95% CI; 0.30 – 0.69], and having a lower risk perception score [ARR= 0.86, 95% CI; 0.82 – 0.90] were associated with reduced risk of being resistant towards the COVID-19 vaccines among local residents in SSA. Among those in the diaspora, respondents who were aged 49 years and older [ARR= 0.17, 95% CI; 0.03 – 0.95], those who work in healthcare sectors [ARR= 0.25, 95% CI; 0.10 – 0.62], as well as those with lower knowledge scores [ARR= 0.82, 95% CI; 0.73 – 0.91] were less likely to resist taking the COVID-19 vaccines.

If 95% confidence intervals (CI) around RRs that lies between 1.00 indicate not statistically significant. All comparisons were made against vaccinated pregnant women (RR=1.0).

Regarding COVID-19 vaccine hesitancy among local residents in SSA, the significant factors included East and Central African origin, aged between 29 – 38 years, being a health care worker, having a bachelor's degree or less, non-Christians, having been previously vaccinated for other conditions, higher knowledge and lower perception scores. While for those in diaspora being a health care worker [ARR= 0.46, 95% CI; 0.16 – 1.35] and having lower knowledge scores [ARR= 0.88, 95% CI; 0.77 – 0.99] were the factors that were significant for being hesitant.

Table 2. Prevalence of vaccine uptake, hesitancy and resistance among SSAs living in (local) and outside Africa (diaspora).

Variable	LOCAL			DIASPORA		
	Uptake n = 340	Resistant n = 1627	Hesitant n = 424	Uptake n = 39	Resistant n = 85	Hesitant n = 30
Age in years						
18 - 28	127 (14.1)	621 (69.2)	150 (16.7)	2 (8.7)	17 (73.9)	4 (17.0)
29 - 38	101 (14.9)	435 (64.3)	141 (20.8)	3 (7.3)	25 (61.0)	13 (31.0)
39 - 48	61 (13.6)	315 (70.0)	74 (16.4)	18 (39.1)	20 (43.5)	8 (17.0)
49+	33 (11.1)	205 (69.0)	59 (19.9)	16 (36.4)	23 (52.3)	5 (11.0)
Sex						
Males	159 (12.6)	887 (70.2)	218 (17.3)	32 (28.6)	58 (51.8)	22 (19.6)
Females	181 (16.1)	740 (65.7)	206 (18.3)	7 (16.7)	27 (64.3)	8 (19.1)
Region						
West Africa	205 (15.4)	897 (67.4)	228 (17.1)	32 (29.9)	54 (50.5)	21 (19.6)
East Africa	6 (5.2)	80 (69.0)	30 (25.9)	0 (0.0)	3 (50.0)	3 (50.0)
Central Africa	58 (20.1)	186 (64.6)	44 (15.3)	6 (25.0)	16 (66.7)	2 (8.3)
Southern Africa	71 (10.8)	464 (70.6)	122 (18.6)	0 (0.0)	4 (80.0)	1 (20.0)
Level of education						
Master's degree and higher	68 (10.2)	472 (70.7)	128 (19.2)	22 (26.8)	42 (51.2)	18 (22.0)
Bachelor's degree	204 (16.5)	815 (65.9)	218 (17.6)	14 (23.0)	38 (62.3)	9 (14.8)
Secondary/high school	49 (11.2)	311 (71.3)	76 (17.4)	3 (33.3)	4 (44.4)	2 (22.2)
Primary/no school	19 (38.0)	29 (58.0)	2 (4.0)	0 (0.0)	1 (50.0)	1 (50.0)
Occupation						
Non-healthcare	157 (9.0)	1,188 (71.2)	313 (18.9)	17 (17.9)	61 (64.2)	17 (17.9)
Healthcare	183 (25.0)	439 (59.9)	111 (15.1)	22 (37.3)	24 (40.7)	13 (19.5)
Working status						
Employed	262 (15.1)	1,149 (66.3)	322 (18.5)	38 (27.3)	76 (54.7)	25 (18.0)
Unemployed	78 (11.9)	478 (72.6)	102 (15.5)	1 (6.7)	9 (60.0)	5 (33.3)
Marital/family status						
Married	126 (12.2)	719 (69.8)	185 (18.0)	29 (31.5)	47 (51.1)	16 (17.4)
Not married ǂ	214 (15.7)	908 (66.7)	239 (17.6)	10 (16.1)	38 (61.3)	14 (22.6)
Religion						
Christians	304 (14.2)	1,439 (67.2)	397 (18.6)	35 (25.4)	78 (56.5)	25 (18.1)
Others	36 (14.3)	188 (74.9)	27 (10.8)	4 (25.0)	7 (43.8)	5 (31.3)
Smoking status						
Ex-smoker	21 (14.8)	98 (69.0)	23 (16.2)	4 (22.2)	13 (72.2)	1 (5.6)
Current smoker	20 (11.9)	113 (67.3)	35 (20.8)	1 (12.5)	5 (62.5)	2 (25.0)
Non-smoker	299 (14.4)	1,627 (68.1)	424 (17.7)	34 (26.6)	67 (52.3)	27 (21.1)
Have you been vaccinated for any condition						
No	30 (7.0)	326 (75.8)	74 (17.2)	3 (20.0)	9 (60.0)	3 (20.0)
Yes	310 (14.2)	1,301 (66.3)	350 (17.9)	36 (25.9)	76 (54.7)	27 (19.4)
Any pre-existing conditions §						
No	280 (13.9)	1,383 (68.4)	359 (17.6)	23 (21.5)	61 (57.0)	23 (21.5)
Yes	60 (16.3)	244 (66.1)	65 (17.6)	16 (34.0)	24 (51.1)	7 (14.9)
Knowledge*	18.7 ± 4.9	18.5 ± 6.3	19.6 ± 3.6	22.7 ± 3.4	18.9 ± 6.0	20.5 ± 3.8
Attitude*	1.2 ± 2.2	0.9 ± 2.1	1.0 ± 2.0	0.7 ± 1.9	0.7 ± 1.8	1.3 ± 2.2
Perception*	6.7 ± 2.7	5.6 ± 3.1	5.8 ± 2.3	7.2 ± 2.4	5.3 ± 3.1	5.9 ± 2.9

Data presented in frequencies (percentages).
*Data presented as mean ± standard deviation.
ǂ includes single, divorced and widowed.
§ includes the presence of any of the following conditions: cancer, diabetes, hypertension, asthma, kidney disease, any heart condition, sickle cell anemia.

Table 3. Relative risk (RR) for factors associated with COVID-19 vaccine uptake, hesitancy and resistance among SSA locals and diasporas. The base reference was COVID-19 vaccine uptake for all variables.

Variable	Local		Diaspora	
	Resistant RR (95%CI)	Hesitant RR (95%CI)	Resistant RR (95%CI)	Hesitant RR (95%CI)
Age in years				
18 - 28	1.00	1.00	1.00	1.00
29 - 38	0.88 (0.66 - 1.18)	1.18 (0.83 - 1.67)	0.98 (0.15 - 6.50)	2.17 (0.26 - 17.89)
39 - 48	1.06 (0.76 - 1.47)	1.03 (0.68 - 1.55)	0.13 (0.03 - 0.65)	0.22 (0.03 - 1.47)
49+	1.27 (0.84 - 1.92)	1.51 (0.93 - 2.46)	0.17 (0.03 - 0.84)	0.16 (0.02 - 1.12)
Sex				
Males	1.00	1.00	1.00	1.00
Females	0.73 (0.58 - 0.93)	0.83 (0.62 - 1.10)	2.13 (0.83 - 5.43)	1.66 (0.53 - 5.25)
Region				
West Africa	1.00	1.00	1.00	1.00
East Africa	3.05 (1.31 - 7.08)	4.50 (1.83 - 11.02)	-	-
Central Africa	0.73 (0.53 - 1.02)	0.68 (0.44 - 1.05)	1.58 (0.56 - 4.45)	0.51 (0.09 - 2.76)
Southern Africa	1.49 (1.12 - 2.00)	1.54 (1.09 - 2.19)	-	-
Level of education				
Master's degree and more	1.00	1.00	1.00	1.00
Bachelor's degree	0.58 (0.43 - 0.77)	0.57 (0.40 - 0.81)	1.42 (0.64 - 3.17)	0.79 (0.28 - 2.23)
Secondary/High School	0.91 (0.62 - 1.36)	0.82 (0.52 - 1.31)	0.70 (0.14 - 3.40)	0.81 (0.12 - 5.42)
Primary/Less	0.22 (0.12 - 0.41)	0.06 (0.01 - 0.25)	-	-
Occupation				
Non-healthcare	1.00	1.00	1.00	1.00
Healthcare	0.32 (0.25 - 0.40)	0.30 (0.22 - 0.41)	0.30 (0.14 - 0.67)	0.59 (0.23 - 1.54)
Working status				
Employed	1.00	1.00	1.00	1.00
Unemployed	1.40 (1.06 - 1.84)	1.06 (0.76 - 1.49)	4.0 (0.55 - 36.83)	7.60 (0.84 - 68.97)
Marital/family status				
Married	1.00	1.00	1.00	1.00
Not married ‡	0.74 (0.58 - 0.95)	0.76 (0.57 - 1.02)	2.34 (1.02 - 5.41)	2.54 (0.92 - 7.00)
Religion				
Christians	1.00	1.00	1.00	1.00
Others	1.10 (0.76 - 1.61)	0.57 (0.34 - 0.97)	0.79 (0.22 - 2.86)	1.75 (0.43 - 7.18)
Smoking status				
Ex-smoker	1.00	1.00	1.00	1.00
Current smoker	1.21 (0.62 - 2.36)	1.60 (0.71 - 3.58)	1.54 (0.14 - 17.33)	8.0 (0.31 - 206.37)
Non-smoker	1.01 (0.62 - 1.65)	1.12 (0.61 - 2.06)	0.61 (0.18 - 2.00)	3.18 (0.34 - 30.10)
Have you been vaccinated for any condition				
No	1.00	1.00	1.00	1.00
Yes	0.39 (0.26 - 0.57)	0.46 (0.29 - 0.72)	0.70 (0.18 - 2.76)	0.75 (0.14 - 4.01)
Any pre-existing conditions§				
No	1.00	1.00	1.00	1.00
Yes	0.82 (0.60 - 1.12)	0.84 (0.58 - 1.24)	0.57 (0.26 - 1.25)	0.44 (0.15 - 1.26)
Knowledge	0.99 (0.97 - 1.01)	1.03 (1.01 - 1.06)	0.82 (0.73 - 0.91)	0.87 (0.77 - 0.98)
Attitude	0.96 (0.91- 1.01)	0.96 (0.90 - 1.03)	0.99 (0.80 - 1.24)	1.15 (0.90 -1.46)
Perception	0.88 (0.84 - 0.92)	0.90 (0.85 - 0.94)	0.77 (0.66 - 0.90)	0.84 (0.70 - 1.01)

If 95% confidence intervals (CI) around RRs that lies between 1.00 indicate not statistically significant.
All comparisons were made against vaccinated pregnant women (RR=1.0).
‡ includes single, divorced, and widowed.
§includes the presence of any of the following conditions: cancer, diabetes, hypertension, asthma, kidney disease, any heart condition, sickle cell anemia

Table 4: Adjusted Relative Risk (ARR) for factors associated with vaccine hesitancy among SSA residents living in (Locals) and outside of Africa (Diaspora). The base reference was COVID-19 vaccine uptake for all variables.

Variable	Local		Diaspora	
	Resistant ARR (95%CI)	Hesitant ARR (95%CI)	Resistant ARR (95%CI)	Hesitant ARR (95%CI)
18 - 28 years	1.00	1.00	1.00	1.00
29 - 38 years	1.32 (0.94 - 1.85)	1.89 (1.26 - 2.84)	1.35 (0.18 - 10.07)	2.6 (0.30 - 23.17)
39 - 48 years	1.28 (0.867 - 1.89)	1.29 (0.80 - 2.07)	0.21 (0.04 - 1.17)	0.29 (0.04 - 2.08)
49 + years	1.39 (0.86 - 2.23)	1.74 (1.00 - 3.05)	0.17 (0.03 - 0.95)	0.15 (0.02 - 1.16)
West Africa	1.00	1.00	-	-
East Africa	3.33 (1.40 - 7.94)	4.64 (1.84 - 11.70)	-	-
Central Africa	0.46 (0.32 - 0.68)	0.44 (0.27 - 0.72)	-	-
Southern Africa	1.32 (0.94 - 1.84)	1.39 (0.94 - 2.06)	-	-
Master's & above	1.00	1.00	-	-
Bachelor's degree	0.54 (0.38 - 0.76)	0.60 (0.40 - 0.90)	-	-
Secondary/ High School	0.52 (0.31 - 0.87)	0.56 (0.31 - 1.02)	-	-
Primary & Less	0.15 (0.07 - 0.32)	0.05 (0.01 - 0.24)	-	-
Non-health care	1.00	1.00	1.00	1.00
Health care	0.24 (0.18 - 0.32)	0.19 (0.13 - 0.27)	0.25 (0.10 - 0.62)	0.46 (0.16 - 1.35)
Christians	1.00	1.00	-	-
Others	0.96 (0.64 - 1.46)	0.50 (0.29 - 0.86)	-	-
Vaccinated for any condition	0.45 (0.30 - 0.69)	0.48 (0.29 - 0.77)	-	-
Knowledge	1.02 (1.00 - 1.05)	1.07 (1.04 - 1.11)	0.82 (0.73 - 0.91)	0.88 (0.77 - 0.99)
Perception	0.86 (0.82 - 0.90)	0.85 (0.80 - 0.90)	-	-
If 95% confidence intervals (CI) around RRs that lies between 1.00 indicate not statistically significant. All comparisons were made against vaccinated pregnant women (RR=1.0).				

Methods

Ethics and consent

Ethical approval to conduct the study was obtained from the Humanities and Social Sciences Research Ethics Committee (approval #: HSSREC 00002504/2021) of the University of KwaZulu-Natal, Durban, South Africa. The study adhered to the tenets of the Declaration of Helsinki involving human participants [38], and anonymous voluntary informed consent was obtained from all participants as part of the preamble accompanying the questionnaire.

Participants were included in this study if they were of African origin, aged 18 years and older, and provided consent. Completion of the questionnaire was only possible after the participants had responded to the consent question, 'do you voluntarily take part in this study?' Those who answered 'No' to this question were automatically locked out from the survey platform.

Study setting and population

The study population included adults who were 18 years and older and were of sub-Saharan Africans residing locally (in Africa) and in diaspora (outside of Africa). Respondents from several countries in SSA, mostly from Cameroun, Ghana, Nigeria, South Africa, Tanzania, and those in diaspora mostly living in Australia, United Kingdom, United States, Saudi Arabia, Canada, China, and India took part in this study.

Sample size determination

The sample size was determined using Cochran's formulae ($n = z^2pq/d^2$) with the assumption of a proportion of 50% at a confidence level of 95% with an error margin of 2.5%. A 20% non-response rate was assumed, and a minimum sample size of 2401 was obtained.

Study design

This was a web-based cross-sectional survey carried out between 14th of March and 17th of May 2021. Due to the continued COVID-19 lockdowns in many of the target countries at the time of this study, web-based study was most appropriate even

though it may have excluded some participants with no access to internet-based phone/ computer services.

The survey instrument and data collection

Data was collected using a validated self-administered questionnaire adapted from a previous study.[39] The survey tool was tested for the internal validity of the items, and Cronbach's alpha coefficient score ranged from 0.70 and 0.74, indicating satisfactory consistency.[40] The questionnaire was designed on survey monkey in both English and French, which are spoken languages in 26 and 21 SSA countries, respectively.[41] The questionnaire was disseminated electronically through an e-link on social media networks such as WhatsApp, Facebook and e-mail. There was an accompanying introductory section that included the background and goal of the study, procedure for participation and informed consent guide. Participants were requested on the introductory page not to participate in the survey more than once.

Confounding variables

The survey instrument showing the various variables collected has been presented in the Supporting information (S1 Table). The independent variables included sociodemographic variables; age, gender, region, marital status, the highest level of education, occupation, employment status, religion, smoking status, previous vaccination for other conditions and pre-existing medical conditions; knowledge of COVID-19 vaccines; perception of risk for contracting COVID-19; and attitude towards vaccination for COVID-19 (S1 Table). The exposure variable was the 'place of residence' (local or diaspora).

The COVID-19 vaccine knowledge items had 10 questions on a Likert scale with five levels as indicated in SI Table 1. The scores for nine of the items ranged from 0 (lowest) to 4 (highest) while, for one item, it was coded as 1 for Yes and 0 for No. The overall knowledge towards COVID-19 vaccination score ranged from 0 -37 points, with a higher knowledge score indicating a better knowledge towards COVID-19 vaccination.

The attitude towards the COVID-19 vaccine items included four items with each assigned 2 points for 'yes', 1 point for 'unsure' and 0 point for 'No'. The total attitude score ranged from 0 to 8, with a higher score denoting a better attitude towards COVID-19 vaccination.

The risk perception for contracting the disease after vaccination included questions on how the participants rate their risk of becoming infected with the virus and risk of dying from the infection. The responses were structured using a Likert scale with five levels (S1 Table), with scores for each item ranging from 0 (lowest) to 4 (highest). The total perception score ranged from 0 to 8, with a higher score representing a higher perception of contracting the infection following COVID-19 vaccination.

Main outcome variables

The main outcomes were vaccine uptake, resistance and hesitancy. Uptake was determined by answering 'yes' to the question "*Have you been vaccinated against COVID-19?*". The vaccine resistant group were those that answered 'no' to the question '*Will you be willing to be vaccinated against COVID-19 if the vaccine becomes available in your country?*', while those who answered 'not sure' were defined as the vaccine 'hesitant' group.

Data analysis

Data were analyzed using STATA/MP version 14 (Stata Corp 2015, College Station, TX, USA. A 95% confidence interval (CI) was set for this survey, and a p-value of <0.05 was considered statistically significant. Descriptive data were summarized and presented in tables and charts using frequencies, percentages, mean and standard deviations as required. Multinomial logistic regression analyses were used to examine the COVID-19 vaccination status on sources of information. As part of the multiple multinomial logistic regression analyses, a staged modelling technique was carried out. Elimination method was conducted using multiple multinomial logistic regression modelling techniques to remove statistically non-significant variables. Demographic factors were first entered into the baseline multiple regression model, followed by health indicators factors and the exposure variables were examined in the final model, which also included knowledge, attitude and risk perception variables, keeping only those variables significant in the previous model. In the final model, we tested and reported any co-linearity. The relative risk with 95% confidence intervals were calculated to assess the adjusted risks of independent variables.

Discussion

The purpose of this study was to compare the uptake, resistance and hesitancy of the COVID-19 vaccine between the local residents and diaspora dwellers in SSA region of the African continent. Uptake of the COVID-19 vaccine was found to be twice as high among residents in the diaspora compared to local SSA residents. The WHO and Centers for Disease Control and Prevention (CDC) have suggested that the low vaccination rates in low-and-middle-income countries is in part, due to inequitable distribution of vaccines. Accessibility to vaccines may have played a role in the low uptake rates in our study. At the time of the study, half of the 52 African countries that had received vaccines had only vaccinated up to 2% of their population at the time of this study, and 15 countries had vaccinated up to 10%.[42] However, majority of those residing in Africa and the diaspora were either resistant or hesitant to get vaccinated. This finding is different from that reported in a previous study [43] where a higher proportion of African residents and those in the diaspora were willing to accept the vaccine when offered. A survey conducted by CDC Africa prior to the introduction of vaccines on the continent found that the willingness to take the vaccine in 15 African countries ranged from 59% to 93%,[44] which was in contrast with our findings of greater resistance towards COVID-19 vaccination. Studies conducted in the US and UK showed that Africans/Blacks were 13 times more likely to be hesitant than Whites [45-46] which is similar to the high proportions of SSA in diaspora who were either hesitant or resistant to taking COVID-19 vaccines.

Socio-demographic characteristics have been shown to play significant roles in vaccine hesitancy and resistance.[46] In this study, age, region of origin, educational level, occupation and religion were significantly associated with either vaccine hesitancy or resistance among local and diaspora residents. Younger age groups among the local residents were almost twice likely to be hesitant and older age groups were less likely to be resistant to vaccines. This finding is consistent with other previous studies,[32,37,46-47] and may also be related to the fact that COVID-19 is more likely to present in the severe form among older age groups, making them more likely to accept the vaccine for their protection.

Local East African respondents were three times more likely to resist and almost five times more likely to be hesitant than West Africans. This may be due to misinformation about COVID-19 [48] and its vaccines [49] which was reported to be more common in East African countries such as Tanzania. The results showed that the least educated respondents were less likely to be resistant or hesitant. This may be as a result of not comprehending the scientific arguments being advanced against the vaccines and having to make choices based on past experiences or the information they do understand. A recent study in the US showed a similar pattern with those with lower levels of education showing less hesitancy than those with higher.[49]This is contrary to the results obtained in other studies.[35-37,42-43] A statement by a 61 year old on Africa news may provide an insight into the mindset of those who are less educated thereby making them more likely to accept vaccination: "If in the time of our mothers, in the time we were little children if these "WhatsApp doctors" had existed (people who post unreliable medical information on social media) I think we would have all died because our mothers who did not go to school agreed to vaccinate us against smallpox, measles, polio — all the other diseases without debate. Today, we are more educated, but curiously, we refuse vaccination. This is a certain danger for our society, according to what I have read here and there. The Congo is being blacklisted because we risk many deaths if we don't accept vaccination".[50]

Both local and diaspora healthcare workers showed less likelihood of being either resistant or hesitant as compared to non-healthcare workers in this study. Resistance and hesitancy have been found among health workers though lower when compared to non-healthcare workers.[50-55] However, Blacks /African health workers still show higher risk than their counterparts of being resistant/hesitant irrespective of the country they are in. Vaccine resistance and/or hesitancy is a hindrance to the vaccination campaign, as such, health workers who should be well educated about the vaccines are likely to exert an influence on others and possibly deter them from getting vaccinated. Most findings in the cited papers found that the fear of side effects was usually the reason for hesitancy and resistance among health workers. [51-53]

Among the local residents, individuals form other religions were less likely to be vaccine hesitant compared to those of the Christian faith. Religion has been reported to play a huge role in the life of Africans and influences their health seeking behavior.[57-58] Olagoke et al. reported that some religious views have contributed to the rejection of vaccination.[59] However, an intervention study conducted among American Christians,[60] showed that with proper presentation of scientific facts, such negative views can be changed. Community engagement with religious leaders has also been advocated as a means of addressing vaccine hesitancy.[61]

Local residents who had been previously vaccinated for other conditions were less likely to be COVID-19 vaccine resistant or hesitant. This finding emphasizes the influence of past experiences which can build confidence in the efficacy of vaccines. Other studies have also shown a willingness to be vaccinated among those who had previously received vaccinations for other diseases such as flu, yellow fever, hepatitis.[62-63] Knowledge of COVID-19 vaccine was a significant factor among both local and diaspora residents. Knowledge has been shown to reduce resistance to vaccine acceptance. Africans in the diaspora were less likely to be hesitant or resistant to vaccines as compared to their counterparts

residing in Africa. This may still be related to misinformation and the need for health messages to be relayed in the languages familiar to the people. Recent studies have shown a decline in those who are hesitant and this has been attributed to the availability of accurate information that reduces fear and leads to making informed decisions.[64] Exposure to accurate information and increased knowledge about COVID-19 vaccines may help those who are hesitant to be more receptive to vaccines. Among local residents, higher perception scores showed a lower odd of being either resistant or hesitant. The perception that one is likely to be at risk of contracting a disease can result in people taking appropriate measures to protect themselves from contracting the disease.

Strengths and limitations

This is the first large scale study to compare acceptance of COVID-19 vaccines between sub-Saharan African local residents and those in the diaspora. The study employed robust analyses to control for potential confounders to reduce the possibility of a bias. The distribution of the questionnaire in both English and French languages using an internet-based methodology, which was the only reliable means to disseminate information at the time of this study to a wider audience. Notwithstanding these strengths, the study has some limitations. For example, the study did not explore concerns about vaccine safety which may be an important determinant of vaccine hesitancy. The cross-sectional nature of the study means that causation cannot be determined. The survey was distributed electronically using social media platforms and emails, and this may have inadvertently excluded some potential participants whose opinions may have differed, such as those without internet access and people living in rural areas, where internet penetration remains relatively low.[65] The survey was presented in English and French and thus inadvertently excluding some of the Portuguese or Arabic-speaking SSA countries from participating. Although the study showed satisfactory internal validity, its generalization or transferability to all SSA countries may be limited. Despite the wide distribution of the survey, only few SSA living in diaspora participated compared to many who lived in SSA. However, the robust analysis ensured adequate control of potential confounders.

Conclusion

The study showed that Africans residing both locally and in diaspora are mostly either resistant or hesitant to the COVID-19 vaccines. Factors that influenced resistance and hesitancy among local residents included younger age, being from East and Central Africa, lower levels of education, history of previous vaccinations, being a health care worker, knowledge and perceptions of COVID-19 vaccine. For Africans in the diaspora, being hesitant or resistant to COVID-19 vaccines are influenced by older age, being a health care worker and having adequate knowledge of vaccines. Appropriate interventions such as public health messaging are required to enhance COVID-19 uptake to achieve sufficient vaccine coverage.

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6. Factors associated with the myth about 5G technology during COVID-19 pandemic in sub-Saharan Africa.

Abstract

Background: Globally, the conspiracy theory claiming 5G technology can spread the coronavirus disease (COVID-19) is making the rounds on social media and this could have significant effect in tackling the spread of the pandemic. This study investigated the impact of the myth that 5G technology is linked to COVID-19 pandemic among sub- Saharan Africans (SSA).

Methods: A cross sectional survey was administered on 2032 participants few weeks immediately after the lockdown in some SSA countries (April 18 – May 16, 2020). Participants were recruited via Facebook, WhatsApp, and authors' technologys. The outcome measure was whether respondent believed that 5G technology was the cause of the coronavirus outbreak or not. Multiple logistic regression analyses using backward stepwise were used to examine the associated factors.

Findings: About 7.3% of the participants believed that 5G technology was behind COVID-19 pandemic. Participants from Central African reported the highest proportion (14.4%) while the lowest proportion (5.4%) was among those from Southern Africa. After adjusting for potential covariates in the multivariate analysis, Central Africans (Adjusted odds ratio, AOR 2.12; 95%CI: 1.20, 3.75), females (AOR 1.86; 95%CI: 1.20, 2.84) and those who were unemployed at the time of this study (AOR 1.91; 95%CI: 1.08, 3.36) were more likely to believe in the myth that 5G technology was linked to COVID-19 pandemic. After adjustment for all potential cofounders, participants who felt that COVID-19 pandemic will not continue in their country were 1.59 times (95%CI: 1.04, 2.45) more likely to associate the 5G technology with COVID-19 compared to those who thought that the disease will remain after the lockdown. Participants who were younger were more likely to believe in the 5G technology myth but the association between level of education and belief that 5G technology was associated with COVID-19 was nullified after adjustments.

Conclusions: This study found that 7.4% of adult participants held the belief that 5G technology was linked to COVID-19 pandemic. Public health intervention including health education strategies to address the myth that 5G was linked COVID-19 pandemic in SSA are needed and such intervention should target participants who do not believe that COVID-19 pandemic will continue in their country, females, those that are unemployed and those from Central African countries in order to minimize further spread of the disease in the region.

Keywords: COVID-19, Myths, sub-Saharan Africa, 5G technology, Attitude

Introduction

During the outbreak of the novel coronavirus disease (COVID-19) and the subsequent global spread of the pandemic, there arose a myth that the outbreak was associated with the fifth generation mobile telecommunication technology, known as 5G [1]. Holding such myths could have implications for compliance with non-pharmaceutical preventive strategies prescribed for the control of the novel coronavirus [2]. These myths include that 5G was the cause of the novel coronavirus; that the electromagnetic radiation from the 5G technology was responsible for the mutation of the coronavirus; and that the 5G technology was a strategy of the industrialized nations to control the population of the less industrialized nations among others [2-4]. This is because of the fact that radiofrequency radiation (RF) is increasingly being identified as a new form of environmental pollution [3].

The fifth generation mobile telecommunication is the new, high-speed wireless communications technology, promising faster bandwidth speeds of 1 – 10 Gbps, wider coverage, reduced congestion and improved latency [4]. The technology is expected to be transformative, fueling innovation across every industry and every aspect of our lives. The combination of its high-speed and potential to transform the human way of life by fully supporting the implementation of Internet-of-things (IoT) solutions generated various myths about 5G.

Whereas myths are usually associated with individuals who may be unlearned in the subject matter, the myths of the harmful effects of 5G have been promoted by some scientists [1]. The evidence for the biological effects of mobile phone technology and non-ionizing radiofrequency used in the 5G technology are inconclusive at present [4-9]. While available research till date, do not reveal any adverse health effect being causally linked with exposure to wireless technologies, [10] further health related studies need to be carried out at the frequencies to be used by 5G. Notwithstanding the lack of evidence to support the link between the 5G technology and the pandemic, the myth has continued to grow globally. Besides the myth linking 5G technology with coronavirus, several other myths have been held regarding COVID-19 [11].

South Africa and Lesotho are the only countries in sub-Saharan Africa that have launched the 5G technology with limited coverage [12]. Notwithstanding, the myths about the association of the technology with the outbreak of COVID-19 continue to be held in sub-Saharan Africa. Myths (unsubstantiated beliefs) [13] [14] held by individuals have played a significant role in public health interventions including acceptance of immunization and use of preventive health strategies [15-18].

As the novel coronavirus outbreak assumed pandemic proportion, and as a result of lack of treatment and vaccine for the disease several community directed strategies are recommended to contain and mitigate the outbreak. Some of the recommended strategies include international and local travel restrictions, quarantine and self-isolation of suspected cases for a period equivalent to the incubation period of the disease (14 days), lockdown of commercial activities in major cities, closure of schools, restriction of movement, frequent hand washing, use of face masks and social distancing [19]. It is widely believed that the spread of the virus in the community can be minimized if citizens follow these recommendations and practices.

There have been concerns with the level of compliance with these preventive strategies in sub-Saharan African (SSA) countries. Using the health belief model (HBM) it has been postulated that behavior and perception influence the development of preventive health behavior [20]. This study was designed to examine factors associated with the myth that 5G technology was linked to COVID-19 pandemic. Findings from this research will enable researchers and policy makers target sub-population who will not comply with preventive measures proposed for the mitigation of the present pandemic and any other outbreaks when myths held by these sub-populations are the reasons for non-compliance.

Methodology

A cross-sectional descriptive study was conducted between April 18 and May 16, 2020 when most of the countries surveyed were under mandatory lockdown and restriction of movement. As it was not feasible to perform nationwide community-based sample survey during this period, the data were obtained electronically via survey monkey. Only participants who had access to the internet, were on the respective social media platforms and used them, may have participated. An e-link of the structured synchronized questionnaire was posted on social media platforms (Facebook and WhatsApp) which were commonly used by the locals in the participating countries, and was sent via emails by the researchers to facilitate response. The questionnaire included a brief overview of the context, purpose, procedures, nature of participation, privacy and confidentiality statements and notes to be filled out.

Study population

The participants were sub-Saharan African nationals from different African countries either living abroad or in their countries of origin including Ghana, Cameroun (only distributed to the English speaking regions), Nigeria, South Africa, Tanzania, Kenya, Uganda etc. To be eligible for participation, participants had to be 18 years and over, and should be able to provide online consent.

Survey questionnaire

The survey tool for the COVID-19 knowledge questionnaire was developed based on the guidelines from the World Health Organization (WHO) for clinical and community management of COVID-19. The questionnaire was adapted with some modifications to suit this study's objective namely to explore the potential impact of the myth about the 5G technology on compliance with strategies to control the spread of the novel coronavirus.

Prior to launching of the survey, a pilot study was conducted to ensure clarity and understanding as well as to determine the duration for completing the questionnaire. Participants (n=10) who took part in the pilot were not part of the research team and did not participate in the final survey as well. This self-administered online questionnaire consisted of 58 items divided into four sections (demographic characteristics, knowledge, attitude, perception and practice). Supplementary Table 1 is a sample of the tables showing the items used in the data analysis.

Dependent variable

The dependent variable for this study was Myth about the 5G technology which was categorized as "Yes" (1 = if COVID-19 is associated with 5G communication) or "No" (0 = if COVID-19 is not associated with 5G communication).

Independent variables

The independent variables included: a) demographic characteristics of the participants which included age, country of origin, country of residence, sex, religion, educational, marital and occupational status; b) attitude towards COVID-19 which included practice of self-isolation, home quarantine, number of people living together in the household;
c) compliance during COVID-19 lockdown which included whether they attended a crowded event, used face mask when going out, practiced regular hand-washing, used hand sanitizers; and d) risk perception which included whether participants think they were at risk of becoming infected, at risk of dying from the infection, if they were worried about contracting COVID-19, and thought the infection will continue in their country (Table 1).

Data analysis

Demographic, compliance during lockdown, attitude and perception variables were summarized as counts and percentages for categorical variables. and two-way frequency table was used to obtain the proportion estimates of those who reported that 5G technology was linked to COVID-19. In the univariate and bivariate analyses, Odds ratios with 95% confidence intervals were calculated in order to assess the unadjusted risk of independent variables on selected covariates.

In the univariate logistic regression analysis, variables with a p-value <0.20 were retained and used to build a multivariable logistic regression model which examined the factors associated with the myth about 5G technology during COVID-19 pandemic. Similarly, we performed a stage modelling technique employed by Dibley et al. [24], and a four-staged modelling technique was employed. In the first stage, regions and demographic factors were entered into a baseline multivariable model. We then conducted a manually executed elimination method to determine factors associated with the myth about 5G technology during COVID-19 pandemic at P <0.05. The significant factors in the first stage were added to attitude towards COVID-19 variables in the second staged model; this was then followed by manually executed elimination procedure and variables that were associated with the study outcomes at P <0.05 were retained in the model.

Table 1. Covariates used in the multiple logistic regression

Model 1	Model 2	Model 3	Model 4
Region*and Socio-demographic *Place of residence* *Age in years* *Sex* *Marital Status* *Highest level of Education* *Employment status* *Religion* *Occupation* *Number living together*	Region*and Socio-demographic[P] Attitude towards Covid-19 *Self-Isolation* *Home quarantined due to Covid-19*	Region*and Socio-demographic and attitude[P] Compliance during lockdown during Covid -19 *Attended crowded religious events* *Wore mask when going out* *Practiced regular Hand washing*	Region*and Socio-demographic and attitude and Compliance[P] Covid-19 risk perception [$] *Risk of becoming infected* *Risk of becoming severely infected* *Risk of dying from the infection* *How much worried are you about COVID-19* *How likely do you think Covid-19 will continue in your country* *Concern for self and family if COVID-19 continues*

* West Africa, East Africa, Central Africa & Southern Africa;

$ High/ very worried/very concerned/very likely for "High/ Concerned/worried & Very High/ Extremely Concerned/extremely worried"⍰ & Low/ not worried/ not concerned/no very likely for" Very low/Not at all/ Very unlikely/ Extremely unconcerned; Unlikely/Unconcerned/ A little & Neither likely nor unlikely/moderate/ Neither Concerned nor Unconcerned

P = only significant variables were added.

We used a similar approach for compliance to public health measures and COVID-19 risk perception factors in the third and fourth stages, respectively. The odds ratios with 95% confidence intervals were also calculated to assess the adjusted factors. All analyses were performed in Stata version 14.1 (Stata Corp, College Station, Texas, USA).

Ethical consideration

Ethical approval for the study was sought and obtained from the Human Research Ethics Committee of the Cross River State Ministry of Health (CRSMOH/HRP/HREC/ 2020/117). The study was carried out in accordance with the Helsinki Declaration for Human Research. The confidentiality of participants was assured in that no identifying information was obtained from participants. The study adhered to the tenets of Helsinki's declaration and informed consent was obtained from all participants prior to completing the survey. Participants were required to answer a 'yes' or 'no' to the consent question during survey completion to indicate their willingness to participate in this study.

Results

Demography of participants

Table 2 shows the descriptive data of the participants. Of the 1969 participants that indicated their country of residence, majority (n=1,108, 56.3%) were from West Africa and few from East Africa (n = 209, 10.6%). Over 65% of the participants were aged 38 years or younger and 55.2% were males. More than two-third of the participants (79.2%) had at least a Bachelor degree while 20.8% had either a secondary or primary (basic) school education. About 52% were living with 4 – 6 persons during the study period while 18.6% lived alone.

Perspective of Sub-Saharan Africans on 5G technology and COVID-19

The belief that 5G technology was linked to the COVID-19 pandemic was upheld by 7.4% of the participants in this study, and some participants (31.3%) stated that they practiced self-isolation while 39.3% practiced home quarantine during the pandemic. Responding to the question of how worried they were about COVID-19, over 57% of the participants stated that they were either very worried or somehow worried about the disease (Table 2). During the COVID-19 lockdown in SSA, nearly half (46%) of the participants in the study attended crowded religious events and a majority (76.1%) wore a mask when going out.

Figure 1 showed the regional proportion and 95% confidence intervals of participants in this study who believed 5G technology was behind COVID-19 pandemic in Sub- Saharan Africa. According to the figure, Central Africa had the highest proportion (14.4%) of participants that believe in the 5G technology myth while few participants (5.4%) from Southern Africa believed in the 5G technology myth.

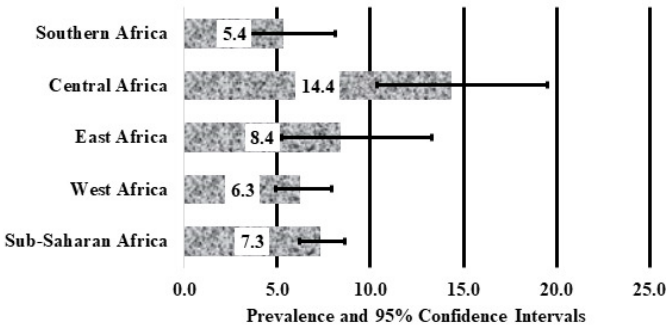

Figure 1. *Regional proportion and 95% Confidence interval of participants who associated 5G with COVID-19 in Sub-Saharan Africa*

Table 2: Respondent characteristics and study variables

Variables	N (%)
Demography	
Region	
West Africa	1,108 (56.3)
East Africa	209 (10.6)
Central Africa	251 (12.7)
Southern Africa	401 (20.4)
Place of residence	
Locally (Africa)	1855(92.5)
Diaspora	150 (7.5)
Age category	
18-28 years	775 (39.0)
29-38 years	530 (26.7)
39-48 years	441 (22.2)
49+years	242 (12.1)
Sex	
Males	1099 (55.2)
Females	892 (44.8)
Marital status	
Married	879(44.1)
Not married	1116 (55.9)
Highest level of Education	
Postgraduate Degree (Masters /PhD)	642 (32.2)
Bachelor's degree	(939) 47.0
Secondary/Primary	416 (20.8)
Employment status	
Employed	1321 (66.0)
Unemployed	679 (34.0)
Religion	
Christianity	1763 (88.4)
Others	232 (11.6)
Occupation	
Non-health care sector	1,471 (77.3)
Health care sector	433 (22.7)
Number living together	
<3 people	506(28.8)
4-6 people	908 (51.7)
6+ people	341 (19.4)

Table 2: Continued

Variables	N (%)
Attitude towards Covid-19	
Self-Isolation	
No	1237 (66.7)
Yes	564 (31.3)
Home quarantined due to Covid-19	
No	1091 (60.7)
Yes	707 (39.3)
Do you live alone during COVID-19	
No	1,624 (81.4)
Yes	372 (18.6)
Compliance during Covid-19 lockdown	
Attended crowded religious events	
No	1097 (54.0)
Yes	935 (46.0)
Wore mask when going out	
No	485 (23.9)
Yes	1547 (76.1)
Practiced regular Handwashing	
No	762 (37.5)
Yes	1270 (62.5)
Covid-19 Risk Perception	
Risk of becoming infected	
High	669 (37.2)
Low	1128 (62.8)
Risk of becoming severely infected	
High	466 (25.9)
Low	1333 (74.1)
Risk of dying from the infection	
High	349 (19.5)
Low	1445 (80.6)
How worried are you because of COVID-19	
worried	1037 (57.5)
not worried	766 (42.5)
How likely do you think COVID-19 will continue in your country	
Very likely	1152 (64.0)
not very likely	649 (36.0)
Concern for self and family if COVID-19 continues	
Concerned	1667 (94.2)
Not concerned	102 (5.8)
Outcome measure	
COVID caused by 5G	
No	1723 (92.6)
Yes	137 (7.4)

Table 3 reported the proportion and unadjusted odds ratio (OR) as well as the 95% confidence interval of the odds ratio that 5G technology was associated with COVID-19. The unadjusted odd ratios revealed that participants from Central African countries, female participants, those who were not married and unemployed, and participants with primary/secondary education qualification, were more likely to believe that 5G technology was linked to the COVID-19 disease. Compared with the younger age group (age 18-28 years), older participants (29 to 48 years) were less likely to believe that 5G technology was linked to the COVID-19 pandemic while, those who perceived that COVID-19 was less likely to continue in their country were 1.50 times (95% confidence interval of unadjusted odds ratio 1.05 – 2.15) more likely to believe that 5G technology was linked to COVID-19 pandemic (see Table 3).

Table 3. Proportion and unadjusted odds ratio (95%Confidence intervals , CI) of factors associated with 5G technology and COVID-19

Variables	Proportion	Odds Ratio	[95%CI]	P value
Demography				
Country of origin				
West Africa	6.3	1.00		
East Africa	8.4	1.38	[0.78, 2.44]	0.271
Central Africa	14.4	2.51	[1.61, 3.93]	<0.001
Southern Africa	5.4	0.85	[0.51, 1.42]	0.531
Place of residence				
Local	7.4	1.00		
Diaspora	8.3	1.15	[0.60, 2.00]	0.678
Age category				
18-28 years	10.7	1.00		
29-38 years	5.6	0.50	[0.32, 0.79]	<0.001
39-48 years	3.7	0.32	[0.18, 0.57]	<0.001
49+years	7.8	0.70	[0.41, 1.21]	0.202
Sex				
Males	5.5	1.00		
Females	9.5	1.80	[1.26, 2.57]	<0.001
Marital Status				
Married	5.7	1.00		
Not married	8.7	1.56	[1.08, 2.25]	0.017
Highest level of Education				
Postgraduate Degree	5.4	1.00		
Bachelor's degree	8.1	1.53	[1.00, 2.35]	0.051
Secondary/Primary	8.8	1.69	[1.02, 2.80]	0.041
Employment status				
Employed	5.6	1.00		
Unemployed	10.9	2.08	[1.46, 2.96]	<0.001
Religion				
Christianity	7.5	1.00		
Others	6.1	0.80	[0.45, 1.45]	0.47
Occupation				
Non-health care sector	7.6	1.00		
Health care sector	7.4	0.96	[0.63, 1.47]	0.856
Number living together				
<3 people	6.3			
4-6 people	8.6	1.41	[0.90, 2.21]	0.133
6+ people	7.8	1.27	[0.73, 2.20]	0.406
Attitude				
Self-Isolation				
No	6.7	1.00		
Yes	8.4	1.29	[0.89, 1.87]	0.186
Home quarantined due to Covid-19				
No	6.3	1.00		
Yes	8.7	1.43	[0.99, 2.05]	0.054
Compliance with mitigation practices				
Attended crowded religious events				
No	6.5	1.00		
Yes	8.6	1.37	[0.96, 1.93]	0.08
Wore mask when going out				
No	7.3	1.00		
Yes	7.4	1.01	[0.68, 1.50]	0.978
Practiced regular Hand washing				
No	9	1.00		
Yes	6.6	0.71	[0.50, 1.01]	0.06
Risk Perception				
Risk of becoming infected				
High	8.5	1.00		
Low	6.5	0.74	[0.52, 1.07]	0.106
Risk of becoming severely infected				
High	9	1.00		
Low	6.6	0.71	[0.49, 1.05]	0.085
Risk of dying from the infection				
High	8	1.00		
Low	7.1	0.87	[0.56, 1.35]	0.533
Worried are you because of COVID-19				
Very worried	7			
not very worried	7.4	1.05	[0.73, 1.50]	0.805
Concern for self and family if COVID-19 continues				
Very concerned	7			
Not very concerned	10.8	1.6	[0.83, 3.08]	0.158
Likelihood of COVID-19 continuing in your country				
Very likely	6.3	1.00		
not very likely	9.1	1.50	[1.05, 2.15]	0.027

Variables with confidence intervals CI that include '1' were not statistically significant in the model.

Table 4 showed the independent predictors of the association between 5G technology and COVID-19 disease. Participants who were living in Central Africa, females, and those who were unemployed at the time of this study were more likely to associate 5G technology with COVID-19. Also, belief in the 5G technology myth was associated with participants' level of risk perception, such that those who felt that the disease was not going to continue in their various countries after the lockdown were more likely to associate 5G technology with COVID-19 disease (adjusted odds ratio [aOR] 1.57, 95%CI 1.07 – 2.31) compared with those who felt that the disease was more likely to remain in their respective countries after the lockdown. Participants with low risk perception of contracting the infection, and those who were aged 39-48 years were less likely to associate 5G technology with COVID-19 compared to those who had high risk perception of contracting the infection and younger participants, respectively.

Table 4. Predictors of the association between belief in 5G technology and COVID-19.

Variables	Predictors		
Demography	Odds Ratio	[95%CI]	P value
Country of origin			
West Africa	1.00		
East Africa	1.30	[0.70, 2.41]	0.406
Central Africa	2.03	[1.25, 3.30]	0.004
Southern Africa	0.79	[0.46, 1.35]	0.39
Age category			
18-28years	1.00		
29-38	0.59	[0.34, 1.05]	0.073
39-48	0.45	[0.22, 0.94]	0.035
49+years	1.07	[0.55, 2.10]	0.835
Sex			
Males	1.00		
Females	1.59	[1.09, 2.34]	0.017
Employment status			
Employed	1.00		
Unemployed	1.64	[1.00, 2.70]	0.049
Risk perception			
Risk of becoming infected			
High	1.00		
Low	0.64	[0.43, 0.94]	0.023
How likely do you think COVID-19 will continue in your country?			
Very likely			
not very likely	1.57	[1.07, 2.31]	0.022

ORs=adjusted odds ratios; CI: Confidence intervals

Variables with confidence intervals CI that include '1' were not statistically significant in the model.

Backward stepwise regression model was conducted.

Discussion

To the best of our knowledge, this is the first study from SSA to examine key factors associated with the myth about 5G technology and COVID-19 as well as how this myth influences compliance with prescribed behavioral measures to control the spread of the disease. The study found that, irrespective of whether participants were living within the sub-region or in the diaspora, nearly one in every thirteen adult participants from SSA believed that 5G technology was linked with the outbreak of COVID-19. This was more among those from Central African and East African countries, where the proportions were 14% and 8%, respectively. After adjusting for all potential cofounders, participants from Central Africa, females, those that were unemployed and individuals in this study who thought that COVID-19 was not going to continue in their country after the lockdown, were more likely to hold this myth. There was a consistent strong association between older age (39-48yrs) and the lower likelihood of believing in the 5G myth. Perception of risk of contracting the infection was associated with the belief in the 5G myth.

The findings of this study were in concordance with a study conducted in England which reported that about 10 – 15% of the participants showed constant and very high levels of endorsements of the myth and those who believed that 5G technology was linked with the COVID-19 pandemic was associated with less compliance with government preventive measures [2]. In a new study conducted in Australia [21], researchers found that men and people aged 18-25 were more likely to believe COVID-19 myths and this was more among people from a non-English speaking background. We found similar associations with young people indicating that

significant proportion of younger people (18-28 years) reported that 5G technology was associated with COVID-19 pandemic while those aged between 39 and 48 years were less likely to believe in the 5G technology myth after adjusting for all potential cofounders. This preponderance of young people may be due to the fact that younger people (aged 18 – 29 years) in SSA are more likely to own smartphones compared to older ones aged 50 and older [22]. There is need to reach young people with health messages particularly, since they are less likely to have symptoms, and as such may not meet testing criteria such as having a sore throat, fever or cough; more likely to have more social contacts through seeing friends more often, which increases their potential for spreading COVID-19, and can potentially be hospitalized with COVID-19 with severe complications in some despite their age.

The study conducted in England observed that endorsement of the coronavirus conspiracy belief was associated with less compliance to government preventive measures [2]. Although the proportion of participants who held the 5G myth was less than those who held similar belief in the England study [2], it should not be treated lightly especially for the fact that currently there is no end in sight for a medication or vaccine for COVID-19 and the fear of a second wave is staggering. Such myths or conspiracy beliefs in the midst of a pandemic crisis can have far-reaching consequences for the introduction of a vaccine in this region, with belief in anti-vaccine myths being linked to potential non-compliance [23,24].

Although the present study could not corroborate these fears as participants, who held the myth that 5G was linked to the coronavirus pandemic had similar rate of compliance with the precautionary measures put in place to minimize the spread of the infection compared with those who did not hold the belief. A study conducted in England observed that endorsement of the coronavirus conspiracy belief was associated with non-compliance with government preventive measures [2], with another worrying phenomenon being that, myths are never benign and people who hold one myth are more likely to believe other unrelated ones [2,25]. In this study, participants who thought the infection will not continue after the lockdown were more likely to associate it with the 5G myth. Our suggestion therefore is that there must be concerted regional and global educational campaigns to recondition the minds of the populace before the introduction of a vaccine. Freeman et al. (2020) did not only observe a significant association between the myths and non-compliance with preventive guidelines but also the participants' skepticism to undertake future tests and vaccinations.

The differing levels of belief in the 5G myth among participants across the SSA sub-region as well as between other studies may reflect varying degrees of drivers of the myths such as mistrust [26] and other related consequences. Social identity including religion and nationality are known to promote the belief of myths [27]. Surveys in the USA and the United Kingdom found strong association between holding the myth and national narcissism (the trust in the greatness of one's country) such that people who scored high in national narcissism were more likely to believe and disseminate myths about COVID-19 [28]. Unlike a previous study [2], the current study did not find any significant association between the 5G myth and the different religious groups. This is probably due to the disproportionate over-representation of Christians over other religious groups in this study.

Factors such as lower income and education levels [29], low social standing [30] and less ability to analyze [31] have all been linked to holding to myths. It was therefore not surprising that in the present study, with everything held equal, participants who have a bachelor's degree or less and those who were unemployed were more likely to believe that the 5G technology was associated with the outbreak of coronavirus infection. Further ramifications are that the worsening economic conditions resulting from the coronavirus counter-measures can trigger or aggravate contiguous myths relating to the pandemic and further derail future efforts towards the introduction of medical interventions through tests and vaccinations. It is important that researchers interpret the finding that education is linked to the myth of 5G technology with caution, particularly as the participants in this study are biased regarding education.

The finding that that after controlling for all potential cofounders, participants who did not think that the infection will continue after the lockdown despite the lack of vaccine were more likely to associate the infection with the 5G technology validates the propositions of the health belief model (HBM). Constructs of HBM, specifically perceived susceptibility and perceived severity postulate that individuals will take actions to prevent or reduce a health problem if they perceive themselves as susceptible to the health problem or if they perceive the health problem will have serious consequences [20]. Perhaps the perception that the pandemic was being engineered by a telecommunication technology also led to their belief that they were less susceptible to the disease or that it would have trivial or minor health consequence.

Since many of the SSA countries still do not have the 5G technology, it is unlikely to accurately predict the impact of such belief on their attitude towards the 5G technology, however, early educational campaigns prior to the launch of the technology is recommended. Ensuring that people understand the benefits of the technology and how this can improve connectivity of people and access to information will facilitate the introduction and dissuade such belief. In addition, further studies targeting the SSA populations most affected by this belief are therefore recommended.

In considering the results from this study and the implications, the following limitations in the study should be noted. Given the difficulty of obtaining random sample from the study population, a convenient sampling technique was employed and this may affect the generalizability of the study results. However, during the lockdown, this was the only feasible way of collecting data from participants and this study provides an insight on the subject matter in the population surveyed. The data may be skewed towards those who may have access to internet and regularly use the social media platforms used in distributing the survey questionnaire. Being an electronic survey, residents in SSA who do not have access to the internet may have been unduly excluded from the study, which may account for the preponderance of the younger age group (over 65% were 38 years or younger). Furthermore, deploying the questionnaire in English language also excluded the non-English speaking residents in SSA such as the French-speaking people from the Central and West African region.

When interpreting the present results, researchers should be cautious especially as non-response is not known most probably because, we do not know who has received an invitation to participate. In addition, as this was a cross-sectional study and findings may be due chance, the estimates reported may have overestimated or underestimated 5G myths linked to COVID-19 in SSA and causality cannot be assumed.

Conclusions

In summary, this study demonstrated that 7.4% of adult participants in this study associated 5G technology with the outbreak of COVID-19, more in young people, females, those living in Central Africa and participants who were unemployed at the time of this study. Public health intervention including health education strategies to address the myth that 5G was linked COVID-19 pandemic in SSA are needed and such intervention should target these participants including those who do not believe that COVID-19 pandemic will continue in their country, in order to minimize further spread of the disease in the region.

Conflicts of interest Authors declare no conflict of interest

Ethics approval This study was approved by the Health Research and Ethics Committee, of the institution and was carried out in accordance with the Helsinki Declaration for Human Research. The confidentiality of participants was assured in that no identifying information was obtained from participants.

Consent to participate Informed consent was obtained online from all participants prior to completing the survey

Consent for publication Not applicable

Availability of data and material All data generated or analysed during this study are included in this published article.

Author contributions

All authors contributed equally to this work.

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Supplementary Table: Sample of survey tool used in the study

CONSENT

I willingly agree to participate in this survey because I am interested in contributing to the knowledge and perceptions on Coronavirus disease (COVID-19) Pandemia. I understand that there are no forms of payments or reward associated with my participation.

UNDERSTOOD, AGREE AND INTERESTED, NOT UNDERSTOOD, DISAGREE AND NOT-INTERESTED

Country of origin
Country of residence
Province/State/County
Gender MALE, FEMALE, OTHERS
Age (Years)
Marital Status SINGLE, MARRIED, SEPARATED/DIVORCED WIDOW/WIDOWER
Religion MUSLIM, CHRISTIAN, AFRICAN, TRADITIONALIST, OTHERS
Highest level of education

PRIMARY SCHOOL, HIGH/SECONDARY SCHOOL, POLYTHECNIC/DIPLOMA, UNIVERSITY DEGREE (Bachelors/Professional), POSTGRADUATE DEGREE (Masters/PhD)

Employment Status SELF EMPLOYED, EMPLOYED ,UNEMPLOYED, STUDENT/NON-STUDENT
Occupation
Do you live alone? YES, NO
If you live with family/friends, how many of you live together?

General

KNOWLEDGE of COVID-19 Origin and outbreak

Are you aware of the Coronavirus disease (COVID-19) outbreak? YES,NO
Are you aware of the origin of the Coronavirus disease (COVID-19) outbreak? YES,NO
Do you think Coronavirus disease (CoVID-19) outbreak is dangerous? YES,NO
Do you think Public Health Authorities in your country are doing enough to control the Coronavirus disease (CoVID-19) outbreak? YES,NO
Do you think Coronavirus disease (COVID-19) has little effect(s) on Blacks than on Whites? YES, NO, NOT SURE

KNOWLEDGE OF PREVENTION

Do you think Hand Hygiene / Hand cleaning is important in the control of the spread of the Coronavirus disease (COVID-19) outbreak
YES, NO, NOT SURE
Do you think ordinary residents can wear general medical masks to prevent the infection by the COVID-19 virus? YES, NO, NOT SURE
Do you think Coronavirus disease (COVID-19) is associated with 5G communication? YES, NO, NOT SURE
Do you think antibiotics can be effective in preventing Coronavirus disease (COVID-19) outbreak? YES, NO, NOT SURE
If yes to Q22 above, have you purchased an antibiotic in response to COVID-19 disease outbreak? YES, NO
Do you think there are any specific medicines to treat Coronavirus disease (COVID-19)? YES, NO, NOT SURE
Do you think there would be a vaccine for preventing Coronavirus disease (COVID-19) outbreak in the next 6 months? YES, NO, NOT SURE
Do you think Coronavirus disease (COVID-19) was designed to reduce world population? YES, NO, NOT SURE

Knowledge of symptoms

The main clinical symptoms of Coronavirus disease (COVID-19) are: (Type "YES" or "NO" to the suggested options as applicable)
FEVER, FATIGUE, DRY COUGH, SORE THROAT
Unlike the common cold, stuffy nose, runny nose, and sneezing are less common in persons infected with the COVID-19 virus.
TRUE, FALSE, NOT SURE
There currently is no effective cure for COVID-2019, but early symptomatic and supportive treatment can help most patients recover from the infection
TRUE, FALSE, NOT SURE
It is not necessary for children and young adults to take measures to prevent the infection by the COVID-19 virus.
TRUE, FALSE, NOT SURE
COVID-19 individuals cannot spread the virus to anyone if there's no fever.
TRUE, FALSE, NOT SURE
The COVID-19 virus spreads via respiratory droplets of infected individuals
TRUE, FALSE, NOT SURE

Knowledge of prevention

To prevent getting infected by Coronavirus disease (COVID-19), individuals should avoid going to crowded places such as train stations, religious gatherings, and avoid taking public transportation TRUE, FALSE, NOT SURE
Isolation and treatment of people who are infected with the Coronavirus disease (COVID-19) virus are effective ways to reduce the spread of the virus. The observation period is usually 14 days TRUE, FALSE, NOT SURE
Not all persons with COVID-2019 will develop to severe cases. Only those who are elderly, have chronic illnesses, and are obese are more likely to be severe cases. TRUE, FALSE, NOT SURE
Have you or anyone you know been affected by the Coronavirus disease (COVID-19) in any way(s)? YES, NO
If Yes to Q36 above, how did the Coronavirus disease (COVID-19) affect you or that person you know? (Type "YES" or "NO" as applicable to the listed effects) LOST JOB, LOST/CLOSED DOWN BUSINESS, CONTRACTED COVID-19, HOSPITALIZED DUE TO COVID-19 COMPLETELY SEPARATED FROM FAMILY, COMPLETELY STRANDED IN A FOREIGN COUNTRY/AWAY FROM REGULAR HOME/IN A DIFFERENT LOCATION FROM USUAL LOCATION OF RESIDENT

PERCEPTION OF RISK OF INFECTION

Risk of becoming infected. VERY HIGH, HIGH,LOW, VERY LOW, UNLIKELY
Risk of becoming severely infected VERY HIGH, HIGH, LOW, VERY LOW, UNLIKELY
Risk of dying from the infection VERY HIGH, HIGH, LOW, VERY LOW, UNLIKELY
How worried are you because of COVID-19? A GREAT DEAL, A LOT, A MODERATE AMOUNT, A LITTLE, NONE AT ALL
How do you feel about the self-isolation? (Type "YES" or "NO" to the suggested options as applicable)
WORRIED, BORED,FRUSTRATED, ANGRY, ANXIOUS
I consider the self-isolation as necessary and reasonable
STRONGLY AGREE, AGREE, NEITHER AGREE, NOR DISAGREE, DISAGREE, STRONGLY DISAGREE
Do you think that if you are able to hold your breath for 10 seconds, it's a sign that you don't have COVID-19? YES, NO, NOT SURE
If you drink hot water, it flushes down the virus
STRONGLY AGREE, AGREE, NEITHER AGREE, NOR DISAGREE, DISAGREE, STRONGLY DISAGREE

WE HAVE TWO OUTCOMES VARIABLES FOR CHLOROQUINE STUDY

Perception and Action

Do you believe that Coronavirus disease (COVID-19) can be cured by taking Chloroquine tablets? YES, NO, NOT SURE
If yes to Q46 above, have you purchased Chloroquine for the Coronavirus (COVID-19)? YES, NO
How likely do you think Coronavirus disease (COVID-19) will continue in your country?
VERY LIKELY, LIKELY NEITHER LIKELY, NOR UNLIKELY UNLIKELY VERY UNLIKELY
If Coronavirus disease (COVID-19) continues in your country, how concerned would you be that you or your family would be directly affected?
EXTREMELY CONCERNED CONCERNED NEITHER CONCERNED, NOR UNCONCERNED UNCONCERNED
EXTREMELY UNCONCERNED

PRACTICE REGARDIING COVID-19

In recent days, have you gone to any crowded place including religious events? ALWAYS, SOMETIMES, RARELY, NOT AT ALL, NOT SURE
In recent days, have you worn a mask when leaving home? ALWAYS, SOMETIMES, RARELY, NOT AT ALL, NOT SURE
In recent days, have you been washing your hands with soap and running water for at least 20 seconds each time?
ALWAYS, SOMETIMES, RARELY, NOT AT ALL, NOT SURE

Are you currently or have you been in (domestic/home) quarantine because of COVID-19?	YES, NO
Are you currently or have you been in self-isolation because of COVID-19?	YES, NO
Since the government gave the directives on preventing getting infected, have you procured your mask and possibly sanitizer?	YES, NO
Have you travelled outside your home in recent days using the public transport	YES, NO
Are you encouraging others that you come in contact with to observe the basic prevention strategies suggested by the authorities?	YES, NO

How much have you changed the way you live your life because of the possibility of continuing of Coronavirus disease (COVID-19)?
A GREAT DEAL, A LOT, A MODERATE AMOUNT, A LITTLE, NONE AT ALL

THANK YOU FOR TAKING OUR SURVEY

(Source: Revised and Adopted from WHO, 2020)

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7. Opinion and Uptake of Chloroquine for treatment of Coronavirus during the Mandatory Lockdown in Sub Sahara African Region

Abstract

Background: As the search for effective treatment of coronavirus infection (COVID-19) continues, the public opinion around the potential use of chloroquine in treating COVID-19 remain mixed.

Aim: To examine opinion and uptake of Chloroquine (CQ) for treating COVID-19 in Sub- Sahara African (SSA)

Methods: Anonymous online survey of 1829 SSAs was conducted during the lockdown using Facebook, WhatsApp and authors' networks. Opinion and uptake of CQ for COVID-19 treatment were assessed using multivariate analyses.

Results: About 14% of respondents believed that CQ could treat COVID-19 and of which, 3.2% took CQ for COVID-19 treatment. Multivariate analyses revealed that respondents from Central (adjusted odds ratios (AOR): 2.54, 95%CI 1.43, 4.43) and West Africa (AOR: 1.79, 95%CI 1.15, 2.88) had higher odds of believing that CQ could treat COVID-19. Respondents from East Africa reported higher odds for uptake of CQ for COVID-19 than Central, Western and Southern Africans. Knowledge of the disease and compliance with the public health advice were associated with both belief and uptake of CQ for COVID-19 treatment.

Conclusions: Central and West African respondents were more likely to believe in CQ as a treatment for COVID-19 while the uptake of the medication during the pandemic was higher among East Africans. Future intervention discouraging the unsupervised use of CQ should target respondents from Central, West and East African regions.

Keywords: Coronavirus; sub-Saharan Africa; chloroquine hydrochloride; Africa; poisoning

Introduction

Global public health authorities must combat dangerous and unproven theories about the use of the antimalarial, chloroquine (CQ), for treating COVID-19 infections despite lack of evidence. Since the declaration of COVID-19 pandemic by the World Health Organization (WHO) in March 11th, 2020[1], vaccines are now being introduced in different countries for treatment of the infection[2] but their effectivity is still in test.[3] Aware that novel treatments and/or vaccines will take time to be distributed to patients, there is growing interest in the use of existing medications, such as CQ and hydroxychloroquine (HCQ), as potential treatments of COVID-19.[4-7] Despite promising in vitro results[8], there is no direct supporting data on the effective role of CQ and HCQ in the treatment for COVID-19.[9] Those reporting that the drug has a favorable effect on the outcomes of COVID-19 were not clinical trials and used poor methodology.[5, 6, 10,11, 12]

CQ and its analogue, HCQ are considered safe and have side effects that are generally mild and transitory. However, there is a narrow margin between the therapeutic and toxic dose, and CQ poisoning has been associated with life-threatening cardiovascular disorders and [13] irreversible blindness from CQ retinopathy.[14] Also, treatment with HCQ has been associated with in-hospital mortality in patients with COVID-19 in New York State.[1] CQ is proven effective as an antimalarial, amoebicide and antirheumatic, and its possible adverse reactions are well documented[15]. The use of this medication outside of these conditions should be appropriately monitored in the hospital as required by the Emergency Usage Authorization (EUA) or in a clinical trial with appropriate screening and monitoring.[16, 17]

Early on in the pandemic, the media environment was awash with misinformation concerning the use of chloroquine in the treatment of the COVID-19 infection. Layered on top of this was the retraction on June 4th, 2020 of the Lancet paper, which claimed that treating COVID-19 with the antimalarial drug raised the heart-related death risk for COVID-19 patients in the hospital without showing any benefit.[18] The study was the basis for the halt of many studies of the antimalarial by WHO. The indiscriminate promotion of this medication by those in authority and widespread use of CQ in Africa has led to extensive shortages, self-treatment, and fatal overdoses.[19] The shortages and increased market prices of this medication left the already weak health systems in Africa vulnerable to substandard and falsified medical products.17 Governments in SSA countries are "strongly considering" putting prescription monitoring programs in place to ensure that off-label use of chloroquine and hydroxychloroquine is appropriate and beneficial for COVID-19 patients.[17]

Considering the public-health emergency nature of COVID-19 and the new challenges of the second wave in SSA[20], it is necessary to investigate the perception and behavior of Africans regarding CQ use for COVID-19. This study sought the opinions of people from SSA about the belief that CQ can cure COVID-19, and the influence of such a belief on their behavior by purchasing the medication to treat the infection and the factors associated with these variables. This study assessed the relationship between respondents' belief and use of CQ as a cure for COVID-19 and the compliance to the mitigation practices put in place by the respective governments to limit the spread of the virus. The findings are important for planning strategies for the control of COVID-19 and future outbreaks and will help to identify the population at greater

risk of CQ abuse, which can be targeted to prevent complications as the pandemic still unfolds. Also, the findings will help to design interventions that will minimize the indiscriminate and/or unauthorized use of this medication among the population.

Methods Study Design

This self-administered web-based survey was conducted during the mandatory lockdown period (April 27th – May 17th, 2020) in most of the countries surveyed. It was not feasible to perform a nationwide community-based sample survey during the lockdown period, so data were obtained electronically through survey monkey. The questionnaire included a brief overview of the context, purpose, procedures, nature of participation, privacy and confidentiality statements and notes to be filled. Informed consent and permission to use de-identifiable information in the publication was obtained from the respondents. Information was sought on the respondents' knowledge of the causes and symptoms of COVID-19 using the WHO validated tool.[21] Respondents were also asked about their belief on the use of CQ for treatment of COVID-19, and if they had purchased and used CQ during the COVID-19 pandemic to avoid contracting the virus. Prior to the launching of the survey, a pilot study was conducted to ensure clarity and understanding as well as to determine the duration for completing the questionnaire. Participants (n=10) who took part in the pilot were not part of the research team and did not participate in the final survey as well. This self-administered online questionnaire consisted of 58 items divided into four sections (demographic characteristics, knowledge, attitude, perception and practice).

Setting

The questionnaire was disseminated on social media platforms (Facebook and WhatsApp) commonly used by the locals in the participating countries. Emails sent to authors' contacts and contact groups were also used by the researchers to facilitate response. On all platforms, recipients were encouraged to share the e-link of the survey with others.

Study population and sample size determination

Data was collected from four SSAs regions including Western, Eastern, Southern and Central Africa which consisted of people from Ghana, Cameroun (English speaking populations), Nigeria, South Africa, Tanzania, Kenya, Uganda, Malawi, Rwanda etc. Classification of countries into regions was based on the regions of the African Union[22]. To be eligible for participation, participants had to be 18 years and over, able to read and understand English and should be able to provide online consent.

The study assumed a proportion of 50% because the main objective of this research was on COVID-19 and no previous study from SSA has examined factors associated with belief and uptake of CQ as a cure for COVID-19 during the pandemic. For expected proportion with 2.5% absolute precision and 90% confidence, an online sample size calculator[23] determined that a sample size of approximately 1408 including 30% non- response rate was required to detect significant differences because it was an online survey. The sample size of 1829 participants used in this study is large enough to detect any statistical differences.

Independent variables

The independent variables included demographic (age, gender, marital status, country of origin (with Southern Africa as the base), education, employment and religion), practice (included compliance to mitigation practices of handwashing, self-isolation, quarantine and use of facemask when going out) and risk perception. Variables were summarized as counts and percentages for categorical variables.

Dependent variables

The dependent variables were the belief on the effectiveness of CQ for COVID-19 treatment, and purchase of the medication for COVID-19. Participants were asked the following questions: "Do you believe that COVID-19 can be cured by taking CQ tablets?" and "have you purchased CQ for COVID-19?". Responses were categorized as "Yes" (1) or "No" (0).

Data analysis

All analyses were performed in Stata version 14.1 (Stata Corp 2015, College Station, Texas, USA). A two-way frequency table was used to obtain the prevalence estimates of those who believed that CQ could be used to treat COVID-19 and those who purchased the CQ. In the univariate analyses, odds ratios with 95% confidence intervals were calculated in order to assess the unadjusted risk of the independent variables on selected covariates. Multiple logistic regression analyses used pooled data of the four sub-regions and different key dependent variables to examine their relationship with the number of years of formal education of the respondents. Also, the logistic regression was used to determine whether any observed effect persisted in the presence of possible confounding variables. In addition, the study determined whether the acquisition of CQ was influenced by the respondent's knowledge and compliance with mitigation practices put in place to stop the spread of the infection. Details of the questions utilized to derive scores for knowledge; compliance with mitigation practices was presented in the supplementary table (S1).

Ethical consideration

Ethical approval for the study was sought and obtained from the Human Research Ethics Committee of the [name deleted to maintain the integrity of the review process] (name deleted to maintain the integrity of the review process/HRP/HREC/2020/117). The study was carried out in accordance with the Helsinki Declaration for Human Research. The confidentiality of participants was assured in that no identifying information was obtained from participants. The study adhered to the tenets of Helsinki's declaration, and informed consent was obtained from all participants prior to completing the survey. Participants were required to answer a 'yes' or 'no' to the consent question during survey completion to indicate their willingness to participate in this study.

Table 1: Descriptive statistics for socio-demographic characteristics, knowledge, risk perception and compliance to practices towards the coronavirus disease 2019 infection.

Variables	n	%
Age category, in years (n = 1800)		
18-28	685	38.06
29-38	488	27
39-48	401	22.28
49+	226	12.56
Sex (n = 1801)		
Males	1005	55.8
Females	796	44
Sub-region (n = 1773)		
West Africa	999	56.4
East Africa	185	10.4
Central Africa	220	12.4
Southern Africa	369	20.8
Employment status (n = 1809)		
Employed	1205	67
Unemployed	604	33.39
Marital status (n = 1805)		
Married	802	44.43
Not married	1003	56
Religion (n = 1806)		
Christianity	1596	88.37
Others	210	11.63
Highest level of education (n = 1809)		
Postgraduate degree (Masters/PhD)	600	33.17
Bachelor's degree	986	54.51
Secondary/Primary	223	12.33
Profession		
Non-healthcare sector	1324	77.16
Healthcare sector	392	22.84
Do you live alone during COVID-19 (n = 1807)		
No	1474	81.57
Yes	333	18.43
Compliance		
Practised self-isolation (n = 1792)		
No	1231	68.69
Yes	561	31.31
Home quarantined because of COVID-19 (n = 1789)		
No	1084	60.59
Yes	705	39.41
Worried about contracting the infection (n = 1829)		
Very worried	574	31.38
Worried	675	36.91
Not worried	580	31.71
Knowledge of COVID-19 transmission †		
Inadequate (0-2 points)	1334	72.94
Adequate (3-4 points)	495	27.06
Knowledge of symptoms ‡		
Inadequate (0-6 points)	1180	64.52
Adequate (7-9 points)	649	35.48
Perception of risk of contracting the infection §		
Inadequate	958	52.38
Adequate	871	47.62
Compliance to mitigation practices		
Low	484	26.46
Moderate	1057	57.79
High	288	15.75

N = 1829

COVID-19, coronavirus disease 2019; PhD, Doctor of Philosophy.

†, the maximum score was 4 points; ‡, maximum score was 9 points; §, maximum score was 24 points.

Mitigation practices included those put in place by the African governments and included hand hygiene, use of facemasks, social distancing during the lockdown, not attending large gatherings including religious events.

Results

Characteristic of the sample

A total of 1829 adults responded to the outcome of interest in the survey and consisted of respondents from four SSA regions. Figure 1 shows the distribution of respondents by country of origin. The mean age was 26 years (range 18 – 50 years); many were aged 18-28 years (38.1%). More than half of the respondents were from Western Africa with a majority (91.3%) resident in their home country at the time of this study. Up to 87.7% had a university degree or higher education (Table 1). The majority were non- healthcare workers and did not live alone at the time of the COVID-19 lockdown.

Most (68.7%) of the African respondents practiced self-isolation during the pandemic, while 60.6% were quarantined at the recommendation of health officers. Many respondents expressed some worry about contracting the virus and knowledge of the transmission and symptoms of the infection were generally inadequate among the respondents, as shown in Table 1.

Prevalence of the belief and uptake of CQ for COVID-19 treatment during the pandemic

Figures 2 and 3 respectively show the prevalence and 95% CI of the belief in chloroquine as a cure for COVID-19 and uptake during COVID-19 pandemic for the four sub-regions, respectively. The prevalence of belief in CQ as a cure for COVID-19 was significantly higher in Central Africa (20, 95%CI: 15.2, 25.8) and lower in Southern Africa (9, 95%CI: 6.2, 12.0; p=0.001). Although there was higher uptake of CQ among East Africans during the pandemic, the difference was not statistically significant (p=0.174).

Of the 47 respondents in SSA who purchased CQ for COVID-19, nineteen of them (40.4%) did not believe that CQ was an effective treatment for COVID-19.

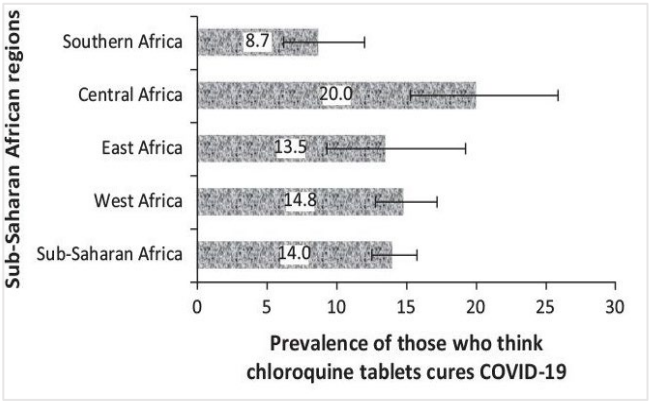

Figure 1: *Percentage distribution of the respondents by country of origin (n=1829) in sub-Saharan Africa*

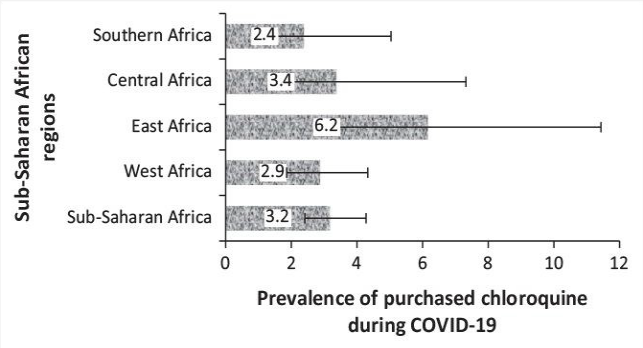

Figure 2: *Prevalence and 95% confidence intervals of the belief in chloroquine tablets for the coronavirus disease 2019 treatment in sub-Saharan African regions.*

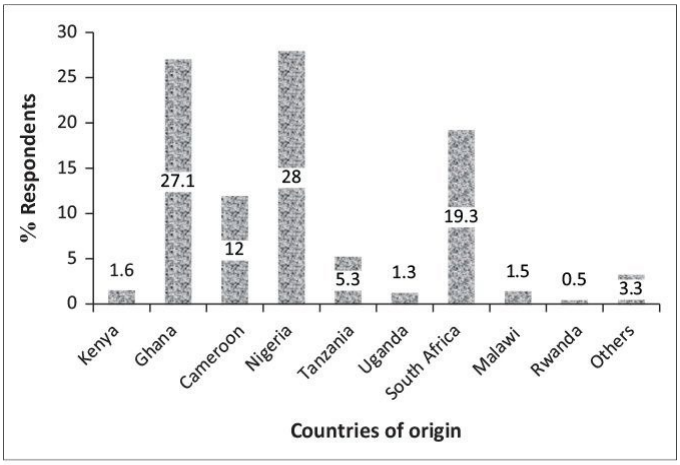

Figure 3: *Prevalence and 95% confidence intervals of chloroquine use for the coronavirus disease 2019 treatment in sub-Saharan African regions.*

Univariate analysis

Table 2 presents the unadjusted odds ratios and 95%CI of perceived effectivity of CQ and uptake among respondents in this study. From the table, respondents living in Central Africa (unadjusted odds ratio, OR 2.63, 95%CI 1.61, 4.30) and West Africa (OR 1.83, 95%CI 1.22, 2.74) were more likely to believe that CQ can cure COVID-19, however, age and educational status were not associated with any of the outcome variables in this cohort. By contrast, no significant association was observed between the uptake of CQ for the COVID-19 treatment and any of the demographic variables. Belief in the use of CQ and its uptake during the pandemic were not dependent on whether the participants lived in their country of origin or outside their country of origin. Respondents who perceived CQ as a cure for COVID-19 were more likely to be those that demonstrated adequate knowledge of how the virus is transmitted (OR 4.11, 95%CI 3.13, 5.39). They were also more likely to highly comply with the mitigation practices (OR 1.58, 95% CI 1.06, 2.34) put in place by the respective African governments to stop the spread of the virus during the pandemic. High compliance with the mitigation practices increased the odds of the demonstrated practice of purchasing CQ for treatment of COVID-19 by up to 4.5 folds compared to those who had poor compliance with the mitigation practices.

Multivariate analysis

Table 3 presents the multivariate analysis, which was adjusted for all potential cofounders. It was revealed that belief in the use of CQ for COVID-19 was predominant among respondents living in Central and West Africa, and was associated with adequate knowledge of the disease transmission (adjusted odds ratio, aOR 4.59, 95%CI 3.38, 6.23). By contrast, uptake of CQ during the pandemic was 3.18 folds (95%CI 1.02, 9.94) higher among East Africans than Southern Africans, after controlling for all the potential cofounders and was associated with high knowledge of the disease transmission and compliance with the mitigation practices during the outbreak.

Table 2: Prevalence and unadjusted odds ratios (95% confidence intervals) for factors associated with belief and uptake of chloroquine tablets for treating the coronavirus disease 2019 and uptake in response to the coronavirus disease 2019 outbreak in four sub-Saharan African regions.

Variables	Perception			Uptake		
	Prevalence	OR	95% CI	Prevalence	OR	95% CI
Sub-region						
Southern Africa	8.67	1	-	2.43	1	-
Central Africa	20	2.63	1.61-4.30	3.37	1.4	0.46-4.24
East Africa	13.51	1.65	0.94-2.87	6.16	2.64	0.96-7.23
West Africa	14.81	1.83	1.22-2.74	2.88	1.19	0.50-2.81
Knowledge of COVID-19						
Transmission †						
Inadequate	8.92	1	-	2.99	1	-
Adequate	28.69	4.11	3.13-5.39	4.08	1.38	0.75-2.52
Symptoms ‡						
Inadequate	14.92	1	-	3.41	1	-
Adequate	13.1	0.86	0.65-1.00	3.13	0.91	0.50-1.69
Perception of risk of contracting the infection§						
Low risk (0-13)	15.66	1	-	3	1	-
High risk (14-24)	12.74	0.79	0.60-1.03	3.64	1.22	0.68-2.19
Compliance to mitigation practices	-	-	-	-	1	-
Low	13	1	-	1.41	1	-
Moderate	13.5	1.05	0.76-1.44	3.37	2.44	0.95-6.37
High	19.1	1.58	1.06-2.34	6.01	4.47	1.59-12.60

COVID-19, coronavirus disease 2019; aOR, adjusted odds ratio; CI, confidence interval.
Only variables with significant association are shown. Confidence intervals (CIs) excluding '1' are statistically significant at $p < 0.05$ level;
†, the maximum score was 4 points; ‡, maximum score was 9 points; §,maximum was 24 points.
Mitigation practices included those put in place by the African governments and included hand hygiene, use of facemasks, self-isolation, social distancing during the lockdown, not attending large gatherings including religious events.

Table 3: Adjusted odds ratio (95% confidence intervals) of belief and uptake of chloroquine tablets for treating the coronavirus disease 2019.

Variables	Perception		Uptake	
	aOR	95% CI	aOR	95% CI
Sub-region				
Southern Africa	1.00	-	1.00	-
Central Africa	2.54	1.43-4.43	1.69	0.49-5.92
East Africa	1.61	0.85-2.93	3.18	1.02-9.94
West Africa	1.79	1.15-2.88	1.48	0.54-4.06
Knowledge of COVID-19				
Transmission †				
Inadequate	1.00	-	1.00	-
Adequate	4.59	3.38-6.23	2.03	1.04-3.97
Symptoms ‡				
Inadequate	1.00	-	1.00	-
Adequate	0.89	0.65-1.22	1.13	0.58-2.21
Compliance to mitigation practices	1.00	-	1.00	-
Low	1.13	0.77-1.65	2.23	0.75-6.62
High	1.56	0.96-2.55	4.33	1.30-14.40

COVID-19, coronavirus disease 2019; aOR, adjusted odds ratio; CI, confidence interval.
Only variables with significant association are shown. Confidence intervals (CIs) excluding '1' are statistically significant at $p < 0.05$ level;
†, the maximum score was 4 points; ‡, maximum score was 9 points; §,maximum was 24 points.
Mitigation practices included those put in place by the African governments and included hand hygiene, use of facemasks, self-isolation, social distancing during the lockdown, not attending large gatherings including religious events.

Discussion

This study provided the first comprehensive evidence on belief in the CQ controversy for COVID-19 treatment perception and behavior among the African population. It provides important knowledge to manage the evolving COVID-19 pandemic in the region. One in seven respondents believed that CQ can cure COVID-19, particularly Central and West Africans and those with adequate knowledge of the disease transmission. East Africans, and those that complied with the government mitigation practices, were also more likely to purchase CQ for COVID-19. The behavior to purchase CQ tablet for COVID-19 contradicts the WHO and the US Food and Drug Administration (FDA) warnings against the use of chloroquine for COVID-19.[16, 17]
The belief that CQ could cure COVID-19 and therefore be used indiscriminately for same may be impacting on the lives of others who depend on CQ for the approved uses.24 As shown in this study, more than two-thirds of those who purchased CQ did not believe in its use for COVID-19 treatment suggesting they may have bought the medication just for stocking to avoid possible future market shortage of the drug should it be proven that it was effective in treating COVID-19. Storage of the medication was already causing shortages across the region and had the potential to further increase the panic among those who depend on this medication for their medical conditions.19 The finding that people with adequate knowledge of the disease transmission were more likely to purchase CQ may be as a result of information overload and medication misinformation regarding cures for COVID-19 that have been shown to spread unnecessary fear and panic leading members of the public to undermine legitimate public health advice.25 Majority of the respondents were young people, were more likely to have internet access, and maybe more exposed to the media, which may not necessarily translate into an increase in actual knowledge. Exposure to the media might enhance the impression of one's knowledge or self- perceived knowledge, as reported previously.[26] Identifying this group of people and discouraging them from indiscriminate use of CQ certainly becomes a responsible public health approach.

The belief and uptake of CQ among the respondents may have also been

encouraged by the socio-behavioral factors of familiarity with the drug and its perceived efficacy.[27] This may explain the lack of association between the outcome variables and educational level in this study. Interestingly, we also found that those who were highly compliant with the government regulations to stop the spread of the disease were also more likely to endorse the CQ misinformation. This finding contrasts with those who believe in conspiracy theories such as the origin of the disease and vaccine efficacy who have been found to be less likely to be compliant to government regulations. [28, 29,30] The former is more likely driven by fear of contracting the disease while the latter is driven by mistrust.

The CQ controversy became the focus of global scientific, media, and political attention after a French virologist, went public on social media to promote the use of chloroquine to treat or prevent COVID-19.[31] His opinion was widely picked up by people across the globe, and many demanded immediate chloroquine for all.[32] Despite other studies that have shown that CQ may not be as efficacious as claimed especially in severe cases,[33-35] it still resulted in a scarcity for those who are on CQ/HCQ for legitimate indications such malaria and lupus. According to WHO guidelines, CQ is restricted and strictly reserved for severe malaria and special cases of uncomplicated malaria in patients allergic to other drugs[36].[37] Although, CQ has been removed as a first line treatment regimen for malaria caused by P*lasmodium falciparum* in SSA countries,[38] it is still available as an over the counter (OCT) medicine in many of them.[31, 36] The fear of contracting the disease as seen in 68% of the respondents who were 'worried about contracting COVID-19' may have driven people to buy whatever the media promotes as a cure for the disease. This behavior has spread beyond CQ to include zinc supplements, aspirin, vitamin C and azithromycin.[39]

Generally considered safe for the well-known approved indications in Africa, intake of CQ has been associated with severe adverse effects in COVID-19. Patients with underlying health issues, such as heart and kidney disease, are more likely to be at increased risk of experiencing heart problems when taking CQ and HCQ according to the FDA.[40] This becomes more disturbing in Africa where many have underlying diseases they are unaware of due to poor health systems and or lack of proper screening programs. With this in mind, and in the light of recent evidence that CQ and HCQ are not effective for the treatment of COVID-19[9], this study will guide SSA countries in formulating temporary prescription guidelines and restrictions around CQ usage. One way of doing this is through legislation of CQ/HCQ as prescription- only-medication and making it available to designated pharmacies within regions. In effect, with CQ/HCQ as prescription-only-medicine, physicians would be 'forced' professionally to state the actual indication for any prescriptions given. The current frontline drugs for malaria are the artemisinin based combination therapies (ACTs) which are also over the counter prescriptions.[41] These medications can be subsidized for this period by governments to make them accessible to the populace.[42] This study also recommends that physicians should place some emphasis on medication history of their patients to identify those who do not need the medication but are taking it, as well as using such encounters to counsel patients on medication safety and associated adverse effects. More importantly, the present finding would encourage concerted health promotional activities through campaigns at various

governmental levels on educating the people on the dangers of self-medication through radio and TV as well as via the commonly used social media platforms in each country. The media strategy was effective during the swine flu outbreak.[43] Series of public service announcements can be crafted, and made available in both English and French to increase awareness of the COVID-19. Such announcements should encourage testing and medical check for symptomatic patients, through emphasis on the benefits of testing, overcoming drug misinformation and increasing people's perceptions of their own ability to control the spread of the disease.

Formal education most often teaches basic reading skills, enlightens, and aids in removing some of the cultural ideologies that lead to the misconceptions that affect proper and adequate prevention and treatment of diseases. Although studies in Africa have shown a significant association between higher levels of education and positive knowledge, attitude and practice towards diseases like malaria,[44] as well as with recognition and appropriate treatment of diseases,[45,46] we found no association between level of education and both perception and uptake of CQ for COVID-19. This was despite the fact that in this study there was a preponderance of highly educated people in this study, though not reflective of the general population of the region.

Strengths and limitations

First, the survey was only administered online. It may not have captured the opinion of those in rural areas where internet penetration remains relatively low[47] and older people who are less likely to use internet compared to younger ones. Since the increase in public interest during the pandemic resulted in greater internet use,[48] this may not have a great impact on the findings coupled with the fact that it was the only reliable means to disseminate information at the time of this study. This was also an innovative way to provide real-time data on the current situation. Second, the survey was available only in English, making it impossible for some SSA francophone countries to participate, and the result may not be generalizable to all Sub-Saharan Africa population because of the sampling technique. Thirdly, there were wide variations in the response rate per region, which may be due to population differences and poverty levels that influence access to internet. Fourthly, the lack of incentive and not receiving assistance with any online company for distribution of the survey may have affected the reach of the survey. It also meant that the social media accounts could not be verified and those with multiple accounts could not be eliminated. The questionnaire however appealed to respondents not to fill the questionnaire more than once and the platform prevented respondents from submitting more than one response from the same account. Lastly, although the sample size was adequate to detect statistical differences, some CIs were stretched, suggesting that the study may benefit from a much bigger sample. Despite these limitations, this is the first study to provide evidence of the CQ controversy during the pandemic while controlling the potential confounders during the analysis. Another advantage of our survey is that it was collected when the restrictions were the strictest in the concerned countries. Data collection method was the same across the countries, and people answered on a voluntary basis. Beyond the reduced cost, another key advantage of online surveys is that the questionnaire is available to a great number of people, at any time of the day; also, the data can be processed in real-time.

Conclusion

In summary, the world faces imperatives to combat dangerous misinformation around COVID-19. In the absence of a known effective therapy, the possibility of a second wave of COVID-19 or another potential public-health emergency, this first population- based survey provided evidence of an avoidable danger of CQ abuse and its associated complications, particularly among East Africans. The gross inadequate knowledge and increasing worry shown by Africans in this study suggest the need for regional educational intervention to create awareness and sensitize the public on COVID-19 transmission as well as re-orientate the communities on the dangers of indiscriminate use of CQ during the pandemic. Pharmaco-medical control should be imposed on the acquisition of CQ by governments to control abuse. Public health officers and clinicians have roles to play in discouraging this attitude by highlighting the non-proven use of CQ in treating COVID-19. There is a risk that Africans who resort to CQ might not follow up on legitimate COVID-19 symptoms with their doctors, which in turn, could facilitate the spread of the virus and put their health, and potentially that of others, at risk.

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Data Availability: Data is available on reasonable request from the corresponding author

Conflicts of Interest: The authors declare no conflict of interest. “The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, or in the decision to publish the results”.

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Supplementary table 1: COVID-19 knowledge and practice survey in Africa

CONSENT/BASIC DESCRIPTION

Consent

- I willingly agree to participate in this survey because I am interested in contributing to the knowledge and perceptions on Coronavirus disease (COVID-19) Pandemia. I understand that there are no forms of payments or reward associated with my participation.
  - UNDERSTOOD, AGREE AND INTERESTED
  - NOT UNDERSTOOD, DISAGREE AND NOT-INTERESTED
- Country of origin
- Country of residence
- Province/State/County
- Gender
  - MALE FEMALE OTHERS
- Age (Years)
- Marital Status
  - SINGLE MARRIED SEOARATED/DIVORCED WIDOW/WIDOWER
- Religion
  - MUSLIM CHRISTIAN AFRICAN TRADITIONALIST OTHERS
- Highest level of education
  - PRIMARY SCHOOL HIGH/SECONDARY SCHOOL POLYTHECNIC/DIPLOMA
  - UNIVERSITY DEGREE (Bachelors/Professional) POSTGRADUATE DEGREE (Masters/PhD)
- Employment Status
  - SELF EMPLOYED EMPLOYED UNEMPLOYED STUDENT/NON-STUDENT
- Occupation
- Do you live alone?
  - YES NO
- If you live with family/friends, how many of you live together?

General Knowledge of COVID-19 Origin and outbreak

- Are you aware of the Coronavirus disease (COVID-19) outbreak?
  - YES NO
- Are you aware of the origin of the Coronavirus disease (COVID-19) outbreak?
  - YES NO
- Do you think Coronavirus disease (CoVID-19) outbreak is dangerous?
  - YES NO
- Do you think Public Health Authorities in your country are doing enough to control the Coronavirus disease (CoVID-19) outbreak?
  - YES NO

- Do you think Coronavirus disease (COVID-19) has little effect(s) on Blacks than on Whites?
    - YES NO NOT SURE

Knowledge of prevention

- Do you think Hand Hygiene / Hand cleaning is important in the control of the spread of the Coronavirus disease (COVID-19) outbreak
    - YES NO NOT SURE
- Do you think ordinary residents can wear general medical masks to prevent the infection by the COVID-19 virus?
    - YES NO NOT SURE
- Do you think Coronavirus disease (COVID-19) is associated with 5G communication?
    - YES NO NOT SURE
- Do you think antibiotics can be effective in preventing Coronavirus disease (COVID-19) outbreak?
    - YES NO NOT SURE
- If yes to Q22 above, have you purchased an antibiotic in response to COVID-19 disease outbreak?
    - YES NO
- Do you think there are any specific medicines to treat Coronavirus disease (COVID-19)?
    - YES NO NOT SURE
- Do you think there would be a vaccine for preventing Coronavirus disease (COVID-19) outbreak in the next 6 months?
    - YES NO NOT SURE
- Do you think Coronavirus disease (COVID-19) was designed to reduce world population?
    - YES NO NOT SURE

Knowledge of symptoms

- The main clinical symptoms of Coronavirus disease (COVID-19) are: (Type "YES" or "NO" to the suggested options as applicable)
    - FEVER FATIGUE DRY COUGH SORE THROAT
- Unlike the common cold, stuffy nose, runny nose, and sneezing are less common in persons infected with the COVID-19 virus.
    - TRUE FALSE NOT SURE
- There currently is no effective cure for COVID-2019, but early symptomatic and supportive treatment can help most patients recover from the infection
    - TRUE FALSE NOT SURE
- It is not necessary for children and young adults to take measures to prevent the infection by the COVID-19 virus.
    - TRUE FALSE NOT SURE
- COVID-19 individuals cannot spread the virus to anyone if there's no fever.
    - TRUE FALSE NOT SURE
- The COVID-19 virus spreads via respiratory droplets of infected individuals
    - TRUE FALSE NOT SURE

Knowledge of prevention

- To prevent getting infected by Coronavirus disease (COVID-19), individuals should avoid going to crowded places such as train stations, religious gatherings, and avoid taking public transportation
    - TRUE FALSE NOT SURE
- Isolation and treatment of people who are infected with the Coronavirus disease (COVID-19) virus are effective ways to reduce the spread of the virus. The observation period is usually 14 days
    - TRUE FALSE NOT SURE
- Not all persons with COVID-2019 will develop to severe cases. Only those who are elderly, have chronic illnesses, and are obese are more likely to be severe cases.
    - TRUE FALSE NOT SURE
- Have you or anyone you know been affected by the Coronavirus disease (COVID-19) in any way(s)?
    - YES NO
- If Yes to Q36 above, how did the Coronavirus disease (COVID-19) affect you or that person you know? (Type "YES" or "NO" as applicable to the listed effects)
    - LOST JOB LOST/CLOSED DOWN BUSINESS CONTRACTED COVID-19

- HOSPITALIZED DUE TO COVID-19 COMPLETELY SEPARATED FROM FAMILY
- COMPLETELY STRANDED IN A FOREIGN COUNTRY/AWAY FROM REGULAR HOME/IN A DIFFERENT LOCATION FROM USUAL LOCATION OF RESIDENT

Perception of risk of infection

- Risk of becoming infected.
  - VERY HIGH HIGH LOW VERY LOW UNLIKELY
- Risk of becoming severely infected
  - VERY HIGH HIGH LOW VERY LOW UNLIKELY
- Risk of dying from the infection
  - VERY HIGH HIGH LOW VERY LOW UNLIKELY
- How worried are you because of COVID-19?
  - A GREAT DEAL A LOT A MODERATE AMOUNT A LITTLE NONE AT ALL
- How do you feel about the self-isolation? (Type "YES" or "NO" to the suggested options as applicable)
  - WORRIED BORED FRUSTRATED ANGRY ANXIOUS
- I consider the self-isolation as necessary and reasonable
  - STRONGLY AGREE AGREE NEITHER AGREE, NOR DISAGREE
  - DISAGREE STRONGLY DISAGREE
- Do you think that if you are able to hold your breath for 10 seconds, it's a sign that you don't have COVID-19?
  - YES NO NOT SURE
- If you drink hot water, it flushes down the virus
  - STRONGLY AGREE AGREE NEITHER AGREE, NOR DISAGREE
  - DISAGREE STRONGLY DISAGREE
- How likely do you think Coronavirus disease (COVID-19) will continue in your country?
  - VERY LIKELY LIKELY NEITHER LIKELY, NOR UNLIKELY
  - UNLIKELY VERY UNLIKELY
- If Coronavirus disease (COVID-19) continues in your country, how concerned would you be that you or your family would be directly affected?
  - EXTREMELY CONCERNED CONCERNED NEITHER CONCERNED, NOR UNCONCERNED
  - UNCONCERNED EXTREMELY UNCONCERNED

Practice regarding covid-19

- In recent days, have you gone to any crowded place including religious events?
  - ALWAYS SOMETIMES RARELY NOT AT ALL NOT SURE
- In recent days, have you worn a mask when leaving home?
  - ALWAYS SOMETIMES RARELY NOT AT ALL NOT SURE
- In recent days, have you been washing your hands with soap and running water for at least 20 seconds each time?
  - ALWAYS SOMETIMES RARELY NOT AT ALL NOT SURE
- Are you currently or have you been in (domestic/home) quarantine because of COVID-19?
  - YES NO
- Are you currently or have you been in self-isolation because of COVID-19?
  - YES NO
- Since the government gave the directives on preventing getting infected, have you procured your mask and possibly sanitizer?
  - YES NO
- Have you travelled outside your home in recent days using the public transport
  - YES NO
- Are you encouraging others that you come in contact with to observe the basic prevention strategies suggested by the authorities?
  - YES NO
- How much have you changed the way you live your life because of the possibility of continuing of Coronavirus disease (COVID-19)?
  - A GREAT DEAL A LOT A MODERATE AMOUNT A LITTLE NONE AT ALL

THANK YOU FOR TAKING OUR SURVEY

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8. Differences in Perceived Risk of Contracting SARS-CoV-2 during and after the Lockdown in Sub-Saharan African Countries

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Abstract:

This study investigated risk perception in sub-Sahara Africa during and after the lockdown of contracting and dying of SARS-CoV-2. Two online surveys were conducted one year apart, with participants 18 years and above living in sub-Sahara Africa or the diaspora. Each survey took four weeks. The first survey was taken from 18 April to 16 May 2020, i.e., during the lockdown. The second survey was taken from 14 April to 14 May 2021, i.e., after the lockdown. A cross-sectional study using adopted and modified questionnaires for both surveys were distributed through online platforms. Question about risks perception of contracting and dying of SARS-CoV-2 were asked. The Helsinki declaration was applied, and ethical approvals were obtained. Total responses for both surveys, i.e., both during and after the lockdown, was 4605. The mean age was similar in both surveys (18–28 years). The mean risk perception scores were higher after lockdown by 3.59%. Factors associated with risk perception of COVID-19 were survey period, age group, region of residence, and occupation. Non–health care workers had a lower risk perception of COVID-19. This first comparative study on the level of risk perception of Africans during and after the lockdown shows that one in every three and every four persons in sub-Sahara Africa felt at high risk of contracting COVID-19 and thought they could die from contracting the same, respectively.

Keywords: SARS-CoV-2; sub-Sahara Africa; risks perception

1. Introduction

Since SARS-CoV-2, a beta coronavirus genre more closely linked to the SARS-CoV-1 (79% sequence identity) than to the MERS-CoV (52% identity) [1], was declared a pandemic by WHO in 2020 [2], the virus has infected over 237 million people, with the death of no less than 4,839,000 people, with US being the worst-affected country recording 727,273 deaths, followed by Brazil—599,414 deaths, India—449,883 deaths, Mexico—279,894 deaths, and Russia—212,625 deaths, as of 7 October 2021. In Africa, South Africa—87,981, Tunisia—24,971, Egypt—17,531, and Morocco—14,390 account for the highest number of deaths from COVID-19 in the region [3]. The SARS-CoV-2 infection presents with dry cough, fever, dyspnea, and lung trouble, among other signs [4]. With no effective cure or current drug for the treatment of the infection insight, SARS-CoV-2 continues to be a source of concern across the globe and more so in sub-Saharan Africa considering the poor health care system [5]. The rollout of the vaccines has been anything but smooth due to the mixed messages from the various governments and the difficulty in accessibility for developing countries [6,7]. This increases the mistrust displayed by citizens across the globe and increases the perception of risk in the community [7].

In sub-Saharan Africa (SSA), the impact of SARS-CoV-2 has remained minimal compared to the Americas, Europe, and Asia; however, there has been an increase in COVID-19 deaths across Africa since mid-July 2021.[§] Although the reasons for this are not well understood, researchers have suggested that the demographic age structure of sub-Saharan Africa is the leading factor of the low morbidity and mortality of COVID-19 compared to other regions of the world [8]. Other factors, such as the lack of long-term care facilities, potential cross-protection from previous exposure to circulating coronaviruses, and low testing of SARS-

CoV-2, have resulted in an undercounting of deaths and effective government public health responses have contributed to the lower burden of the disease [8]. According to data from the US Centers for Disease Control and Prevention (CDC), 80% of COVID-19-related deaths occur in individuals aged 65 years and older [9], with UK data demonstrating that advanced age is the strongest risk for death and dramatically outweighs the risks associated with any other demographic factor or medical condition [10]. The median age of the SSA population is considerably lower than other regions, with a median age of 18 and only 3.0% of the African population older than 65 years [11,12].

South Africa has one of the highest infection and deaths rates due to COVID-19 in Africa. In addition, countries have already implemented the recommended public health regulations, such as strict, partial, or full lockdown procedures [4]; social distancing; mask-wearing in public places; and vaccination rolled out in the majority of the SSA countries. Countries that embarked on total lockdown were avoiding any national resurgence. Wide-scale domestic, foreign, and religious events have been cancelled for fear of SARS-Cov-2 outbreak as they were considered super-spreaders of the virus [13,14]. Such actions have an enormous socio-economic impact on the country [15], and the shutdown has upstretched fears of economic repercussions [16]. Due to this pandemic, everything about human life, including exports and imports of goods, business, infrastructural development, agriculture, and education, seem to have stopped, and these have a direct and indirect negative effect on the economy [17] given the already weak economy of some SSA countries and the resultant drawback risks.

In South Africa, a study showed that a higher perceived risk of COVID-19 infection was associated with greater depressive symptoms and, with such high rates of severe mental illness coupled with the low availability of mental healthcare amidst COVID-19 in the region, there is a need for studies to understand if the change in time has any effect on the level of risk perception for targeted intervention, including the need for immediate and accessible psychological resources [18]. In our recent study conducted during the early lockdown, SSA displayed high individual risk perception scores, which was greater in older participants and those working in health care sectors after adjusting for covariates [19]. It is unclear whether similar risk perceptions and associated factors remain after participants have grown in their knowledge of the disease spread and the commencement of the vaccine rollout in most SSA countries. The current study aims to investigate the individual perception of risk for contracting SARS-Cov-2 and the associated factors by comparing the data obtained during lockdown with those obtained in the post-lockdown period in SSA. The findings of this study will provide an understanding of the population at higher risk for which can be used to implement emergency policies to counter the spread of SARS-Cov-2.

2. Materials and Methods

We conducted two online surveys one year apart in the SSA region, including West Africa, Southern Africa, East Africa, and Central Africa. Participants were aged 18 years and over (n = 1005 and n = 1,004) living in Africa and outside Africa (Diaspora). The first survey was conducted on 18 April–16 May 2020 (during the lockdown), when most of the countries in the region were under mandatory lockdown and restricted movement, and the second survey was conducted between 14 March–14 April 2021(after the lockdown), when

most of the mandatory lockdown was over. and anonymized. Testing for the internal validity of the survey items, the Cronbach's alpha coefficient score ranged from 0.70 and 0.74, indicating satisfactory consistency.

2.2 Measures

The questionnaire collected data on sociodemographic variables (Table 1), self-assessment of risks about COVID-19, and if they think the public health authorities in their country are doing enough to contain the virus, whether they or any of their close relative was affected by COVID-19, and whether or not they think COVID-19 is real. Other questions relating to knowledge of COVID-19, habits during lockdown, and attitudes towards the infection were included in survey 1, while questions related to knowledge and attitude towards COVID vaccination were included in one of the two surveys. Those questions that were not in both surveys are not included in the current analysis, but the interested reader on these topics is referred to the published articles for a description of items and responses.

Table 1. Sociodemographic characteristics of respondents in both surveys.

Demographics	Total (N = 4551)	During Lockdown (n = 2001)	Post-Lockdown (n = 2550)
Age category in years			
18-28 years	1697 (38.0)	774(39.1)	923 (37.2)
29-38	1242 (27.8)	526 (26.5)	716 (28.9)
39-48	939 (21.1)	439 (22.2)	500 (20.2)
49+ years	584 (13.1)	242 (12.2)	342 (13.8)
Sex			
Males	2467 (54.5)	1095 (55.2)	1372 (53.8)
Females	2057 (45.5)	889 (44.8)	1168 (45.8)
SA Region of Origin			
West Africa	2572(56.5)	1122 (56.1)	1450 (56.9)
East Africa	347(7.6)	212 (10.6)	135 (5.3)
Central Africa	570 (12.5)	253 (12.6)	317 (12.4)
Southern Africa	1062 (23.3)	414 (20.7)	648 (25.4)
Country of residence			
Africa	4250 (93.6)	1852 (92.6)	2398 (94.4)
Diaspora	291 (6.4)	149 (7.4)	142 (5.6)
Marital Status			
Married/de facto	2003 (44.3)	876 (44.1)	1127 (44.4)
Not married †	2522 (55.7)	1112 (55.9)	1410 (55.6)
Educational status			
Master's degree or more ‡	1383 (30.7)	639 (32.1)	744 (29.5)
Bachelor's degree α	2383 (52.9)	1086 (54.6)	1297 (51.5)
Secondary/primary	741 (16.4)	264 (13.3)	477 (19.0)
Working status			
Employed/self employed	3001 (66.9)	1353 (68.0)	1648 (65.9)
Unemployed/retired	1488 (33.1)	636 (32.0)	852 (33.1)
Religion			
Christianity	4042 (89.7)	1758 (88.4)	2284 (90.8)
Others ᵖ	462 (10.3)	230 (11.6)	232(9.2)
Occupation β			
Healthcare sector	1240 (31.5)	443 (24.3)	797 (37.6)
Non-healthcare	1602 (40.6)	1014 (55.7)	588 (27.7)
Student	1099 (27.9)	364 (20.0)	735 (34.7)

†, divorced, separated, widowed and single; ‡ included Masters and PhD; postgraduate,
α, diploma and bachelor degree;
ᵖ, included Muslims and African traditionalist;
β = no response from 610 respondents for this variable (13.4%).
SD = standard deviation. Values are numbers (%) except for mean age.

2.3 Assessment of Risks about COVID-19

Self-assessments of risks about COVID-19 were measured with two items which was common in both surveys. The first item concerned the perception of the risk of being infected by COVID-19 (Q1: "Please rate your risk of being infected with the Coronavirus (COVID-19)"), and the second item was the self-assessment of the risk of dying from the infection (Q2: "Please rate your risk of dying from the Coronavirus (COVID-19) infection"). Each question used a Likert scale with five levels [21]. The scores for each item ranged from 0 (lowest) to 4 (highest). The perceived risk towards COVID-19 score ranged from 0–8 points.

2.4 Ethical Consideration

This cross-sectional study was approved by the Human Research Ethics Committee of the Cross River State Ministry of Health, Nigeria (CRSMOH/RP/REC/2020/116) for the first survey, and by the Humanities and Social Sciences Research Ethics Committee (HSSREC 00002504/2021) of the University of KwaZulu-Natal, Durban, South Africa for the second survey. The study adhered to the principles of the Helsinki declaration (as modified in Fortaleza 2013) for research involving human subjects [22]. Prior to the study, an explanation detailing the nature and purpose of the study was provided to all participants using an online preamble. Informed consent was obtained from the participants who were required to answer either a 'yes' or 'no' to a question on whether or not they were willing to participate in the survey voluntarily. The confidentiality of participants' responses was assured, and anonymity was maintained. To ensure that only one response per respondent was included in the study per survey, participants were instructed not to take part in the survey at both periods more than once, and, during analysis, we also restricted the data by IP address of the participants.

2.5 Statistical Analysis

Continuous variables were summarized using descriptive statistics, including the number of observations used in the calculation (n), mean, and standard deviation (SD), while categorical variables were summarized as counts and percentages of each category for all demographic characteristics for during and post lockdown. To profile the risk of being infected by COVID-19 and the risk of dying from the infection, the Chi- square test was used to determine their prevalence. Each demographic characteristic was compared with a t-test for 2 groups, and one-way analysis of variance (ANOVA) for 3 or more groups. Simple linear regression analysis was used to report the unadjusted coefficient and retained those variables with p value < 0.20 in order to build a multiple linear regression analysis. For multiple linear regression, an elimination procedure was applied to remove non-significant variables (p > 0.05). All analyses were performed using 'SVY' commands in STATA/MP V.13.0 (Stata Corp, College Station, TX, USA).

3. Result

3.1 Descriptive Statistics

The descriptive statistics of the sociodemographic variables are presented in Table 1,[§§] showing the summary of responses from those who participated in the survey during the lockdown and after the lockdown periods. Total responses were a combination of both survey responses. The mean age of the respondents 34.4 ± 11.7 years was similar in both surveys (34.1 ± 11.6 and 34.6 ± 11.8 years, during and post-lockdown respectively).

Table 1 shows that most of the respondents were in the 18–28 years age group (38%, *n* = 1697). There was an almost equal representation of male and female respondents. Most respondents (55.7%, *n* = 2522) were not married, about half of them (52.9%, *n* = 2383) completed post-secondary education, and many were employed (66.9%, *n* = 3001) and worked in a non-healthcare sector (40.5%, *n* = 1602) at the time of this study. Furthermore, 89.7% of the respondents (*n* = 4042) were Christians.

Figure 1a and b presents the percentage of responses for the items that make up the dependent variable:) the risk of becoming infected with COVID-19 and the risk of dying from COVID-19 infection, respectively. For each item, the proportion from both surveys who felt either at high or very high risk of contracting the infection was 39.9%, and about a quarter thought they were at risk of dying from the infection. Compared with during lockdown, significantly more respondents felt at high risk [17.12%; 95%CI 16.05–18.24% versus 9.27% 95%CI 8.46–10.15] and very high risk [7.21%, 95%CI 6.49–9.00% versus 5.34%, 95%CI 4.72–6.03%] of becoming infected from COVID-19 post-lockdown. Similarly, 11.76% [95%CI 10.85–12.72%] of respondents felt at high risk of dying from COVID-19 infection after the lockdown compared with 4.92% [95%CI 4.33–5.59%] during the lockdown.

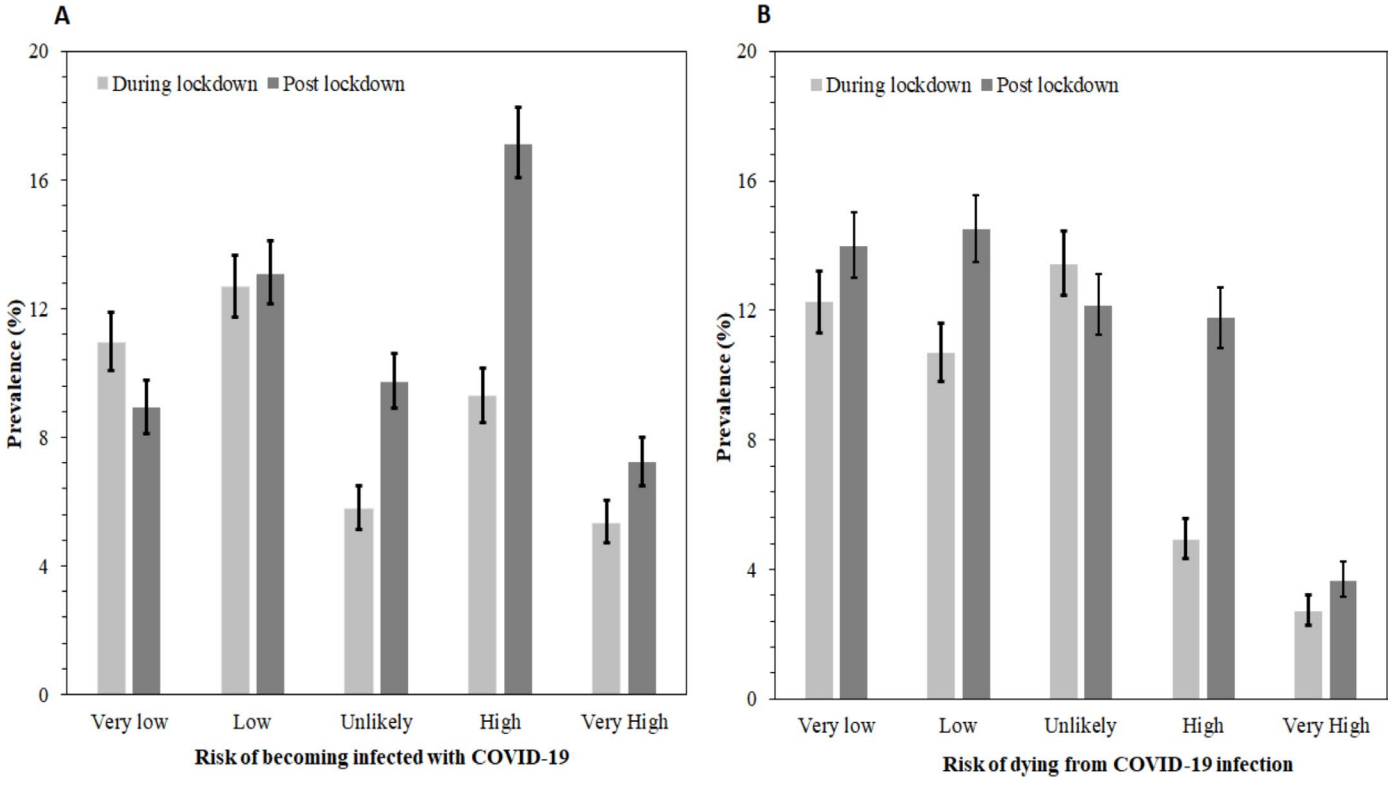

Figure 1. *Proportion of responses for perceived risks of COVID-19:*
A) *, the risk of becoming infected with COVID-19;*
B) *the risk of dying from COVID-19 infection Error bars are 95% confidence intervals. Unlikely means no risk.*

3.2 Mean Scores and Unadjusted Factors of Risk Perception for Contracting COVID-19

Figure 2 shows the mean scores for the perceived risk of COVID-19 at 95% CIs (presented as error bars). SSA respondents had significantly higher mean risk perception scores after the COVID-19 lockdown compared with during the lockdown period ($p < 0.0005$). The perceived risk estimated from the second survey was 0.49 higher than that of the lockdown period. This translates to a Cohen's D value of 0.21 SD (i.e., the mean of survey 2 and survey 1, and the pooled standard deviation for the entire sample) [23] which was higher than the mean scores of the perceived risk of COVID-19 during the lockdown. From the Emslie data [24], respondents who participated in the post lockdown survey were 58% more likely to perceive a risk of contracting or dying from COVID-19 compared with those that participated in the survey during the lockdown period. This is clinically significant [24].

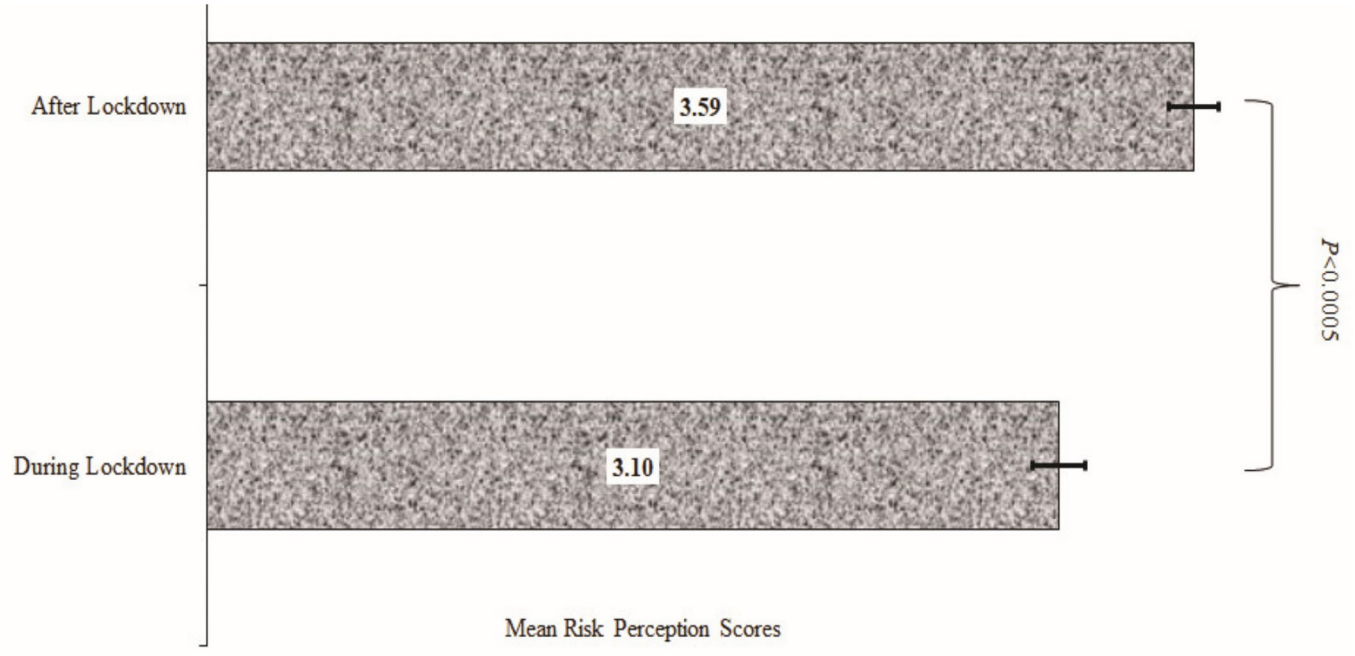

Figure 2. *Mean score for the perceived risk of contracting COVID-19 after and during lockdown.*

Table 2 presents the mean risk perception scores as well as the unadjusted odd ratios and their 95% CIs for factors associated with risk perception by the demographic characteristics. Data presented were pooled from both surveys. The mean risk perception scores were significantly different between the study periods. Compared with the lockdown period, the results indicated that perceived risk scores for contracting COVID-19 post-lockdown reduced by 0.49 (95%CI 0.36, 0.63, $p < 0.0005$) and increased with age. Respondents aged above 28 years had significantly higher risk perceptions scores compared with those aged 18–28 years.

Other factors associated with perceived risk scores for contracting COVID-19 in the unadjusted analysis are region of origin, marital, educational and working status, and respondents' occupation.

Table 2. Mean scores and unadjusted coefficients (B) for factors associated with perceived risk of contracting COVID-19 during lockdown and post-lockdown.

Variables	Mean Scores (±SD)	B [95%CI]	p-Value
Survey period			
Period 1 (during lockdown)	3.10 (2.19)	Ref	
Period 2 (post-lockdown)	3.59 (2.36)	0.49 [0.36, 0.62]	<0.001
Demography			
Age category in years			
18-28 years	3.13 (2.24)	Ref	
29-38	3.51 (2.31)	0.38 [0.22, 0.55]	<0.001
39-48	3.57 (2.35)	0.44 [0.26, 0.63]	<0.001
49+ years	3.58 (2.30)	0.45 [0.23, 0.66]	<0.001
Sex			
Males	3.42 (2.32)	Ref	
Females	3.34 (2.27)	−0.08 [−0.22, 0.005]	0.226
SSA Region of Origin			
West Africa	3.26 (2.24)	Ref	
East Africa	3.78 (2.41)	0.51 [0.26, 0.77]	<0.001
Central Africa	3.22 (2.44)	−0.05 [−0.26, 0.16]	0.658
Southern Africa	3.61 (2.30)	0.35 [0.19, 0.52]	<0.001
Country of residence			
Africa	3.39 (2.30)	Ref	
Diaspora	3.26(2.23)	−0.13 [−0.40, 0.15]	0.36
Marital status			
Married	3.52(2.30)	Ref	
Not married	3.27(2.30)	−0.25 [−0.39, −0.12]	<0.001
Educational status			
Master's degree or more	3.50(2.25)	Ref	
Bachelor's degree	3.37(2.32)	−0.13 [−0.28, 0.02]	0.089
Secondary/Primary	3.20 (2.32)	−0.31 [−0.51, −0.10]	0.004
Working status			
Employed/self employed	3.54 (2.30)	Ref	
Unemployed/retired	3.10 (2.26)	−0.43 [−0.57, −0.29]	<0.001
Religion			
Christianity	3.37(2.30)	Ref	0.676
Others	3.42(2.29)	0.05 [−0.17, 0.27]	
Occupation			
Healthcare sector	3.83 (2.34)	Ref	
Non-healthcare	3.20 (2.23)	−0.63 [−0.80, −0.46]	<0.001
Student	3.09 (2.24)	−0.75 [−0.93, −0.56]	<0.001

SD, standard deviation; CI, confidence interval that do not include 0.00 were significant.

SSA, sub-Saharan Africa; Ref, reference (0.00).

3.3 Factors Associated with Perceived Risk for Contracting COVID-19 during Lockdown and Post-Lockdown

Table 3 shows the adjusted coefficients (β) with 95% CIs of the factors influencing perceived risk for contracting COVID-19 during and post-lockdown period in SSA countries. After adjusting for potential confounding factors, the post-lockdown period and age >28 years were significantly associated with increased risk perception. Respondents from East and Southern Africa reported higher risk perception scores compared with those from West Africa. Working in a non-healthcare sector (β −0.56, 95% CI −0.73, −0.38) and being a student (β −0.60, 95% CI −0.82, −0.38) were associated with a reduction in the risk perception scores for contracting COVID-19.

Table 3. Factors associated with perceived risk of contracting COVID-19 in sub-Saharan Africa.

Variables	β [95%CI]	p-Value
Year of survey		
Period 1 (during lockdown)	Ref	
Period 2 (post-lockdown)	0.42 [0.27, 0.57]	<0.001
Demography		
Age category in years		
18-28 years	Ref	
29-38	0.25 [0.04, 0.46]	0.02
39-48	0.31 [0.08, 0.54]	0.01
49+ years	0.31 [0.05, 0.58]	0.02
SSA Region of Origin		
West Africa	Ref	
East Africa	0.55 [0.28, 0.82]	<0.001
Central Africa	0.08 [-0.15, 0.31]	0.49
Southern Africa	0.37 [0.19, 0.54]	<0.001
Occupation		
Healthcare sector	Ref	
Non-healthcare	-0.56 [-0.73, -0.38]	<0.001
Student	-0.60 [-0.82, -0.38]	<0.001

CI, confidence interval that does not include 0.00 were significant.

SSA, sub-Saharan Africa; Ref, reference (0.00).

β is the adjusted coefficient from the linear regression model.

4. Discussion

To the authors' ability, this is the first study to compare the level of risk perception of Africans during and after the COVID-19 lockdown period. The study found that more than one in every three persons in this SSA sample and about one in every four respondents felt at high risk of contracting COVID-19 and thought they could die if they contracted COVID-19, respectively, even after the lockdown. Compared with a pre-lockdown period, respondents who participated in the post-lockdown survey reported a significantly higher risk of COVID-19, particularly the older people and respondents that lived in East and Southern Africa. Compared with a pre-lockdown period, respondents who participated in the post-lockdown survey reported a significantly higher risk of COVID-19, particularly the older people, and respondents that lived in East and Southern Africa. The perceived risk of contracting COVID-19 increased significantly between the two surveys showing that respondents overestimated their chances of contracting or dying from COVID-19 by 58%.

Although such finding does not reflect a strong deviation from rational behavior, it is common in the literature [25,26], and the likelihood of overestimating small risks fatalities occurs rationally in a Bayesian model when learning is based on partial information [27]. Furthermore, those who worked in health care sectors reported higher risk perception of COVID-19 whereas students who participated in the survey after the lockdown reported lower risk perception compared with other groups.

This increase in risk perception after the lockdown which was found in this study may be attributed to various factors, including the

rise in the COVID-19 infections and related deaths in the region after the lockdown [26]. In addition, the controversies surrounding the rolling out of the COVID-19 vaccine globally and the uncertainty of vaccine acceptance in the region [28]. Despite the government efforts at increased sensitization of the populace on the disease, their inability to answer the questions raised about the COVID-19 vaccine [29] could have necessitated the increased risk perception of getting infected after the lockdown.

Past repeat studies have found differences in risk perception of COVID-19 over a time period. A fourth-round survey of respondents in Kenya, East Africa demonstrated that the perceived risk of coronavirus remained about the same, but the proportion that said they are at high risk because they interact with a lot of people every day more than doubled (from 20% to 54%) [30]. In France, two successive representative surveys, one conducted about 2 weeks after lockdown started, and the other about 2 weeks before lockdown ended, found significantly higher risk perception in the second survey than in the first survey. The authors attributed the comparative pessimism in survey 2 to a concomitant increase in the respondents' perceived chances to contract the disease and a decreased expected prevalence rate [26].

In the present study, we found that older age (≥28 years) was associated with an increased risk of susceptibility to COVID-19; this was consistent with past studies [29,31–33] which showed that older individuals had a higher risk perception of contracting the infection and were more likely to develop more severe complications of COVID-19 or die compared with the younger individuals [32]. The sigh of relief brought about by the post–lockdown era had a serious effect on the younger age groups who, at that time, had a lower risk perception for contracting the infection, as seen in a study by Dillard et al. [30]. The perceived low risk of infection by younger respondents may make them less cooperative and less compliant with the safety measures [34], thus encouraging the spread of the virus while putting a greater part of the population at risk of COVID-19 infections [29,30]. This finding could be attributable to the fact that younger people are the more active age group in any given population.

In his write up about medical students during this COVID-19 era, Flaxman et al. stated that students are not essential workers [35], which implies that they are not yet classified as healthcare workers since they are not paid or tasked with the responsibility of patient care in healthcare facilities [36]. In this study, people working in non-healthcare sectors, including students, felt less susceptible to the infection. This finding can be attributed to exposure of healthcare workers to infected people; the absence of personal protective equipment, particularly in SSA countries [37]; over crowdedness of medical facilities; and inadequate provision of needed health management instruments [37]. There is a need for regular educational intervention and training programs on infection control practices for COVID-19 across all healthcare professions.

The study also found regional differences in the level of perceived risk for contracting COVID-19 during and after the lockdown. Although the risk perception scores were reduced after the lockdown among East Africans, they and Southern Africans felt at greater risk of COVID-19 infection compared with West African respondents. Such regional differences with regard to COVID-19 infection was reported to vary from location to location with significantly varying degrees of impact [38]. In this study, we noted that respondents from two of the participating SSA countries reported higher risk perception scores for contracting the virus, and, for the other two regions—Western and central Africa—the risk

perception remained unchanged. Although a cross-sectional study from China did not find a significant regional variation in the risk perception of the SARS-CoV-2 pandemic [39], there are factors that come to play, including the cultural beliefs and inclinations of the people, their religious orientations, the governmental policies in place for the control of the spread of the disease, and the individual tendencies for survival among many others [40].

The study has some limitations which should be interpreted within the context of the study. Using a perceived risk score than ranged from 0–8 points may violate some linear regression assumptions [19,41]. The use of an online survey has the potential to result in selection bias and could have unduly excluded residents in SSA without internet access. The preponderance of educated persons in this study is another limitation that is a characteristic of most survey studies in Africa [19,20,37,42] and elsewhere [43]. These study findings may not be generalizable to the entire SSA of the study findings because not all countries are in SSA answered the questions. Besides these limitations, this is the first study on the knowledge, attitude, and perception of COVID-19 vaccine to include all four SSA regions which also employed comprehensive inferential data analyses.

5. Conclusions

It is clear that, during the lockdown, people had some measure of certainty regarding the SARS-CoV-2, which dissipated after the lockdown as the rates of infection across the globe, particularly in SSA, were seen to be on the surge with a reported increasing number of deaths. Notably, the factors influencing risk perception scores remained the same during and after the lockdown and this included age, region of origin, and occupation. The rollout of the COVID-19 vaccine and the controversies regarding the effectiveness of the vaccines, as well as the media focus on the new variant, may have heightened the perceived risk of infection. There is the need for governments in SSA to intensify the public awareness of the emergence of new variants of the virus and design compatible ways of ensuring that the vaccines are at the reach of everyone and that everyone should be encouraged to receive his/her shot of the vaccine to stay safe and alive. Furthermore, further studies need to be carried out to ascertain the post lockdown risk perception since, from existent studies, there seems to be non- availability of data on the post lockdown risk perception of contracting SARS-CoV-2 and with the ongoing vaccination in view.

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of KwaZulu-Natal, Durban, South Africa for the second survey

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: The datasets analyzed during this study are available from the authors on reasonable request.

Conflicts of Interest: All authors declared no conflict of interest.

NOTES

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https://www.afro.who.int/news/covid-19-deaths-africa-surge-more-40-over-previous-week

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9. Analysis of Perception, Reasons, and Motivations for COVID-19 Vaccination in People with Diabetes across Sub-Saharan Africa: A Mixed-Method Approach

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Abstract:

Diabetes mellitus (DM) is associated with severe COVID-19 infection and complications. This study assesses COVID-19 vaccine acceptance and hesitancy in people with DM, and explores the reasons for not being vaccinated. This was a web- based cross-sectional survey using a mixed-method approach conducted in March–May 2021, corresponding to most sub-Saharan African (SSA) countries' early vaccine rollout period. Participants were those aged ≥18 years with self-reported DM in 11 Sub-Saharan African (SSA) countries. Responses to comments on the reasons for vaccine hesitancy and facilitators for vaccine uptake were analyzed. Of the 73 participants with DM, 65.8% were males, older than 35 years (86.3%), had postsecondary education (90%), and a significant proportion were from South Africa (39.7%), Nigeria (28.8%) and Ghana (13.7%). At the time of this study, 64.4% experienced COVID-19 symptoms, 46.6% were tested for COVID-19, of which 19.2% tested positive. Few participants (6.8%) had received a COVID-19 vaccination, 65.8% were willing to take the vaccine when it becomes available in their country, while 26.0% either refused or remained hesitant towards taking the vaccine. The main identified reasons for not taking the vaccine were: advice from religious leaders; concerns about the safety, effects, and efficacy of the vaccines; mistrust of the pharmaceutical companies producing the vaccines and the process of production; the conspiracy theories around the vaccines; and the personal belief of the participants regarding vaccination. However, participants stated they would take the vaccine if they were more educated about it, received positive feedback from those vaccinated, were rewarded for taking the vaccine, or if vaccination became a condition for travel and employment. In conclusion, this study shows that the uptake of the COVID-19 vaccine was very low in this high-risk group. Efforts to increase the uptake of COVID-19 vaccines among people with diabetes are imperative, such as the provision of education and relevant information.

Keywords: diabetes; survey; Sub-Saharan Africa; coronavirus; vaccine; hesitancy; refusal; qualitative; lockdown

1. Introduction

Diabetes mellitus (DM) has reached epidemic proportions, globally affecting approximately 463 million people [1]. It is a leading cause of avoidable hospitalizations, amputations, cardiovascular events, renal failure, fetal malformations, and blindness [2]. Three-quarters of those with DM live in low- to middle-income countries (LMIC), and this is projected to increase [3], mostly due to increasing urbanization, demographic, and nutritional changes in the region [4-6]. Studies found that Sub- Saharan Africa (SSA) is particularly affected by obesity and diabetes [7]. This risk represents a substantial challenge for the overburdened healthcare systems in the region faced by COVID-19 challenges [8]. Understanding the challenges of this high- risk group is crucial to COVID-19 recovery and lessons learnt in informing preparation for future pandemics.

Prior to the development and rollout of COVID-19 vaccines, stringent lockdowns and other public health safety measures were the predominant methods used to curb the spread of the SARS-CoV-2 virus [9]. Some of these measures, such as stay-at- home policies and mandatory quarantine, promote a sedentary lifestyle, leading to an increase in obesity. This predisposes individuals to a greater risk of poor glycemic control due to physical inactivity. Following the global development and rollout of COVID-19 vaccines, most governments, especially in developed countries, rapidly vaccinated their populations as a public health preventative measure to contain the spread of the virus [10]. However, access and distribution of COVID-19 vaccines remain an issue in most developing countries, particularly in low-income African countries [10], despite recent global efforts to render the vaccines affordable and available to these countries.

The development of the COVID-19 vaccines may have come as a welcome relief for people living with DM in terms of the opportunity to resume outdoor exercises and activities, and in terms of their higher risk of infection and severe complications from being infected with the virus [11, 12]. People with DM have poorer health outcomes, such as higher hospitalization and mortality rates from COVID-19 infection compared with their counterparts without the disease [11, 12]. As a result, most governments shifted their focus from previously prioritizing healthcare workers to receive the vaccine to including those with chronic illnesses, including DM [13]. In some SSA countries such as Cameroon, priority for vaccination was given to people with Types 1 and 2 DM who were on two or more medications [14].

The breakthrough in COVID-19 vaccine discovery, manufacture, and availability was accompanied by issues of myths and misinformation, followed by resistance and hesitancy [15]. There is a paucity of information on COVID-19 vaccine hesitancy among people with DM in SSA countries. Higher prevalence of vaccine hesitancy in Italy (14.2%) [16] and Saudi (29.0%) [17] was reported for individuals with DM. In SSA, people with DM are not left out of these controversies, with reports of mistrust for pharmaceutical companies and concerns about the safety of the COVID-19 vaccines featuring prominently in previous studies conducted elsewhere [16, 17]. However, similar concerns with vaccine safety and side effects, the lack of trust in pharmaceutical industries and vaccination trials, and misinformation or conflicting information from the media have been expressed among the general population in SSA countries [18, 19].

Considering that almost every person needs to receive the COVID-19 vaccine to achieve herd immunity [20], and individuals with DM are more severely affected by COVID-19 disease [21, 22], this survey was conducted to assess

COVID-19 vaccine acceptance and hesitancy or unwillingness among people with DM in SSA. It also assesses the barriers and beliefs that affect their willingness to receive the COVID-19 vaccine. The findings help in narrowing the current knowledge gap and improving health outcomes for people living with DM in SSA countries.

2. Materials and Methods

2.1. Study Design

This study used a web-based embedded cross-sectional survey using a mixed-method approach to evaluate the study objectives and responses. The self-administered questionnaire had been validated [23] and was adapted with minor modifications to suit this study's objective. The questionnaire was pretested with 10 participants who were not included in the final study and were not part of the research group. The pilot study was to ensure clarity and understanding, and to determine the duration for completing the questionnaire prior to dissemination. The survey tool was tested for the internal validity of the items, and Cronbach's alpha coefficient scores ranged from 0.70 and 0.74, indicating satisfactory consistency [23]. The final survey in English was translated into a French version to allow for wider participation from SSA countries. Researchers from the Department of Linguistics at the University of Bamenda, Cameroon translated the survey tool. There was also a backward translation from French to English to ensure that the meaning of the items was retained.

2.2. Ethical Approval

Ethical approval for this study was obtained from the Humanities and Social Sciences Research Ethics Committee of the University of KwaZulu-Natal, Durban, South Africa (HSSREC 00002504/2021). The study adhered to the principles of the 1967 Helsinki Declaration (as modified in Fortaleza, 2013) for research involving human subjects. Participation in this survey was voluntary, and informed consent was sought prior to the survey. The confidentiality of the participants was maintained, and all data were kept anonymous. As part of the preamble, participants were instructed not to take part in the survey more than once, and the IP address of the participants also restricted analysis of the data to prevent multiple and repeat participation in the survey.

2.3. Participants

Consenting English- and French-speaking participants aged 18 years and above who had been born in any of the 46 SSA countries and self-reported DM at the time of this survey were eligible to participate in this study. In contrast, data for participants with no record of age or those younger than 18 years, who did not state their DM status, or had no DM were excluded.

2.4. Data Collection

The survey was distributed online between March and May 2021. A convenient sampling technique was used to include all the participants in the survey, and those who self-reported DM during the study were extracted. An invitation link to the survey created in Survey Monkey was disseminated in English and French (which are the spoken languages in 21 of 26 SSA countries [24]) using social media platforms (Facebook and WhatsApp) and by email through the authors' networks.

The survey items included: 11 sociodemographic variables, items on smoking status; past vaccinations for other conditions (hepatitis, influenza, chickenpox, whooping cough, tuberculosis, yellow fever, measles/mumps/rubella (MMR), diphtheria, pertussis, and tetanus (DPT)), the presence of pre-existing conditions, including heart disease, kidney disease, hypertension,

diabetes, obesity, asthma, and sickle cell anemia; knowledge of COVID-19 vaccination; COVID-19 test and result; if they had received any COVID-19 vaccination. For those who had not been vaccinated at the time, a follow-up question was asked to gauge their willingness to receive a COVID-19 vaccine when it became available in their country. This allowed for participants to provide comments on their opinions. There were also questions to understand the participants' sources of information on COVID-19 and their perception of risk for COVID-19 (four items: three utilizing a Likert scale, and the other a 'yes', 'no', or 'not sure' response).

2.5. Qualitative Responses

Two questions were asked to the participants who were hesitant or refused to receive the COVID-19 vaccines, and their responses were qualitatively analyzed. Both questions required the participants to select from ten options, with an additional section for added comments if they chose to. For the first question, 'which of the following factors contribute to your decision to not accept a COVID-19 vaccine?, the options were: advice from religious leaders, advice from politicians, mistrust for the pharmaceutical company, mistrust of the health system in my country, mistrust in the medical process for developing the vaccine, mistrust for the country where the vaccine was produced, personal beliefs or past historical experiences with vaccines, concerned about safety of the COVID-19 vaccine, not enough information from healthcare providers, and information from the media.

For the second question, 'what can be done to encourage you to get the vaccine?', the options were: "I am more likely to accept the COVID-19 vaccine (1) if financial incentives are given to everybody; (2) if monetary rewards are given to healthcare providers involved in the vaccination; (3) if it is given for free; (4) if there is adequate information regarding the specific vaccine; (5) if I can get more education on the vaccines, their side effects, and how effective they are; (6) if it is a travel condition; (7) if it is an employment condition; (8) if many people start receiving the vaccine; (9) if I get positive feedback from those who have been vaccinated'.

2.6. Statistical Analysis

Statistical analysis was conducted using IBM SPSS Statistics for Windows, version 27 (IBM Corp., Armonk, NY, USA). The frequency and percentage of categorical variables are reported. The proportions of participants with DM who were vaccinated against COVID-19 and those who expressed uncertainty towards being vaccinated were determined. The vaccinated group were those who responded in affirmation (Yes) to the question 'have you been vaccinated against COVID-19?' Similar to a previous study [25], those who responded 'not sure' or 'no' regarding being vaccinated against the COVID-19 vaccine were asked if they were willing to be vaccinated when the vaccine became available in their home countries. The responses of 'not sure' or 'no' to the follow-up question were used to derive the 'hesitant or refused to accept COVID-19 vaccine' estimation, and the association with demographic variables was determined with Fisher's exact test due to the small number of persons in the cells.

The selected options and the open-ended comments obtained from the qualitative section of the questionnaire on their reasons for not receiving the vaccination and what would encourage them to become vaccinated were grouped into major topics and analyzed qualitatively. The significant recurrent and silent points are also reported using quotations, and their frequencies are reported descriptively.

3. Results

3.1. Characteristics of the Study Population

Of the total of 2572 participants in the general survey, only the responses from 73 (2.94%) participants with self-reported DM (of any type) were used in this study. Figure 1 shows the flowchart of the participant selection from the larger study population.

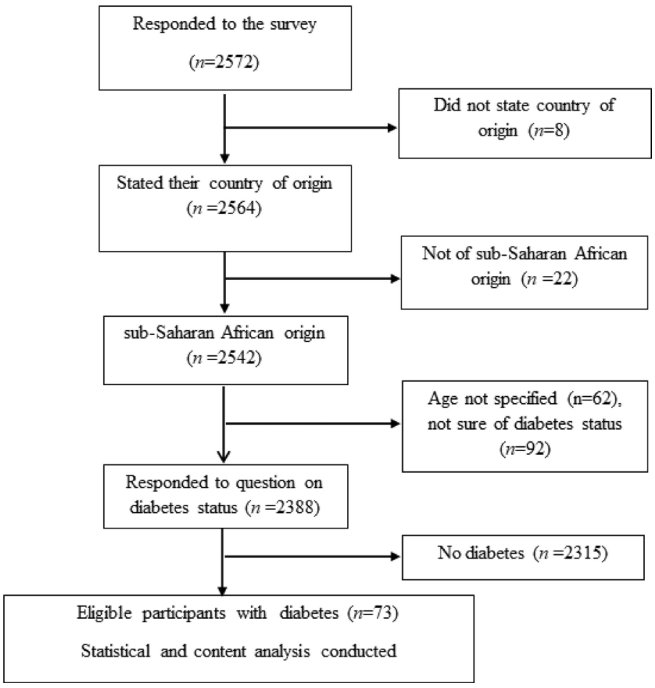

Figure 1. *Flowchart of study participants.*

The characteristics of the study sample presented in Table 1 show that the majority (65.8%) were males, more than two-thirds were aged 35 years and older, and most had at least a tertiary education (90% had either a diploma, university, or higher education), the majority were married (72.6%) and employed (79.5%), and few were working in a healthcare sector (31.5%) (Table 1).

Table 1. Sociodemographic characteristics of study participants (*n* = 73).

Variables Demography	Frequency n (%)
Age category in years	
<35	10 (13.7)
≥35	63 (86.3)
Sex	
Males	48 (65.8)
Females	25 (34.2)
Place of residence ≠	
Local	62 (84.9)
Diaspora	9 (12.3)
SSA region of origin	
Central Africa	7 (9.6)
East Africa	5 (6.8)
Southern Africa	30 (41.1)
West Africa	31 (42.5)
Marital status	
Not married	20 (27.4)
Married/de facto	53 (72.6)
Highest level of education	
Secondary or less	6 (8.2)
University/diploma	35 (48.0)
Postgraduate (master's/PhD)	32 (43.8)
Employment status ≠	
Unemployed	14 (19.2)
Employed	58 (79.5)
Religion	
Non-Christians	16 (21.9)
Christians	57 (78.1)
Occupation ≠	
Nonhealthcare sector	48 (65.8)
Healthcare sector	23 (31.5)
Smoking status	
Current smoker	9 (12.3)
Ex-smoker	11 (15.1)
Nonsmoker	53 (72.6)
Previous vaccination	
Yes	64 (87.7)
No/not sure	9 (12.3)
≠ frequencies do not add up to 100% due to some missing responses	

Figure 2 presents the participants' countries of origin, indicating that the participants were mostly from South Africa (39.7%), Nigeria (28.8%) and Ghana (13.7%), while other SSA countries had minimal participation.

There were few smokers (12.3%), and nearly all the participants reported they had been vaccinated for other conditions, mostly yellow fever, tuberculosis, polio, and hepatitis, which are shown in Figure 3.

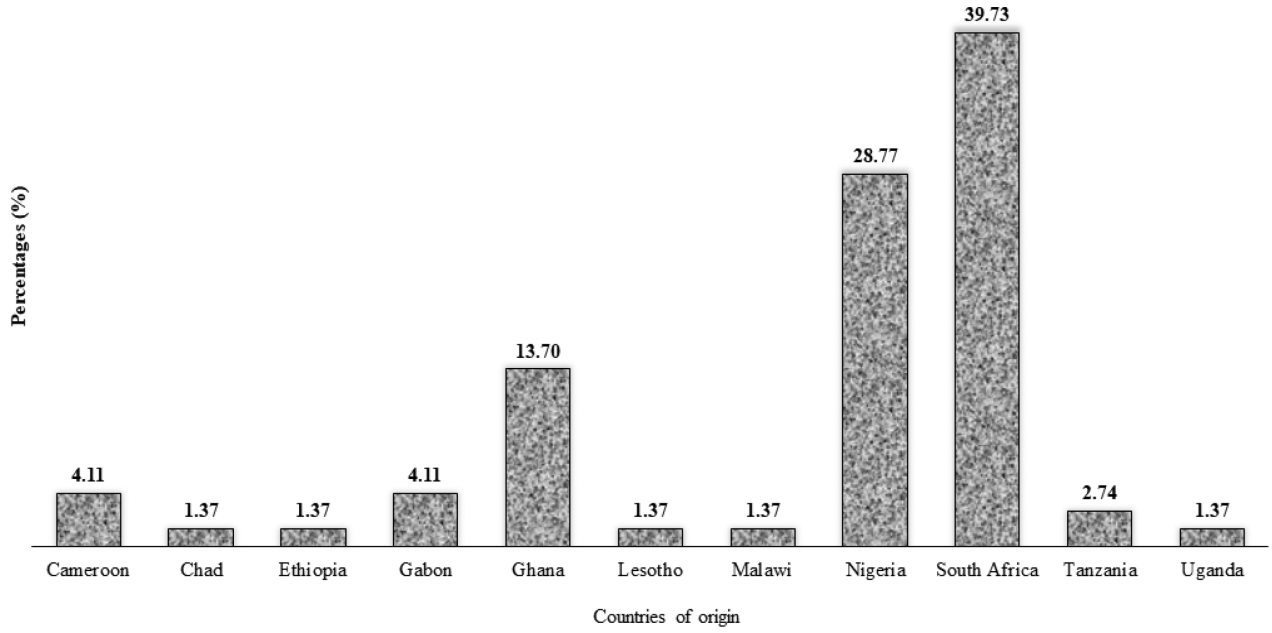

Figure 2. *Distribution of study participants (n = 73) by country of origin.*

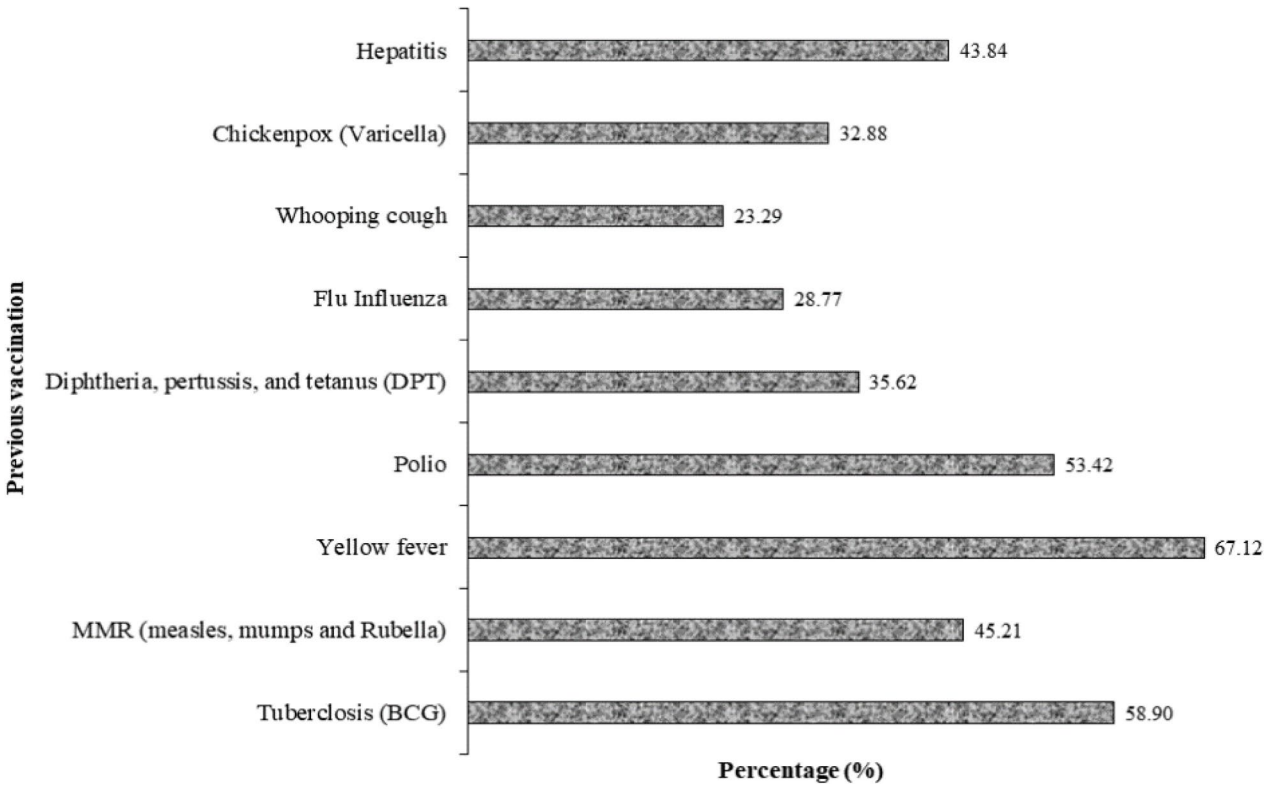

Figure 3. *Percentage of previous vaccinations for other conditions among the study participants.*

Table 2 presents the self-reported health conditions of the participants. More than half (63.0%) had other chronic diseases, mostly hypertension (46.6%), and obesity (20.5%), and related cardiovascular diseases coexisting with diabetes.

Table 2. Other self-reported health conditions of study participants (*n* = 73).

Variables	Frequency n (%)
Any chronic disease !	
Yes	46 (63.0)
No	27 (37.0)
Asthma ǂ	
Yes	6 (8.2)
No	59 (80.8)
Hypertension ǂ	
Yes	34 (46.6)
No	36 (49.3)
Sickle cell anemia ǂ	
Yes	1 (1.4)
No	67 (91.7)
Obesity ǂ	
Yes	15 (20.5)
No	55 (75.3)
Any heart condition ǂ	
Yes	8 (11.0)
No	62 (85.0)
Kidney disease ǂ	
Yes	2 (2.7)
No	66 (91.8)
! = asthma, hypertension, obesity, kidney disease, sickle cell anemia, any heart condition; ǂ = few missing responses.	

3.2. Information Related to COVID 19 and Vaccination Uptake

Approximately two-thirds (64.4%) of the participants had had a symptom of COVID-19 during the pandemic, about half had been tested for COVID-19 at least once (46.6%), and 41.2% (n = 34) had tested positive for COVID-19. Nearly every one of the participants was aware that COVID-19 vaccines had been developed. However, only 5 of the 73 people with DM (6.8%) had already received a COVID-19 vaccine (34.7%), while the rest were either hesitant (65.8%) or refused (26.0%) to be vaccinated. Most participants (93%) believed that COVID-19 was real, and more than half either agreed or strongly agreed that the vaccine could protect or prevent them from contracting COVID-19 infection. Regarding their perception of risk, about two-thirds (64.3%) felt that they were at risk of contracting the virus, and a slightly lower proportion thought they could die from the infection if they contracted the virus (Table 3).

The sources through which the participants obtained information related to COVID-19 are presented in Figure 4. The figure shows that about 88% of the participants obtained information from Internet sources during the pandemic, including via personal search on Google, scientific journals, health websites (WHO, CDC, and Ministry of Health websites). A breakdown of the various internet sources listed by the respondents is presented as a supplementary figure. Social media were the second highest source of information used by the participants during the pandemic, followed by TV, while the least-cited source of information was newspapers, which were used by slightly more than half of the participants (52.1%) for COVID-19-related information during the pandemic.

Table 3. Awareness and risk perception of COVID-19 vaccine among study participants.

Variables	Frequency (%)
Awareness of COVID-19 vaccination	
Symptom of COVID-19	
Yes	47 (64.4)
No/not sure	26 (35.6)
Tested for COVID-19	
Yes	34 (46.6)
No	38 (52.1)
Tested positive for COVID-19 ǂ	
Yes	14 (41.2)
No	20 (58.8)
Aware that COVID-19 vaccines have been developed	
Yes	71 (97.3)
No	1 (1.4)
Have you been vaccinated against COVID-19	
Yes	5 (6.8)
No	67 (91.8)
Will you be willing to take COVID-19 vaccine when it becomes available in your country?	
Yes (willing)	48 (65.8)
No/not sure (refusal/hesitancy)	19 (26.0)
Risk perception of COVID-19 vaccination	
Do you think COVID-19 virus is real	
Yes	68 (93.2)
No/not sure	5 (6.8)
COVID-19 vaccine can prevent COVID-19 infection and its complications	
Strongly agree	17 (23.3)
Agree	25 (34.2)
Don't know	15 (20.5)
Disagree	8 (11.0)
Strongly disagree	1 (1.4)
Perception of risk of dying from COVID-19 infection	
Very high	13 (17.8)
High	25 (34.2)
Unlikely	7 (9.6)
Low	18 (24.7)
Very low	8 (11.0)
Perception of risk of becoming infected	
Very high	12 (16.4)
High	35 (47.9)
Unlikely	8 (11.0)
Low	16 (21.9)
Very low	2 (2.7)
ǂ = denominators are those that were tested for COVID-19.	

3.3. Association between Hesitancy or Refusal towards COVID-19 Vaccine and the Study Variables

Results of Fisher's exact test revealed significant associations between hesitancy or refusal of vaccine and sex, region of origin, and place of residence (local and diaspora, see Table 4). In addition, a significant proportion of those who had expressed concern about the safety of the vaccine were less likely to receive the COVID-19 vaccine when it became available in their country ($p < 0.0001$) compared with those who had no such concern. Compared with participants who had not been tested for COVID-19 at the time of this study, significantly more people who had performed a COVID-19 test were willing to accept the vaccine. Other variables not shown in Table 4, including previous vaccination history and the presence of other health conditions such as hypertension, did not show significant association with COVID-19 vaccine hesitancy or refusal.

Table 4. Association between COVID-19 vaccine hesitancy or refusal and the demographic variables of the participants. Only significant variables are shown.

Variables	No/ Not Sure	Yes	*p*-Value
Gender			
Male	7 (14.6)	36 (75.0)	0.008
Female	12 (48.0)	12 (48.0)	
SSA region of origin			
Central Africa	2 (28.6)	5 (71.4)	0.045
East Africa	2 (40.0)	3 (60.0)	
Southern Africa	5 (16.7)	25 (83.3)	
West Africa	10 (32.3)	15 (48.4)	
Place of residence			
Diaspora	3 (33.3)	3 (33.3)	0.009
Local	15 (24.2)	44 (71.0)	
Have you been tested for COVID-19?	7 (20.6)	26 (76.5)	0.006
Are you concerned about the vaccine safety?	11 (64.7)	5 (29.4)	<0.001

Responses of those who answered 'no' or 'not sure' corresponding to 'hesitancy and refusal' to the question, 'will you be willing to receive COVID-19 vaccine when it becomes available in your country?' were merged.

p-value are results of chi-squared analysis.

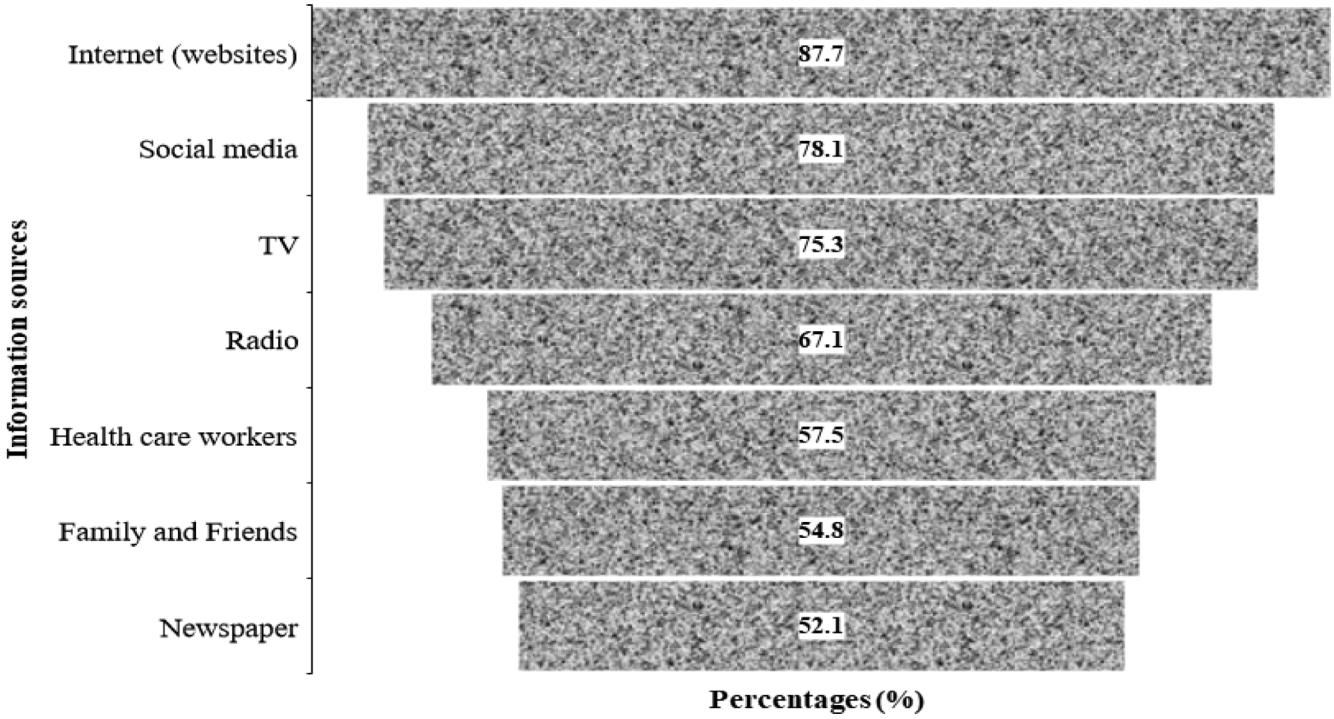

Figure 4. Main sources of COVID-19-related information used by the participants.

3.4. Reasons for COVID-19 Vaccine Hesitancy or Refusal among Participants

The responses of 19 participants who had said they were either not sure or unwilling to receive the COVID-19 vaccine when it became available in their respective countries were categorized into 7 major headings. These are represented in Figure 5, and the participants' statements are presented in Supplementary Table S1. From the figure, two in five people who were unwilling to take the vaccine cited advice from their religious leaders as their main reason, followed by 22% of participants, including three pregnant individuals and one with a compromised immune system, who cited concerns about the safety of the vaccines as the main reason for not receiving them (Supplementary Table S1). A participant from an Eastern African country said, 'vaccines have been used against black people for far too long—Kenya infertility, Tuskegee, etc.', while another participant from West Africa said, 'this vaccine is questionable, and its benefits for politicians far outweigh its care to manage this self-limiting bug'. Few participants did not trust pharmaceutical manufacturing companies, the countries where the vaccines were produced, or the manufacturing process of the vaccine, which was reflected in the following participant statements: 'the vaccines have been developed so quickly'; 'I don't trust the research done about it'; 'there is not enough scientific data on clinical trials for the vaccines', and 'I would rather prefer self-protection for prevention purposes than trust the vaccine'. Few others refused the vaccine due to personal beliefs or past historical events, including one person who stated, 'I have not seen a need for it'. For other participants, different conspiracy theories circulating regarding the COVID-19 vaccine discouraged them from taking the vaccine, with statements such as 'the vaccine is meant to reduce world population, especially Africans', 'It could be a birth control procedure to reduce world population' (see Supplementary Table S1). The lack of trust in their country's health system was reported by a few participants as the main reason for not accepting the vaccine, 'my country is making money with COVID-19, and there is no trace of the disease here', and someone mentioned that refusal to take the vaccine was because of the advice received from some politicians.

3.5. Factors That Would Encourage Uptake of Vaccination in People with DM

The following factors were reported to influence the participants' decision towards receiving COVID-19 vaccination when it became available in their countries. Education about the vaccines (n = 19), was top in the list of factors that would encourage uptake of COVID-19 vaccines, and this was reflected by this statement: 'If I can get more education on the vaccines, their side effects, and how effective they are, I will take it'. More than half of the participants (n = 11) said they would consider receiving the vaccine if they get positive feedback from those who already got it 'I will decide after I hear positive feedback from those who have been vaccinated'. Four participants reported that high uptake in the population (i.e., after many people had already received theirs) and if the vaccination was free would encourage them to receive the vaccine, as reflected in the following statements: 'I will accept the vaccination only after many people start receiving the vaccine' and 'I will accept the vaccination if I don't have to pay or bribe someone to get vaccinated', respectively. Others were more likely to accept the COVID-19 vaccine if there was a monetary reward for receiving it (n = 2): 'I will accept the vaccine if monetary rewards are given to health care providers involved in the vaccination', or if it was an employment or travel requirement (n = 3).

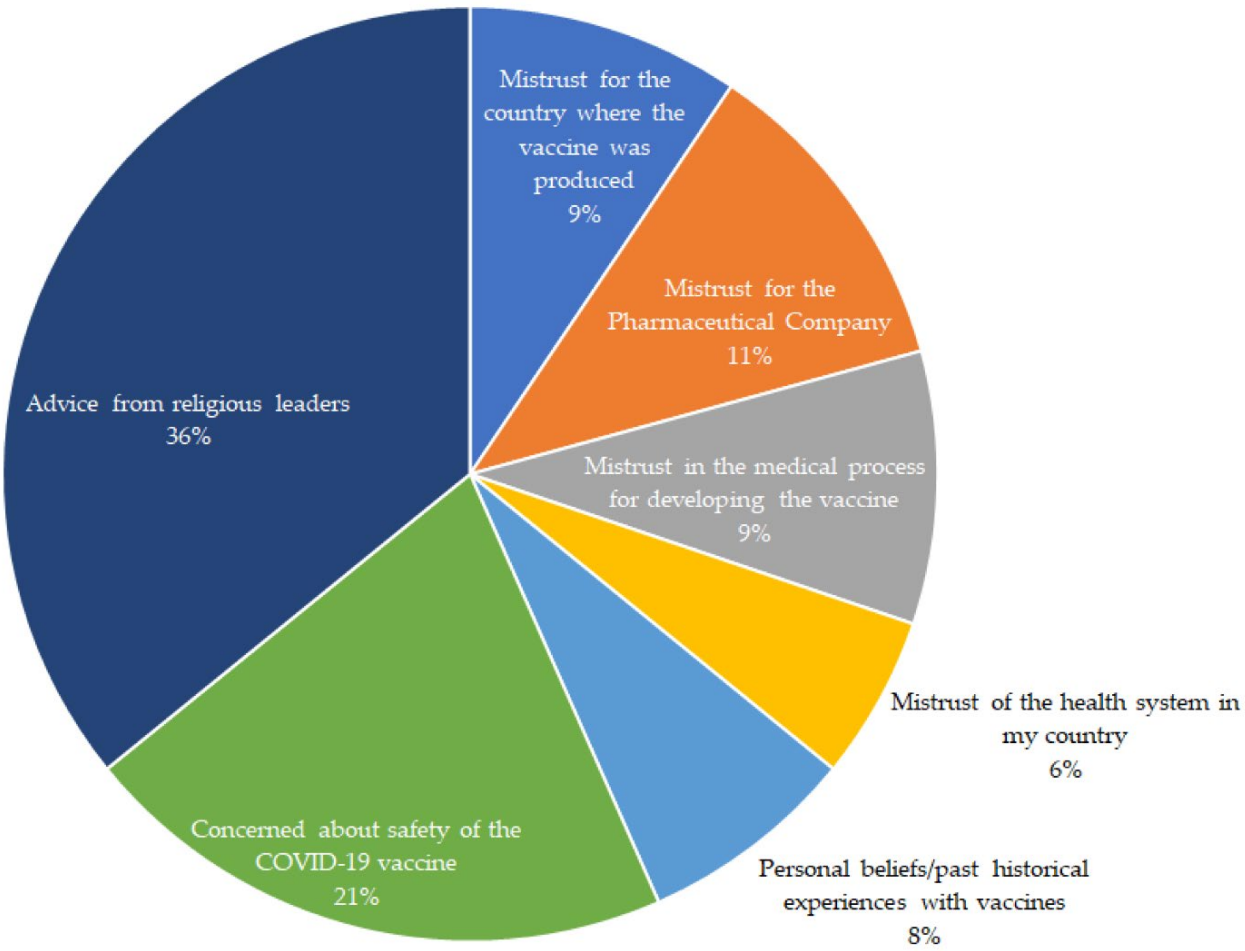

Figure 5. Main reasons for vaccine hesitancy or refusal among people with diabetes (n= 19).

4. Discussion

The COVID-19 pandemic has caused massive global disruption in diagnosing and treating chronic illnesses such as DM, leading to an increase in morbidity and mortality risks [26]. This can partially be explained by the increased tendency to manifest a cytokine storm characterized by severe COVID-19 due to disruptions in the cytokine/ chemokine pathway [27]. This cross-sectional survey assessed vaccine hesitancy among adults with DM in SSA. The uptake of COVID-19 vaccines was very low among the respondents, even though most of them had had previous vaccinations for other conditions and had pre-existing comorbidities, mostly hypertension, which increases their risk of severe complications. Male participants, those from Central and Southern African countries, people who lived locally, and those who had been tested for COVID-19 were significantly more willing to be vaccinated when the vaccines were available in their country compared with their counterparts in this study. While advice from religious leaders, concern about the safety of the vaccine, and mistrust in pharmaceutical companies were the main reasons behind vaccine hesitancy, participants reported that education about the side effects and efficacy of the vaccines, and receiving positive feedback from those vaccinated would encourage them to become vaccinated. Participants reported that Internet sources, including Ministry of Health websites, were their main source of information, followed by social media platforms. The World Health Organization (WHO) and Centers for Disease Control and Prevention (CDC) strongly advocate for individuals with DM to be vaccinated against SARS-CoV-2 [28, 29]. The very low uptake of COVID-19 vaccines found in this study may be attributed to the very slow rollout of the vaccines due to their unavailability in SSA at the time of this study [10]. It also reflected the overall low rate of COVID-19 vaccination (defined by total vaccines per a population of 100 individuals) in SSA [30], which only rose by 15% between January and February 2022 across the continent due to vaccination campaigns by the SSA countries [31], but remains considerably poor compared with resource-rich developed countries [10]. Evidence demonstrates increased vulnerability to severe COVID-19 illness [32, 33] and about three times greater risk of hospitalization in people with DM compared with those without DM [32, 34]. The risk of severe infections in our participants could be much higher, with many of them reporting other comorbidities such as hypertension that adversely affect viral clearance, thereby worsening prognosis during a COVID-19 infection [35]. Ensuring that vaccination is promoted among this high-risk group is important due to the poor outcomes of people with DM when admitted due to COVID-19, despite having good glycemic control prior to admission [36].

The present study found that more males than females were willing to take the COVID-19 vaccine. In a review study [37], the authors suggested that the relationship between sex and vaccine acceptance is ambiguous. For instance, whereas some studies reported more COVID-19-hesitant females than males [25, 37, 38] and vaccine hesitancy generally [39, 40], others [17, 18] showed that males were more hesitant than females towards vaccination [17]. In a study conducted in Saudi Arabia among people with DM, researchers found that the female sex, the longer duration of diabetes, and having no history of influenza vaccination increased the likelihood of accepting the COVID-19 vaccine after adjusting for potential confounders. The inconclusive findings suggest the need for further research on the impact of sex and to see whether females may respond differently to different health promotion approaches.

Past vaccination history is linked to willingness to be vaccinated [41, 42], such as in a UK study where individuals previously

vaccinated for the flu were more willing to be vaccinated against COVID-19 compared to their counterparts [41]; in another study, individuals who had previously refused any vaccination were less likely to accept the COVID-19 vaccine [42]. Although nearly all the participants in this study had had previous vaccinations for other conditions, this had no significant effect on the participants' hesitancy or refusal to receive the COVID-19 vaccine.

Various perceptions are widespread among people with DM, and these may affect their health outcomes. This focus of this study was on individuals with DM in SSA countries to better understand their barriers and enablers to vaccine acceptance. While almost all the participants were aware of COVID-19 vaccines, more than half of them also believed that the vaccines could prevent COVID-19 infection and complications, and nearly all the participants did not believe that the disease was a hoax. The participants reported a high-risk perception of contracting the infection, and about two-thirds felt at risk of being severely infected with the COVID-19 virus, while some of them thought they could die from contracting the infection. These findings agreed with a Dutch study among young adult students that suggested that stronger perceptions of the severity of COVID-19 infection heightened the worries of being infected, but positively influenced the individual's intentions towards vaccination. This resulted in a higher likelihood of COVID-19 vaccine uptake and vice versa [43]. These perceptions can be traced back to the various sources of information (mainly the Internet and social media platforms) used by the respondents during the early phase of the COVID-19 vaccine rollout in SSA.

The female sex and concern about vaccine safety were key considerations for hesitancy towards COVID-19 vaccination in this study. Facilitators of vaccination uptake included education [44-46], which was also reported to improve uptake of the COVID-19 vaccine by the participants. The observation that more education about the vaccine may improve uptake of the vaccine could be attributed to the fact that the majority of participants in this study were educated and may tend to be more curious about the vaccine prior to uptake [47].

A similar finding was reported among healthcare workers, where those with more knowledge about the vaccine mechanism of action and sources reported higher vaccine uptake [48]. A landmark population survey of South Africans in June–July 2021 also found that concerns about the side effects, distrust of government, belief in conspiracy theories, low or no income, and dependence on alternate decision makers were independent predictors of COVID-19 vaccine hesitancy [49]. Therefore, campaigns and sensitization programs geared toward increasing vaccination rates should consider these factors as very essential.

About two in five participants who were hesitant or refused to take the vaccine cited advice from their religious leaders as one of their main reasons for nonvaccinating. This finding is consistent with those of previous reports [50, 51] that demonstrated the key role of religious leaders in the uptake of vaccination programs. The attitude of religious leaders towards vaccination varies from full acceptance to clear refusal, and their views are reflected in those of their local congregation members [50]. The beliefs of some religious leaders such as orthodox Protestants who object to vaccination are rooted in religious doctrine; through their authority, they decide how to interpret and apply this doctrine [50]. A study from F Viskupič and DL Wiltse [51] found that, when messages were endorsed by a religious leader, they had a positive and statistically significant effect on people's interest in becoming vaccinated, whereas those that were endorsed by a political or medical leader had no significant effect. There needs to be a dialog with the religious leaders on how they can help in controlling epidemics

by other means than vaccination [51]. While concern about the vaccine's safety and mistrust in pharmaceutical companies were the other main reasons behind vaccine hesitancy or refusal, participants reported that education about the vaccine, its side effects, and efficacy, and receiving positive feedback from those vaccinated would encourage them to get vaccinated. Participants reported that the ministry website was their main source of information, followed by social media.

Limitations and Strengths

The study has some limitations that should be considered when interpreting the results or comparing them with those of other studies. First, the small sample limited the generalizability of findings beyond the study, as the survey sample is not representative of all those with DM in the region and of the opinion of the general SSA population. Second, key indicators such as diabetes type and duration, and metabolic measures such as glycated hemoglobin A1c (HbA1c) were not asked because the study was not designed specifically for people with DM. Third, the self-reported DM, COVID-19, and other health conditions were not objectively verified. Fourth, there is the issue of the social desirability factor where the opinion of the participants in surveys might not represent their true opinion on the asked questions. Fifth, the inequality in the vaccine supply across the different SSA regions and the unavailability of vaccines in SSA at the time of this study may have led to an overestimation of the unvaccinated participants. Sixth, as a cross-sectional study, we were unable to determine causation. Seventh, the use of social media platforms and emails for survey distribution may limit the generalizability of the findings because the opinion of rural residents, where Internet penetration remains relatively low [52], and those who do not have access to the Internet may have not been captured. Despite these limitations, this study provided the first evidence from SSA on the reasons for nonvaccinating in a high-risk group of adults who are prone to adverse COVID-19 outcomes. It captured opinions from Francophone and Anglophone countries through the dissemination of the survey tool in both English and French languages. In addition, the analysis of the comments provided qualitative evidence that can be used to inform public health control measures for this and future pandemics.

5. Conclusions

The current study investigated COVID-19 vaccine acceptance by exploring many factors, including the effect of history of vaccination, pre-existing conditions, and past diagnosis of COVID-19, and the reasons for vaccine hesitancy and facilitators to COVID-19 vaccine uptake. The findings reveal that the uptake of the COVID-19 vaccine was very low in this high-risk group, and it is imperative that there be efforts to increase the uptake of the vaccine through providing education and information about the vaccine, and some financial incentives. Through these findings, public policies, guidelines, and communication strategies can be formulated to enhance the public's confidence in the various COVID-19 vaccines. This can lead to an overall increase in vaccine uptake. That many of the participants expressed concern about inadequate information calls for action to provide accurate information through healthcare and community health workers, as this can go a long way towards the success of vaccination efforts in the region. Considering the increased supply of vaccines in the region and the availability of more evidence on the COVID-19 vaccine, similar studies exploring COVID-19 vaccine refusal or hesitancy and the reasons for nonvaccinating are needed, particularly in such high-risk groups, including people with hypertension, to understand their reasons for nonvaccinating and whether this has changed over time for those with DM.

Supplementary Materials: The following supporting information can be downloaded at: www.mdpi.com/xxx/s1, Table S1: Participants comments on reasons for their unwillingness to accept the COVID-19 vaccines (n = 19); Figure S1: Percentage breakdown of internet sources used by the participants (n = 64) to retrieve COVID-19 vaccine related information during the pandemic. Totals exceed 100% due to multiple responses.

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10. Prevalence and Factors Associated with Mental and Emotional Health Outcomes among Africans during the COVID-19 Lockdown Period: A Web-based Cross-Sectional Study

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Abstract:

Mental health and emotional responses to the effects of COVID-19 lockdown in sub- Saharan Africa (SSA) are of serious public health concern and may negatively affect the mental health status of people. Hence, this study assessed the prevalence of mental health symptoms as well as emotional reactions among sub-Saharan Africans (SSAs) and associated factors among SSAs during the COVID-19 lockdown period. This was a web-based cross-sectional study on mental health and emotional features from 2005 respondents in seven SSA countries. This study was conducted between 17 April and 17 May 2020 corresponding to the lockdown period in most SSA countries. Respondents aged 18 years and above and the self-reported symptoms were feeling anxious, being worried, angry, bored and frustrated. These were the main outcomes and were treated as dichotomous variables. Univariate and multivariate logistic regression analyses were used to identify the factors associated with these symptoms. We found that over half (52.2%) of the participants reported any of the mental health symptoms and the prevalence of feeling bored was 70.5% followed by feeling anxious (59.1%), being worried (57.5%), frustrated (51.5%) and angry (22.3%) during the COVID-19 pandemic. Multivariate analysis revealed that males, those aged >28 years, those who lived in Central and Southern Africa, those who were not married, the unemployed, those living with more than six persons in a household, had higher odds of mental health and emotional symptoms. Similarly, people who perceived low risk of contracting the infection, and those who thought the pandemic would not continue after the lockdown had higher odds of mental health and emotional symptoms. Health care workers had lower odds for feeling angry than non-healthcare workers. During the COVID-19 lockdown periods in SSA, about one in two participants reported mental health and emotional symptoms. Public health measures can be effectively used to identify target groups for prevention and treatment of mental health and emotional symptoms. Such interventions should be an integral component of SSA governments' response and recovery strategies of any future pandemic.

Keywords: COVID-19; sub-Saharan Africa; mental health; feeling anxious; worried; frustrated; psychological problem; bored and angry

1. Introduction

The outbreak of coronavirus disease is causing considerable acute risk to public health and might also have an unanticipated impact on the mental health symptoms exhibited by people across the globe [1]. At the time of this writing, there were more than
63.8 million confirmed cases and 1.48 million deaths from COVID-19 globally. Africa has recorded more than 2.18 million confirmed cases, and 52,000 people have died from COVID-19. Apart from the personal hygiene practices, the imposition of tight restrictions on movements through lockdowns, most governments also implemented social distancing, self-isolation and quarantine measures worldwide in order to contain community spread of the pandemic. These measures brought about a trail of near economic standstill [2,3] and devastating mental health, emotional and psychosocial consequences [4,5].

The enforcement of strict nationwide lockdown measures disrupted the day-to-

day lives of the general public as a result of the closure of businesses, culminating in the shrinkage of the already fragile economies of most of the underdeveloped Sub-Saharan African (SSA) countries [6]. These measures have also resulted in mass unemployment and huge job losses across many countries, especially in SSA, where most citizens are self-employed and live below the poverty line [7]. These uncertainties, and worries relating to finances, job insecurity and access to quality health coverage, have a detrimental impact on mental wellbeing [8]. The insecurity about the future, the ceaseless news coverage and overbearing daily social media messages serve as stressors of feeling anxious resulting in disruptions in sleeping and eating patterns leading to irritability, low motivation, and increased alcohol and drug abuse [9].

Recent surveys report an increase in the cases of post-lockdown anxiety and paranoia, and a general feeling of loss, including loss of income and routine or social interaction [10,11,12]. Previous epidemics have induced widespread fear, loneliness and psychological consequences and COVID-19 is showing similar effects. An evaluation using the experience from previous outbreaks such as the 2003 SARS in China and later four countries, recommend intensification of the ongoing surveillance and monitoring of the psychological consequences for outbreaks of pandemics from life-threatening diseases, establishing early targeted mental health interventions, should become routine as part of preparedness efforts worldwide. There has been about 60% increase in emergency calls related to domestic violence across Europe [13], an increase in domestic abuse incidents of 32–36% in France, 21–35% increase across the USA, and a 25% increase in the UK [9]. A survey carried out by the United Nations Population Fund (UNFPA) for West, and Central Africa revealed a 35% increase in gender-based violence (GBV) and rape cases in West Africa and a 62% affirmation of GBV experiences since the lockdown [14].

Children and adolescents have also had their own challenges, including the closure of schools and universities, resulting in significant disruption to daily routines and leisure, examination postponement and graduation cancellations [15,16]. Closure of recreation facilities, national parks and playgrounds have had the unintended consequences of a reduction in physical activity and increase in sedentary lifestyle and obesity, exposing the population to an increased risk of developing or deteriorating existing chronic health conditions such as diabetes mellitus and hypertension [17]. Furthermore, the United Nations World Tourism Organization (UNWTO) indicates that international tourist arrivals to Africa decreased by 35% between January to April 2020 as a result of the pandemic and therefore countries that are heavily dependent on the expenditure of international tourists have witnessed dwindled injections of tourism-based foreign income, and massive job losses [18]. Together with the confusion caused by the rapid spread of various misinformation about COVID-19 [19], these present a vicious cycle between preventive measures against the virus and increase in the risk factors associated with severe manifestations of COVID-19.

Even though COVID-19 infection rates and related mortality among Africans fall far below the forecasts by the WHO [14], the values were not meeting the prediction at the time of writing. The impact of the disease on mental health symptoms in SSA could be dire, given the region's weak health care systems and low uptake of mental health services [20]. COVID-19 has not only created mental health disorders with catastrophic emotional changes but has also

interrupted essential mental health services just when they were needed most [7]. However, as shown in a rapid review of published articles on mental health services during COVID-19 involving six SSA countries, the authors suggested that efforts to control the disease transmission should be contextualized in the region [6]. This study builds upon the findings from Semo et al. [6] which identified sub-population most affected that could be targeted for future mental health services in the region. As noted elsewhere, mental health services and resources are being delivered through online platforms [17], but the sub-regions low digital literacy penetration makes virtual mental health services a limited preference for service delivery [6].

Deployment of the mass media for disseminating self-help measures and communicating survivor experiences to the general populace has been recommended for the reduction of stress during this pandemic [6]. In the SSA context, these approaches could improve the coping strategies of the populace, particularly those who are susceptible to biological or psychosocial stressors. Additionally, previous studies have shown that many communities in SSA rely on social resources for dealing with mental health issues as the utilization of orthodox mental health care services is generally low [12,20]. Hence, this paper aimed to investigate mental health and emotional effects of COVID-19 pandemic across SSA region as well as to identify those at greater risk, who could be targeted for improved mental and emotional health, during this and future pandemic.

2. Methodology

2.1. Setting and Study Participants

This online survey was conducted via Survey monkey between 27 April and 17 May 2020, corresponding to the mandatory lockdown period in most SSA countries. At the time, it was not feasible to undertake a conventional Africa-wide community-based sampling survey due to the lockdown and restricted movement. A one-page project information statement that doubled as a recruitment poster was posted/reposted to WhatsApp chat groups and individual WhatsApp accounts. The page also had the contact email of the lead researcher if participants needed further information regarding any part of the study. A link to the online survey was provided. Recipients were further encouraged to send on or 'snowball' the e-link of the survey to other WhatsApp groups that they knew as well as to friends and other social media outlets. We also sent out the link by email to selected groups and individuals in all of the target countries relying on the authors' networks with collaborating academics and local people living in SSA countries. Survey responses were saved and stored on survey monkey regional data center, and anonymized data was retrieved at the end of the study period for analysis.

2.2. Survey Design

The survey instrument was adapted and developed from WHO-recommended questions used in a previous survey (Cronbach's alpha coefficients of 0.74) [21] and had a brief overview of the context, purpose, procedures, nature of participation, privacy and confidentiality statements and notes to be filled out. For this study, we used a twenty-four item self-administered online questionnaire (Appendix A) which was divided into five sections (Sociodemographic and household factors, public attitudes toward compliance to COVID-19, mitigation measures, and risk perception for contracting COVID-19 infection). All questions relating to

sociodemographic and household factors were mandatory.

Prior to the launching of the survey, a pilot study was conducted to ensure clarity and understanding as well as to determine the duration for completing the questionnaire. Participants (n = 10) who took part in the pilot were not part of the research team and did not participate in the final survey as well. In order to minimize bias, responses to the risk perception and attitude items of the online survey used a five-point Likert scale with provisions for neutral responses, so that the answers were not influenced in one way or another. The participants did not receive any incentives; their responses were voluntary and anonymous. The Kudar-Richardson 20 (KR-20) Cronbach's alpha coefficient measuring internal consistency reliability for measures with dichotomous responses for the five mental health symptoms ranged from 0.70 to 0.74, indicating satisfactory consistency.

2.3. Inclusion and Exclusion Criteria

To be eligible for participation, the participants had to be SSA nationals either living abroad or in their countries of origin, which included Ghana, Cameroon (mostly distributed to the English-speaking individuals), Nigeria, South Africa, Tanzania, Kenya and Uganda, aged 18 years or more, and able to provide online consent. Non-SSA participants were excluded from this study.

2.4. Consent and Ethical Consideration

The Human Research Ethics Committee of the Cross-River State Ministry of Health, Nigeria approved this study (number of ethical approval: CRSMOH/RP/REC/2020/116). The study was carried out in accordance with the Helsinki Declaration for Human Research. The section also advised participants not to complete the survey a second time if they had already done so, and that only those aged 18 years were eligible to participate. The confidentiality of participants was assured in that no identifying information was obtained from participants.

This was followed by a consent section where participants were required to voluntarily respond with either a "yes" or "no" to the question inquiring whether they voluntarily agreed to participate in the survey. Participants who answered "yes" were directed to complete the survey. All participants gave written informed consent before participation in this study.

2.5. Data Analysis

2.5.1. Outcome Variables

The outcome variables in this study were derived from the item asking participants: "how do you feel about the COVID-19 lockdown measures?" (item 16 of Appendix A). The measures were, "frustrated", "angry', "bored", "anxious" and "worried" about COVID-19. Each of these five outcome variables were coded as binary, "1" for yes and "0" for no.

2.5.2. Confounding Variables

The confounding variables used in this study included the demographic characteristics (age group, gender, marital status, and place of current residence, education, employment, occupation, religion; household factors (whether they lived alone and the number of household members which was an open-ended question, see item 12 of Appendix A). The items required a true/false, yes/no response with an additional "I don't know/unsure" option provided. The public attitude towards COVID-19 mitigation practice variables were obtained from questions on whether the respondents practiced self-isolation, or home quarantine, and adhered to the precautionary public health measures such as, avoiding crowded places or religious events, use of face mask when leaving their homes, and practicing hand hygiene (washing hands with soap for at least 20 s each time or using hand sanitizers).

These items were added to identify the effect of compliance to the mitigation practices put in place during the lockdown period to prevent the spread of the virus. For these variables, each question used a Likert scale with five levels with scores for each item ranging from 0 (lowest) to 4 (highest). As with epidemiological studies, the Likert scales were dichotomized to aid epidemiological interpretations and to describe the type of outcome under study (prevalence study and odds ratios). The risk perception variables were derived from questions on whether or not the respondents thought they were "at risk of becoming infected", "at risk of dying from the infection", "at risk of becoming severely infected", "how worried they were because of COVID-19" if they thought "the infection would continue in their country" and how concerned they were of the possibility of being infected. These were included because individuals who perceived the risk as severe are more likely to reduce the spread of the virus.

2.6. Statistical Analysis

Initial analyses involved frequency tabulations of all confounding factors in the study population presented in Table 1. This was followed by cross-tabulation to determine the prevalence and their corresponding 95% confidence intervals (CIs) of the mental health symptoms such as feeling anxious and emotional features that included being bored, frustrated, worried and angry. Univariate logistic regression was performed to examine the independent association between the five mental and emotional health symptoms (feeling bored, anxious, frustrated, worried and angry) and confounding factors (see Table 1 for details).

Table 1. Characteristics of the study population (N = 2005).

Variables	Number	Percentages
Sociodemographic characteristics		
Place of Origin (n = 1969)		
West Africa	1108	56.27
East Africa	209	10.61
Central Africa	251	12.75
Southern Africa	401	20.37
Place of residence		
Africa	1855	92.52
Diaspora	150	7.48
Age in years (n = 1988)		
18–28 years	775	38.98
29–38	530	26.66
39–48	441	22.18
49+ years	242	12.17
Sex (n = 1991)		
Men	1099	55.2
Women	892	44.8
Marital Status (n = 1995)		
Married	879	44.06
Not married †	1116	55.94
Highest level of Education (n = 1997)		
Postgraduate Degree (Masters/PhD)	642	32.15
Bachelor's degree	1090	54.58
Secondary/Primary	265	13.27
Employment status (n = 2000)		
Employed	1321	66.05
Unemployed	679	33.95
Occupation type (n = 1904)		
Non-healthcare	1471	77.26
Healthcare	433	22.74
Religion (n = 1995)	1995	
Christianity	1763	88.37
Islam/others †	232	11.63
Household factors		
Do you live alone during COVID-19 (n = 1996)		
No	1624	81.36
Yes	372	18.64
Number living together (n = 1775)		
1–3 people	506	28.83
4–6 people	908	51.74
6+ people	341	19.43
Public attitudes toward compliance with COVID-19		
Practiced self-isolation (n = 1801)		
No	1237	68.68
Yes	564	31.32
Home quarantined due to COVID-19 (n = 1798)		
No	1091	60.68
Yes	707	39.32
Gone to a crowded event (n = 1797)		
No	1550	86.25
Yes	247	13.75
Perception of risk		
Risk of becoming infected (n = 1821)		
High	674	37.01
Not high	1147	62.99
Risk of becoming severely infected (n = 1823)		
High	471	25.84
Not high	1352	74.16
Risk of dying from infection (n = 1818)		
High	352	19.36
Not high	1466	80.64
Possibility of you/family member being affected (n = 1794)		
Concerned	1692	94.31
Not Concerned	102	5.69
Likelihood of COVID-19 continuing (n = 1827)		
Likely	1167	63.88
Not Likely	660	36.12

Note: Total count 2005 unless otherwise given in brackets.
† = single, previously married, divorced or widowed.

Multivariable logistic regression was also carried out to determine factors associated with the five mental and emotional health symptoms. The odds ratios (OR) with their 95% CIs were calculated to assess the adjusted odds of the confounding variables and those with p-value < 0.05 were considered as factors associated with the five variables (see, bolded adjusted OR and their 95% CIs in Table 2). All analyses were conducted using STATA/MP version 14.1 (Stata Corp 2015, College Station, TX, USA).

3. Results

3.1 Sample Characteristics

Table 1 presents the details of the demographic variables of participants in this study. A total of 2005 adults from SSA completed the survey, about half of them were males, not married, and many were aged 18 to 38 years. At the time of this study, majority of the respondents lived in their SSA countries of origin, particularly in West Africa, were non-healthcare workers, had completed at least a bachelor's degree, were employed and lived alone. Due to the web-based design, it was not possible to estimate how many persons were reached by social network advertisement and no response rate could be estimated.

More than one third experienced self-quarantine due to COVID-19 and nearly all respondents (94.3%) were concerned about contracting COVID-19 while some (19.4%) thought they were at high risk of dying from the infection. A high percentage of respondents believed that COVID-19 would not continue after the lockdown (1167, 63.9%). Further details are presented in Table 1.

3.2. Prevalence of Mental Health/Emotional Symptoms

The prevalence of self-reported mental health and emotional issues and their 95% CIs are shown in Figure 1. The prevalence was highest for respondents who were bored (57.5%, 95% CI 55.2%, 59.7%]), followed by those who felt anxious (59.1%, 95% CI 56.7%, 61.5%) and worried (57.5%, 95% CI 55.2%, 59.7%) about the pandemic. Overall, more than 52.2% of the participants reported mental and emotional health symptoms.

3.3. Univariate Analysis of Factors Associated with Mental Health Symptoms

The univariate analysis of factors associated with the symptoms of mental health and emotional effects in the study population is presented in Table 2. Living in Central Africa, with six or more people in the household was associated with increased odds of feeling bored, frustrated, angry and anxious among the respondents. Those who lived with more than six persons in the household showed significantly higher odds for all the dependent variables except for "feeling worried" and East African respondents had remarkably higher odds of feeling frustrated due to COVID-19. Compared to men, women were more likely to feel bored (OR 1.28, 95% CI 1.02, 1.59) and anxious (OR 1.24, 95% CI 1.02, 1.53) and those who were not married were more likely to feel frustrated (OR 1.25, 95% CI 1.02, 1.52) and angry (OR 1.30, 95CI 1.02, 1.66) compared to the married respondents. Higher odds of feeling 'angry' was found among those who were unemployed (OR 1.29, 95% CI 1.04, 1.59), and among respondents who thought that COVID-19 would not continue in their respective countries after the lockdown (OR 1.40, 95% CI 1.08, 1.81).

Individuals who were concerned that they or their family members could be infected with COVID-19 were less likely to feel worried and anxious about contracting the infection. Similarly, participants who felt at lower risk of being infected (OR 0.34, 95% CI 0.27, 0.41), or being severely infected (OR 0.26, 95% CI

0.20, 0.33) and those who thought their risk of dying from the infection was low (OR 0.18, 95% CI 0.14, 0.25), were less likely to worry about COVID-19, in this study.

3.4 Multivariate Analysis of Factors Associated with Mental Health/Emotional Symptoms

Table 3 shows the factors associated with the symptoms of mental and emotional health, after adjusting for all potential covariates. Age became a significant factor influencing the respondents' experience of mental health symptoms. Participants aged 29–38 years had higher odds for feeling bored (aOR 1.81, 95% CI 1.05, 3.10), and frustrated (aOR 1.95, 95% CI 1.20, 3.19), while those aged 39-48yrs (aOR 2.09, 95% CI 1.22, 3.56) were more likely to feel frustrated due to COVID-19 compared to younger participants (18–28years). Central African respondents reported higher odds of feeling frustrated (aOR 1.49, 95% CI 1.01, 2.19), angry (aOR 2.12, 95% CI 1.37, 3.29), and anxious (aOR 1.60, 95% CI 1.05, 2.43), whereas respondents from Southern African countries reported higher odds of feeling frustrated (aOR 1.46, 95% CI 1.06, 2.00), compared to those from the West African countries. Other factors associated with higher odds of mental and emotional health symptoms in this study included being unmarried, being unemployed, living with six or more people in the household during the pandemic, perception of low risk of contracting the infection and the thought that COVID-19 will not continue after the lockdown.

Overall, respondents who perceived a low risk of being infected by COVID-19 were less likely to be worried about the disease and those from the Southern African countries were less likely to feel bored during the pandemic (aOR 0.59, 95% CI 0.42, 0.82), compared to the respondents from West Africa.

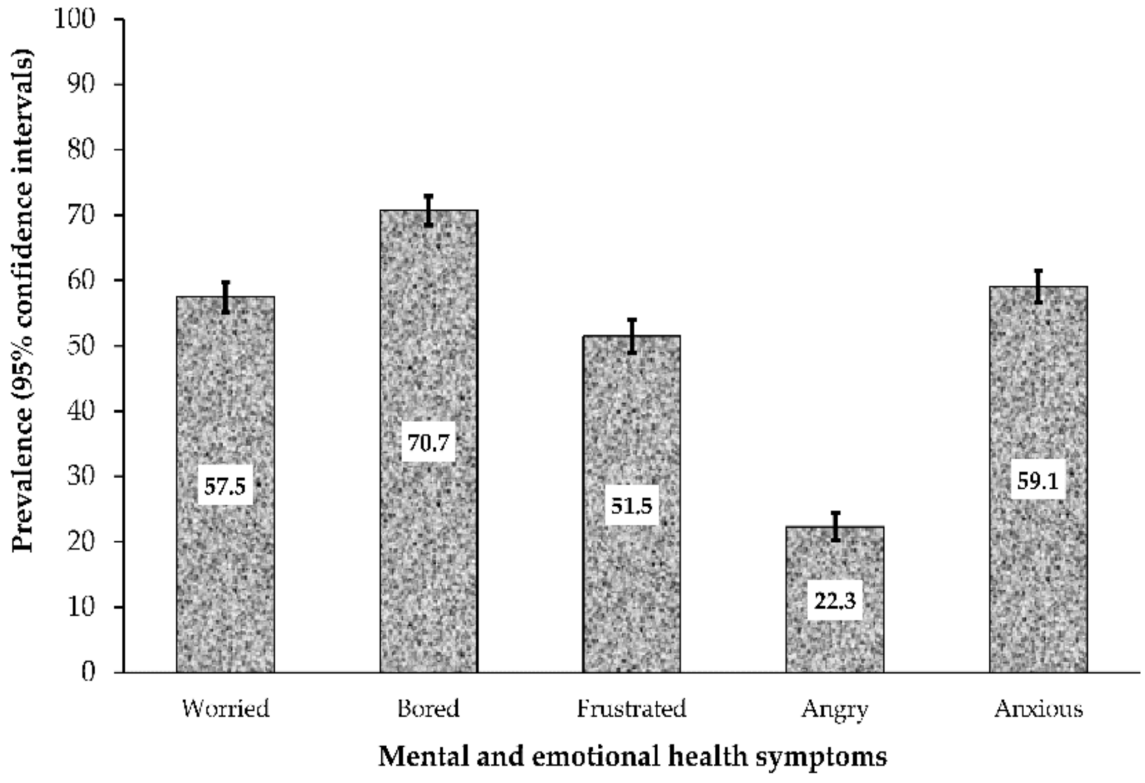

Figure 1. Prevalence of mental health and emotional effects in Sub Sahara African respondents (n = 2005) during the COVID-19 Pandemic. Error bars are 95% confidence interval

Table 2. Univariate analysis of factors associated with five mental health/emotional symptoms of COVID-19 among Sub-Sahara Africans during the lockdown.

Variables	Worried		Bored		Frustrated		Angry		Anxious	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Demography										
Place of Origin										
West Africa	1.00		1.00		1.00		1.00		1.00	-
East Africa	1.34	[0.97, 1.85]	0.61	[0.43, 0.86]	**1.56**	**[1.12, 2.18]**	1.27	[0.85, 1.89]	1.09	[0.78, 1.52]
Central Africa	1.19	[0.89, 1.60]	**1.56**	**[1.06, 2.30]**	**1.64**	**[1.20, 2.24]**	**2.38**	**[1.69, 3.35]**	**1.98**	**[1.41, 2.79]**
Southern Africa	1.21	[0.95, 1.54]	0.6	[0.4, 0.79]	**1.48**	**[1.14, 1.92]**	1.05	[0.76, 1.46	0.99	[0.76, 1.28]
Place of residence										
Africa	1.00		1.00		1.00		1.00		1.00	
Diaspora	0.76	[0.53, 1.08]	1.23	[0.80, 1.89]	0.82	[0.56, 1.19]	0.9	[0.56, 1.44]	0.84	[0.57, 1.24]
Age in years		-	-	-	-	-	-	-	-	-
18-28	1.00		1.00		1.00		1.00		1.00	
29-38	1.17	[0.91, 1.51]	1.12	[0.83, 1.50]	0.86	[0.66, 1.13]	0.85	[0.61, 1.18]	0.92	[0.70, 1.21]
39-48	1.09	[0.81, 1.48]	1.03	[0.72, 1.48]	1.1	[0.80, 1.53]	0.91	[0.61, 1.35]	0.75	[0.54, 1.04]
49+	1.04	[0.83, 1.32]	0.13	[0.71, 1.21]	0.84	[0.66, 1.08]	0.95	[0.71, 1.29]	0.96	[0.75, 1.24]
Sex										
Men	1.00	-	1.00	-	1.00	-	1.00	-	1.00	-
Women	0.98	[0.82, 1.19]	**1.28**	**[1.02, 1.59]**	0.98	[0.80, 1.20]	0.89	[0.70, 1.14]	**1.24**	**[1.02, 1.53]**
Marital Status	-	-	-	-	-	-	-	-	-	-
Married	1.00	-	1.00	-	1.00	-	1.00	-	1.00	-
Not married †	1.06	[0.88, 1.28]	1.12	[0.90, 1.40]	**1.25**	**[1.02, 1.52]**	**1.3**	**[1.02, 1.66]**	1.16	[0.95, 1.42]
Highest level of Education	-	-	-	-	-	-	-	-	-	-
Postgraduate Degree (Masters /PhD)	1.00		1.00	-	1.00	-	1.00	-	1.00	-
Bachelor's degree	**1.24**	**[1.01, 1.52]**	**0.72**	**[0.56, 0.91]**	1.12	[0.90, 1.40]	0.94	[0.72, 1.23]	1.03	[0.82, 1.29]
Secondary/Primary	1.02	[0.75, 1.39]	1.04	[0.72, 1.51]	1.23	[0.89, 1.69]	0.74	[0.49, 1.12]	0.98	[0.71, 1.36]
Employment status	-	-	-	-	-	-	-	-	-	-
Employed	1.00	-	1.00	-	1.00	-	1.00	-	1.00	-
Unemployed	1.09	[0.90, 1.33]	1.02	[0.81, 1.28]	**1.29**	**[1.04, 1.59]**	1.01	[0.78, 1.30]	1.01	[0.81, 1.24]
Occupation type	-	-	-	-	-	-	-	-	-	-
Non-healthcare	1.00	-	1.00	-	1.00	-	1.00	-	1.00	-
Healthcare	1.10	[0.88, 1.39]	0.9	[0.70, 1.17]	**0.78**	**[0.61, 0.99]**	**0.64**	**[0.46, 0.88]**	1.17	[0.91, 1.49]
Religion	-	-	-	-	-	-	-	-	-	-
Christianity	1.00	-	1.00	-	-	-	-	-	-	-
Islam/others †	1.20	[0.89, 1.61]	0.91	[0.65, 1.28]	0.89	[0.65, 1.22]	1.02	[0.70, 1.49]	0.89	[0.65, 1.22]
Household factors										
Number living together		-	-	-	-	-	-	-	-	-
1-3 people	1.00	-	1.00		1.00		1.00		1.00	
4-6 people	1.13	[0.90, 1.43]	1.15	[0.89, 1.49]	1.07	[0.83, 1.36]	1.27	[0.93, 1.72]	1.14	[0.89, 1.46]
6+ people	0.97	[0.73, 1.29]	**1.57**	**[1.11, 2.23]**	**1.42**	**[1.04, 1.95]**	**1.64**	**[1.12, 2.37]**	**1.39**	**[1.01, 1.93]**
Attended crowded event										
No	1.00	-	1.00	-	1.00	-	1.00	-	1.00	-
Yes	1.15	[0.87, 1.51]	1.02	[0.73, 1.42]	1.06	[0.78, 1.42]	0.99	[0.68, 1.43]	1.2	[0.87, 1.68]
Public attitudes towards compliance to COVID-19										
Self-Isolation										
No	1.00	-	1.00	-	1.00	-	1.00	-	1.00	-
Yes	1.07	[0.87, 1.31]	0.96	[0.75, 1.22]	0.97	[0.77, 1.21]	0.8	[0.60, 1.06]	0.85	[0.67, 1.06]
Home quarantined due to COVID-19	-	-	-	-	-	-	-	-	-	-
No	1.00	-	1.00	-	1.00	-	1.00	-	1.00	-
Yes	1.03	[0.85, 1.25]	1.04	[0.82, 1.31]	1.01	[0.81, 1.25]	0.86	[0.66, 1.11]	0.96	[0.77, 1.20]
Perception of risk										
Risk of becoming infected	-	-	-	-	-	-	-	-	-	-
High	1.00	-	1.00	-	1.00	-	1.00	-	1.00	-
Not high	**0.34**	**[0.27, 0.41]**	**1.16**	[0.92, 1.46]	1.22	[0.99, 1.52]	**1.51**	**[1.15, 1.99]**	1.12	[0.90, 1.39]
Risk of becoming severely infected	-	-	-	-	-	-	-	-	-	-
High	1.00	-	1.00	-	1.00	-	1.00	-	1.00	-
Not high	**0.26**	**[0.20, 0.33]**	1.11	[0.86, 1.43]	1.05	[0.83, 1.33]	1.14	[0.85, 1.53]	1.06	[0.84, 1.35]
Risk of dying from infection	-	-	-	-	-	-	-	-	-	-
High	1.00	-	1.00	-	1.00	-	1.00	-	1.00	-
Not high	**0.18**	**[0.14, 0.25]**	1.3	[0.98, 1.72]	1.12	[0.86, 1.46]	1.06	[0.77, 1.47]	1.08	[0.83, 1.41]
Possibility of you/family member being affected	-	-	-	-	-	-	-	-	-	-
Concerned	1.00	-	1.00	-	1.00	-	1.00	-	1.00	-
Not Concerned	**0.17**	**[0.10, 0.27]**	0.92	[0.58, 1.48]	0.8	[0.51, 1.24]	0.70	[0.39, 1.26]	**0.63**	**[0.40, 0.98]**
Likelihood of COVID-19 continuing	-	-	-	-	-	-	-	-	-	-
Likely	1.00	-	1.00	-	1.00	-	1.00	-	1.00	-
Not Likely	0.62	[0.51,0.75]	1.12	[0.58, 1.48]	1.17	[0.94, 1.45]	1.40	[1.08, 1.81]	1.08	[0.86, 1.34]

OR = odds ratio; **Bolded:** confidence intervals (CIs) are significant. † = single, previously married, divorced or widowed.

Table 3. Multivariate analysis of factors associated with mental health/emotional impact of COVID-19 among Sub-Sahara Africans during the lockdown.

Variables	Worried		Bored		Frustrated		Angry		Anxious	
	aOR	0.95 CI	aOR	0.95 CI	aOR	0.95 CI	aOR	0.95 CI	aOR	0.95 CI
Demography										
Place of Origin										
West Africa	1.00	-	1.00	-	1.00	-	1.00	-	1.00	-
East Africa	1.1	[0.77, 1.66]	**0.5**	**[0.32, 0.72]**	1.2	[0.78, 171]	1.1	[0.65, 1.70]	1	[0.67, 1.47]
Central Africa	1.1	[0.74, 1.56]	1.4	[0.85, 2.21]	**1.5**	**[1.01, 2.19]**	**2.1**	**[1.37, 3.29]**	**1.6**	**[1.05, 2.43]**
Southern Africa	1.2	[0.87, 1.58]	0.6	[0.42, 0.82]	**1.5**	**[1.06, 2.00]**	0.9	[0.58, 1.31]	0.9	[0.65, 1.23]
Place of residence										
Africa	1.00	-	1.00	-	1.00	-	1.00	-	1.00	-
Diaspora	1.00	[0.59, 1.69]	1.7	[0.86, 3.38]	0.9	[0.53, 1.64]	0.9	[0.42, 1.78]	0.9	[0.49, 1.58]
Age in years										
18–28	1.00	-	1.00	-	1.00	-	1.00	-	1.00	-
29–38	1.1	[0.76, 1.65]	1.3	[0.83, 1.96]	**1.6**	**[1.03, 2.34]**	1.1	[0.69, 1.79	0.9	[0.62, 1.40]
39–48	1.5	[0.94, 2.35]	**1.8**	**[1.05, 3.10]**	**2**	**[1.20, 3.19]**	1	[0.56, 1.81]	0.9	[0.57,1.52]
49+	1.2	[0.72, 1.98]	1.6	[0.87, 2.81]	**2.1**	**[1.22, 3.56]**	1	[0.49, 1.82]	0.7	[0.40, 1.17]
Sex										
Men	1.00	-	1.00	-	1.00	-	1.00	-	1.00	-
Women	1.1	[0.82, 1.33]	1.2	[0.88, 1.52]	0.8	[0.60,1.00]	**0.7**	**[0.50, 0.93]**	1.2	[0.90, 1.51]
Marital Status	-	-	-	-	-	-	-	-	-	-
Married	1.00	-	1.00	-	1.00	-	1.00	-	1.00	-
Not married †	1.10	[0.79, 1.52]	**1.5**	**[1.04, 2.42]**	**1.7**	**[1.16, 2.33]**	**1.8**	**[1.19, 2.75]**	1.4	[0.99, 1.99]
Highest level of Education										
Postgraduate Degree (Masters/PhD)	1.00	-	1.00	-	1.00	-	1.00	-	1.00	-
Bachelor's degree	1.3	[0.96, 1.74]	0.8	[0.56, 1.11]	1.2	[0.87, 1.63]	1	[0.69, 1.49]	0.9	[0.69, 1.28]
Secondary/Primary	1.1	[0.70, 1.80]	1.2	[0.72, 2.14]	1	[0.62, 1.64]	0.6	[0.29, 1.04]	0.6	[0.40, 1.05]
Employment status										
Employed	1.00	-	1.00	-	1.00	-	1.00	-	1.00	-
Unemployed	**1.4**	**[1.03, 2.02]**	0.9	[0.64, 1.37]	**1.5**	**[1.01, 2.07]**	0.8	[0.53, 1.24]	0.8	[0.54, 1.13]
Occupation type										
Non-healthcare	1.00	-	1.00	-	1.00	-	1.00	-	1.00	-
Healthcare	1	[0.77, 1.36]	1	[0.71, 1.34]	0.8	[0.55, 1.00]	**0.6**	**[0.41, 0.90]**	1.2	[0.87,1.59]
Religion										
Christianity	1.00	-	1.00	-	-	-	-	-	-	-
Islam/others†	1.2	[0.78, 1.69]	0.9	[0.60, 1.45]	1	[0.66, 1.47]	1.3	[0.77, 2.05]	0.9	[0.59, 1.34]
Household factors										
Number living together										
<3 people	1.00		1.00	-	1.00	-	1.00	-	1.00	-
4–6 people	1.1	[0.85,1.47]	1.3	[0.94, 1.72]	1	[0.78, 1.38]	1.2	[0.81, 1.66]	1.2	[0.92, 1.63]
6+ people	0.9	[0.66, 1.32]	**1.7**	**[1.13, 2.56]**	1.4	[0.99, 2.05]	1.2	[0.77, 1.87]	1.3	[0.90, 1.90]
Attended crowded event										
No	1.00	-	1.00	-	1.00	-	1.00	-	1.00	-
Yes	1.1	[0.76, 1.56]	1	[0.68, 1.56]	1.1	[0.76, 1.60]	0.9	[0.55, 1.40]	1.1	[0.72, 1.57]
Public attitudes toward compliance to COVID-19										
Self-Isolation										
No	1.00	-	1.00		1.00		1.00		1.00	
Yes	1	[0.72, 1.28]	0.9	[0.62, 1.18]	0.9	[0.64, 1.15]	0.7	[0.48, 1.00]	0.9	[0.63, 1.14]
Home quarantined due to COVID-19										
No	1.00	-	1.00	-	1.00	-	1.00	-	1.00	-
Yes	1	[0.77, 1.31]	1	[0.70, 1.29]	1.1	[0.79, 1.38]	1.2	[0.83, 1.63]	1	[0.73, 1.29]
Perception of risk										
Risk of becoming infected										
High	1.00	-	1.00	-	1.00	-	1.00	-	1.00	-
Not high	**0.6**	**[0.45, 0.80]**	0.9	[0.64, 1.39]	1.3	[0.93, 1.88]	**1.8**	**[1.16, 2.93]**	1.1	[0.78, 1.59]
Risk of becoming severely infected										
High	1.00	-	1.00		1.00		1.00		1.00	
Not high	**0.60**	[0.39, 0.93]	0.9	[0.57, 1.48]	0.8	[0.54, 1.88]	0.8	[0.47, 1.48]	1	[0.63, 1.52]
Risk of dying from infection										
High	1.00	-	1.00	-	1.00	-	1.00	-	1.00	-
Not high	**0.4**	**[0.25, 0.58]**	1.5	[0.97, 2.30]	1.2	[0.79, 1.76]	0.9	[0.53, 1.48]	1.2	[0.80, 1.78]
Possibility of you/family member being affected										
Concerned	1.00	-	1.00	-	1.00	-	1.00	-	1.00	-
Not Concerned	**0.2**	**[0.09, 0.33]**	1.1	[0.57, 1.97]	0.8	[0.46, 1.45]	0.9	[0.45, 1.79]	0.6	[0.36, 1.14]
Likelihood of COVID-19 continuing										
Likely	1.00	-	1.00	-	1.00	-	1.00	-	1.00	-
Not Likely	**0.8**	**[0.59, 0.97]**	1.1	[0.81, 1.45]	1.3	[0.98, 1.66]	**1.5**	**[1.08, 2.04]**	1.2	[0.89, 1.53]

aOR = adjusted odds ratio; Bolded: confidence intervals (CIs) are significant. † = single, previously married, divorced or widowed.

4. Discussion

The current study explored both mental and emotional health symptoms among SSA respondents, during the COVID-19 lockdown. This is the first study using a web- based cross-sectional survey to examine the prevalence and factors associated with mental and emotional health symptoms of COVID-19 in SSA. This study found that the COVID-19 pandemic had a major impact on the mental and emotional health of respondents in SSAs (including health care workers). More than half of the respondents reported feeling anxious, worried, frustrated and bored, whereas approximately one in four respondents reported feeling angry during the COVID-19 lockdown period. The study also revealed that those older than 28 years who lived in the Central and Southern African countries, respondents who were not married, the unemployed, as well as those who lived with more than six persons in a household, had higher odds of mental and emotional health symptoms during the COVID-19 lockdown period. In addition, respondents who felt that at lower risk of being infected by the virus and those who did not think that COVID-19 will continue after the lockdown, were more likely to feel angry about the pandemic. The study also found that people working in health care sectors were less likely to report mental and emotional health symptoms during the COVID-19 pandemic.

Compared with previous rates of any mental health/emotional symptoms in Low and Middle-Income Countries (LMIC) and SSA countries (10–20% at any one time [20,22]), the impact of the pandemic on the state of mental health (which includes emotional and psychological well-being) of SSAs in this study was profound and increased by three folds. Reports from China [23,24], the USA (53% reported feeling anxious and stress relating to the coronavirus) [25], India (30.5% reported depression) [26] and Italy (41.6% reported moderate stress) [27], found much lower prevalence of mental illness/emotional symptoms than the present study. Although COVID-19 infections and deaths are lower in SSA region than other regions, the higher prevalence of mental health symptoms found in this study suggests that the SSA population could be particularly vulnerable to emotional distress in the current pandemic. Given the already existing situations of poverty, unemployment and weak health systems [20] and the unavailability of effective treatment, it is expected that the rate of mental and emotional health symptoms will increase. This suggestion is substantiated in Table 2, whereby it is observed that respondents were more worried about the likelihood of COVID-19 continuing (63.9%) than their risk of becoming severely infected (25.8%) or dying (19.4%) from the disease. This finding is consistent with a recent study from the UK, which found that the citizens were more concerned about how societal changes would influence their psychological and financial wellbeing, than their risk of becoming unwell with the virus [28]. Prevention efforts such as screening for mental health and emotional problems and psychoeducation [29] focusing on the identified groups at risk for adverse psychosocial outcomes are needed.

The higher odds of mental illness/emotional symptoms among health care workers (HCWs) than non-healthcare workers (NHCWs) found in previous studies among Chinese residents [9,11] were not found in this study. Rather, we found that HCWs were less likely to report any COVID-19 related mental health symptom than NHCWs, particularly with respect to feeling ‘angry’. Despite the lower odds of mental health/ emotional symptoms among HCWs, they are particularly vulnerable to emotional distress in the current pandemic. This is due to their level of exposure to the virus, concern about being infected and caring for their loved ones, shortages of personal protective equipment (PPE), longer work hours, and involvement in emotionally and

ethically fraught resource-allocation decisions [30]. HCWs should be monitored for a change in routine and behavior. Similar to the previous reports from Italy [27] and China [9,31], the present study found a significantly higher odds of mental health symptoms among women than men during the pandemic (Table 3). This finding may be explained in part by the report that women including those who are pregnant or have young children were more likely to develop the fear of becoming infected or transmitting the virus [32].

As part of the measures to deal with mental health and psychological issues during the COVID-19 pandemic, the WHO had encouraged individuals to stay with friends and families [10]. This guideline was supported by our findings of higher odds for feeling bored, frustrated, and angry among respondents who were single. On the other hand, living with more than six persons in the household was associated with higher odds of mental and emotional health symptoms of feeling anxious, angry, and frustrated. This may also suggest that living with many people in the household could make people feel more anxious. Evidence from a systematic review and meta-analysis on household transmission studies of COVID-19 found that the risk of infection is 10 times higher among household contacts than other contacts [33]. These trends have challenged the traditional SSA social structure of communalism, a crucial socio-cultural factor, whose maintenance could be important in dealing with mental health issues in the SSA context [6]. Many communities in SSA rely on social resources for dealing with mental health issues as utilization of orthodox mental health care services is generally low [12,20]. Some of the resources people access for relief from mental problems within the SSA context include keeping in touch with others, attending faith and religious events, and engaging in prayers [6].

In the wake of the COVID-19 lockdowns in SSA, access to social resources was limited, and alternative ways of delivering mental health resources were needed [12]. Prior to COVID-19, there was already a huge gap of unmet mental health services for older adults in SSA [12,34] which is fueled by factors such as stigma, poor awareness that older adults suffer from mental illness, deficient primary health care services, inadequate community healthcare workers and psychogeriatricians [35]. In addition to these factors, the low levels of digital literacy in SSA hindered the deployment of online or virtual mental health service delivery [6] as alternatives to overcome disruptions to in-person services. While more than 80% of high-income countries have started the utilization of alternative mental health interventions to bridge gaps in mental health services, the patronage by low-income countries has been less than 50% [7]. In line with WHO's guideline, SSA countries must allocate resources to mental health as an integral component of their response and recovery strategies. Utilization of the mass media to share survivor experiences to mental health patients and the public could be a good alternative for delivering counselling measures [6]. Additionally, educational campaigns are needed to increase the awareness and enlightenment of the public regarding the fact that older adults can suffer from mental illnesses and recognize the benefits of orthodox management of mental illnesses [12].

The present findings indicate that individuals who perceived themselves or their family members to be at a lower risk of being infected by COVID-19 or dying from the disease reported lower odds for worrying about COVID-19. Strong coping mechanisms are necessary to deal with mental health and emotional issues during a pandemic, and one of these coping strategies is to be less concerned about the consequences and impact of the disease and remain cautious. According

to the WHO, people should reduce the amount of information they receive about COVID-19 to reduce feeling anxious [10]. Consistent with our finding, a study in China found that people who spent too much time thinking about disease outbreak were more likely to develop symptoms of anxiety [11]. This may explain the higher prevalence of mental health/emotional symptoms, which we found among the unemployed respondents. The mental health and psychological impact of the pandemic because of rising economic recession and massive job losses within the context of struggling economies cannot be underestimated. Therefore, mental health support services should be an integral part of the disease response strategy in SSA.

5. Limitations and Strengths

This study has some limitations. First, the data was collected using an online survey and may not be a true reflection of the opinion of other SSAs living in rural areas where internet penetration and connectivity remain relatively low [36] or the older people who are less likely to use the internet. However, the increase in the use of internet recorded among the general population during the pandemic meant that many people may have participated [37]. Also, this was the only reliable, cost effective means to disseminate information at the time of this study and obtain real-time data on the current situation. Second, the survey was available only in English, making it difficult for people living in French-speaking countries including some part of Cameroon, to participate. Third, there was limited participation of East African respondents in this study, which may be attributed to the government instructions for residents to refrain from giving out information regarding the pandemic. Fourth, the research methodology did not allow us to reach people with medically examined mental health symptoms; therefore, the provision of the results may not fully reflect the severity of the mental health symptoms among SSA population. Fifth, this study did not use the tools designed specifically for the COVID-19 pandemic, such as the coronavirus anxiety scale (CAS). Future studies using the tools developed especially for the COVID-19 pandemic will provide a concrete finding and facilitate the demand for a focused public health initiative. Another limitation peculiar to web-based surveys was the inability to verify the eligibility of the participants and the validity of their responses. Despite these limitations, this is the first study to provide comprehensive evidence of the mental health impact of the pandemic across SSA region. With a web-based questionnaire, the study was able to assess the prevalence of mental health symptoms among SSA respondents, while maintaining the WHO recommended "social distance" during the COVID-19 pandemic, which otherwise would be impossible. Furthermore, using a robust analysis, we were able to minimize bias by controlling for all potential confounders in the analysis. That no incentives were not given to participant's ensured that their participation and response rates were not influenced [38].

6. Conclusions

In conclusion, amidst relatively lower disease and death ratios, this study highlights a high prevalence of mental health and emotional symptoms during COVID-19 in Sub Sahara African region. Despite the lack of a baseline mental health study of the study population prior to COVID-19, the findings strongly suggest markedly elevated mental health symptoms whose rates are consistent with those of other study populations worldwide [39]. Such a high impact of the disease may be related to the weak health systems and low access to alternative mental health service delivery within the sub- region. While three out of every four persons surveyed reported feeling bored, about one in every two persons, felt frustrated and worried about the

lockdown. Southern and Central Africans had a greater risk of mental health and emotional symptoms during COVID-19 pandemic. Implementing community-based strategies to support resilience among these psychologically vulnerable individuals such as the older adults, those who neither are married nor employed, as well as people living with many household members during the COVID-19 crisis is fundamental for the SSA communities. The psychological impact of fear and feeling anxious induced by the rapid spread of pandemic needs to be clearly recognized as a public health priority for both authorities and policymakers who should rapidly adopt clear behavioral strategies to reduce the burden of disease, plan for long-term fallout of the disease and the dramatic mental health consequences of this outbreak. Most importantly, mental health service resources must be as an integral component of SSA governments' response and recovery strategies of the COVID-19 pandemic.

Author Contributions

Conceptualization, all authors; methodology, K.E.A., U.L.O., P.C.G., and R.L.; Software, K.E.A., U.L.O.; validation, T.I., R.O., B.E., O.N., K.P.M., E.K.A., C.A.M. and T.C.G.; formal analysis, K.E.A. and U.O; investigation, all authors; resources, all authors; data curation, R.L., K.E.A., T.C.G., D.D.C., P.C.G.; writing—original draft preparation, R.L., P.C.G., U.L.O., E.K.A.; writing—review and editing, T.I., B.E., G.O.O.-O., U.L.O., K.E.A., K.P.M., E.K.A., C.A.M., R.O., and T.C.G.; supervision, K.E.A., U.L.O., T.I., B.E., K.P.M.; project administration, K.E.A., U.L.O. and T.I. All authors have read and agreed to the published version of the manuscript.

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Institutional Review Board Statement

The study was conducted according to the guidelines of the Declaration of Helsinki, and approved by the Ethics Committee of The Human Research Ethics Committee of the Cross-River State Ministry of Health, Nigeria (protocol code CRSMOH/RP/REC/2020/116 on 19 May 2020).

Informed Consent Statement

Informed consent was obtained from all subjects involved in the study.

Data Availability Statement

The data presented in this study are available on request from the corresponding author.

Conflicts of Interest

All authors declared no conflict of interest.

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Appendix A. Questionnaire for the effect of COVID-19 on family welfare.

CONSENT

- I willingly agree to participate in this survey because I am interested in contributing to the knowledge and perceptions on Coronavirus disease (COVID-19) Pandemia. I understand that there are no forms of payments or reward associated with my participation.
  - UNDERSTOOD, AGREE AND INTERESTED
  - NOT UNDERSTOOD, DISAGREE AND NOT-INTERESTED
- Country of origin
- Country of residence
- Province/State/County
- Gender MALE FEMALE OTHERS
- Age (Years)
- Marital Status SINGLE MARRIED SEPARATED/DIVORCED WIDOW/WIDOWER
- Religion MUSLIM CHRISTIAN AFRICAN TRADITIONALIST OTHERS
- Highest level of education
  - PRIMARY SCHOOL HIGH/SECONDARY SCHOOL POLYTHECNIC/DIPLOMA
  - UNIVERSITY DEGREE (Bachelors/Professional) POSTGRADUATE DEGREE (Masters/PhD)
  - Employment StatusSELF EMPLOYED EMPLOYED UNEMPLOYED STUDENT/NON-STUDENT
- Occupation
- Do you live alone? YES NO
- If you live with family/friends, how many of you live together?

PERCEPTION OF RISK OF INFECTION

- Risk of becoming infected. VERY HIGH HIGH LOW VERY LOW UNLIKELY
- Risk of becoming severely infected VERY HIGH HIGH LOW VERY LOW UNLIKELY
- Risk of dying from the infection VERY HIGH HIGH LOW VERY LOW UNLIKELY
- How do you feel about the COVID-19 lockdown measures? (Tick the option that best describes how you feel. You can choose more than one option)
  - WORRIED (Yes/No)
  - BORED (Yes/No)
  - FRUSTRATED (Yes/No)
  - ANGRY (Yes/No)
  - ANXIOUS (Yes/No)
- How likely do you think Coronavirus disease (COVID-19) will continue in your country?
  - VERY LIKELY LIKELY NEITHER LIKELY, NOR UNLIKELY UNLIKELY VERY UNLIKELY
- If Coronavirus disease (COVID-19) continues in your country, how concerned would you be that you or your family would be directly affected?
  - EXTREMELY CONCERNED CONCERNED NEITHER CONCERNED, NOR UNCONCERNED
  - UNCONCERNED EXTREMELY UNCONCERNED

PUBLIC ATTITUDE TOWARDS COMPLIANCE WITH COVID-19 RECOMMENDED PRACTICES

- In recent days, have you gone to any crowded place including religious events
  - ALWAYS SOMETIMES RARELY NOT AT ALL NOT SURE
- In recent days, have you worn a mask when leaving home?
  - ALWAYS SOMETIMES RARELY NOT AT ALL NOT SURE
- In recent days, have you been washing your hands with soap and running water for at least 20 seconds each time?
  - ALWAYS SOMETIMES RARELY NOT AT ALL NOT SURE
- Are you currently or have you been in (domestic/home) quarantine because of COVID-19? YES NO
- Are you currently or have you been in self-isolation because of COVID-19? YES NO
- Have you travelled outside your home in recent days using the public transport YES NO

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11. Risk Perception of COVID-19 among Sub-Sahara Africans: A Web-based Comparative Survey of Local and Diaspora Residents

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Abstract

Background: Perceived risk towards the coronavirus pandemic is key to improved compliance with public health measures to reduce the infection rates. This study investigated how Sub-Saharan Africans (SSA) living in their respective countries and those in the diaspora perceive their risk of getting infected by the COVID-19 virus and associated factors.

Methods: A web-based cross-sectional survey on 1969 participants aged 18 years and above (55.1% male) was conducted between April 27th and May 17th 2020. The dependent variable was the perception of risk for contracting COVID-19 scores. Independent variables included demographic characteristics, and COVID-19 related knowledge and attitude scores. Univariate and multiple linear regression analyses identified the factors associated with risk perception towards COVID-19.

Results: Among the respondents, majority were living in SSA (n=1855, 92.8%) and 143 (7.2%) in the diaspora. There was no significant difference in the mean risk perception scores between the two groups (p=0.117), however, those aged 18-28 years had lower risk perception scores (p = 0.003) than the older respondents, while those who were employed (p = 0.040) and had higher levels of education (p < 0.001) had significantly higher risk perception scores than other respondents. After adjusting for covariates, multivariable analyses revealed that SSA residents aged 39-48 years (adjusted coefficient, β = 0.06, 95% CI [0.01, 1.19]) and health care sector workers (β = 0.61, 95% CI [0.09, 1.14]) reported a higher perceived risk of COVID-19. Knowledge and attitude scores increased as perceived risk for COVID-19 increased for both SSAs in Africa (β = 1.19, 95% CI [1.05, 1.34] for knowledge; β = 0.63, 95% CI [0.58, 0.69] for attitude) and in Diaspora (β = 1.97, 95% CI [1.16, 2.41] for knowledge; β = 0.30, 95% CI [0.02, 0.58] for attitude).

Conclusions: There is a need to promote preventive measures focusing on increasing people's knowledge about COVID-19 and encouraging positive attitudes towards the mitigation measures such as vaccines and education. Such interventions should target the younger population, less educated and non-healthcare workers.

Keywords: Africa, pandemic, diaspora, lockdown, risk perception, Sub-Sahara Africa, knowledge, COVID-19.

Introduction

Risk perception refers to people's subjective assessments of the possibility of outcomes that may follow undesirable events such as disasters and pandemics[1]. The ongoing novel *coronavirus* SARS-CoV2 (COVID-19) pandemic has caused enormous global mortality and public health devastation[2]. While the 2014 West African Ebola Virus Disease (EVD) pandemic was limited to African countries, and the severe acute respiratory syndrome (SARS) of 2002–03 limited to Asian countries, COVID-19 has been a global and unprecedented 'black swan' event [3, 4]. COVID-19 infection is highly contagious, and mortality caused by the virus has exceeded 3.4 million deaths as of 27th of May 2021 – more than any of its predecessors[5]. It is, therefore no surprise that countries are in a race towards developing and administering an effective vaccine[6, 7].

In response to the COVID-19 global threat[8], the World Health Organization (WHO) immediately raised awareness of healthcare workers around the world[9]. The WHO has also raised funds globally and developed Strategic Preparedness and Response Plans (SPRP) to support and protect poorer countries with weak healthcare systems[10]. The goal of the SPRP was to control infection, limit transmission, communicate key information, provide early acute care, and minimize disastrous economic and social effects. National governments locked down their populations, stopped the mobility of goods and services, closed all schools and universities, and shut all state and international borders with many employees working from homes [11-14]. Nonetheless, these mitigating measures' success depends upon the public's readiness to comply, which in turn is inspired by their risk perceptions about the pandemic[15].

Globally, devastating pandemics such as COVID-19 can provide valuable opportunities to learn about human risk perception and attendant behavior[16, 17] and how findings from such studies can be used to inform the allocation of resources within such countries and within international multilateral organizations and agencies such as the WHO[18, 19]. Such studies can also provide an evidence base for the formulation of public health and risk policies. Severe outcomes from natural disasters are often influenced by the level and distribution of economic resources and income within the population of a country (or region)[20, 21]. Several seminal bodies of literature highlight the role of resources or the lack of them in societal responses to disasters[22] and show how positive psychology can contribute to community development during disasters[23]. Culture and risk perception are closely linked and cultural beliefs and values may contribute to the success or otherwise of efforts to control the COVID 19 pandemic[24, 25]. As a result of the different cultural exposures of African residents and Africans living in the diaspora (living outside Africa), this comparative analysis will bring to the fore what specific local context risk management strategies should be implemented by SSA governments. For instance, Quinn et al. showed that people's attachment to their place of residence affected their perceived disaster-related risks [26]. The findings of this web-based cross-sectional study will highlight the implications of the analysis for what we might expect of Africans living in Africa and Africans living outside Africa as well as policy implications in disaster risk management in general. For policymakers tasked with communicating risk, this research would provide a particularly valuable lens through which we can address the emotional underpinnings of adaptation behavior.

Methods

Design and Setting of the study

This was an online survey created in Survey monkey to assess the risk perceptions of Africans. The study was conducted between April 27th and May 17th 2020 corresponding to the mandatory lockdown period in most SSA countries. The survey instrument shown in the Supplementary Table, was adapted and developed from the WHO recommended questions [27] and have been used in previous studies[27]. It was not feasible to undertake a conventional Africa-wide community-based sampling survey at this particular period of lockdown and restricted mobility. A one-page project information statement, which doubled as a recruitment poster, was posted/reposted to WhatsApp and Facebook chat groups and individual accounts together with an e-Link to the online survey. The information sheet and poster contained a brief introduction on the background of the study, its objectives, procedures, the voluntary nature of participation, the declaration of anonymity, privacy and confidentiality, as well as instructions for completing the questionnaire.

We also posted the poster and questionnaire on various websites and official accounts of several local organisations and individuals. Survey questionnaires were also sent out by email to selected groups and individuals in all the target countries, relying on the authors' networks with collaborating academics and local people.

Questionnaire

The questionnaire was divided into three sections, including demographics, knowledge, risk perception, feeling about self-isolation, attitude towards public health practices to mitigate the spread of COVID-19 (compliance) as presented in Table 1. Most of the items on the questionnaire that assessed the respondent's knowledge of COVID- 19, required mostly a 'true' or 'false' or a 'yes' or 'no' response with an additional "Not sure" option. Each question used a binary scale, and a correct answer was assigned 1 point, whereas an incorrect/unsure answer was assigned 0 points. The knowledge score ranged from 0–18 points. These items have been validated elsewhere to have an acceptable internal consistency[28]. To reduce unintended bias, we conducted a statistical test using Kuder Richardson correlation coefficient for binary outcomes by creating two dummy variables. One of the dummy variables included 'Yes' and 'Not sure' and the other dummy variable was the combination of 'No' and 'Unsure' and the alpha coefficient for the two dummy variables was 0.86, indicating a strong relationship.

For the risk perception items shown in P1–P6 of Table 1, each question used a Likert scale with five levels, and the scores ranged from 1 for 'lowest' and 5 for 'highest' with a maximum score range of 5 to 30 points. We determined the Cronbach's alpha coefficients of the perception items to be 0.84, which indicated a satisfactory internal consistency of perception items. Questions were asked on "How the respondents felt about self-isolation" (P7–P12) were classified as "Yes" or "No" The Kuder Richardson Cronbach's alpha coefficient of the "How the respondents felt about the quarantine items" was 0.74, which indicated an acceptable internal consistency. Respondents were also asked about their attitude towards the public health measures put in place by the respective governments to reduce the spread of the virus in items A1-A8. The Likert scale in items A3-A5 was scored as 0 for 'lowest' and 4 for "highest" with the score ranging from 0 -17 points and the alpha coefficients of the attitude items were 0.73 and demonstrated that the internal consistency of the attitude items was satisfactory.

Characteristics of the participants

Participants were those living in South Africa, Nigeria, Ghana, Kenya, Tanzania and Malawi. Respondents in the diaspora, including those living in the UK, USA, Australia, Canada, New Zealand and Germany, were also included. Recipients were further encouraged to send on or 'snowball' the survey questionnaire to other WhatsApp groups that they know as well as to friends. Eligibility criteria included that respondents had to be of African nationality, aged 18 years or older, able to understand the contents of the poster/questionnaire, and agreed to participate in the study.

Dependent variable

The dependent variable for this study was the perception of risk for contracting COVID-19, which was categorized as continuous. The items utilized to measure the risk perception of COVID-19 are shown in Table 1 (P1-P6). The responses included very high, high, low, very low, and unlikely. The items ranged from 1 (unlikely) to 5 (very high).

Table 1. Survey items for knowledge, attitude and perception towards COVID-19.

Knowledge	
K1	Are you aware of the Coronavirus disease (COVID-19) outbreak?
K2	Are you aware of the origin of the Coronavirus disease (COVID-19) outbreak?
K3	Do you think Coronavirus disease (COVID-19) outbreak is dangerous?
K5	Do you think Hand Hygiene / Hand cleaning is important to control the spread of the Coronavirus disease (COVID-19) outbreak?
K6	Do you think ordinary residents can wear general medical masks to prevent the infection by the COVID-19 virus?
K7	Do you think there are any specific medicines to treat Coronavirus disease (COVID-19)?
K8	The main clinical symptoms of Coronavirus disease (COVID-19) are: Fever, Fatigue, dry cough, sore throat
K9	Unlike the common cold, stuffy nose, runny nose, and sneezing are less common in persons infected with the COVID-19 virus.
K10	There currently is no effective cure for COVID-2019, but early symptomatic and supportive treatment can help most patients recover from the infection
K11	It is not necessary for children and young adults to take measures to prevent the infection by the COVID-19 virus
K12	COVID-19 individuals cannot spread the virus to anyone if there's no fever
K13	The COVID-19 virus spreads via respiratory droplets of infected individuals
K14	To prevent getting infected by Coronavirus disease (COVID-19), individuals should avoid going to crowded places such as train stations, religious gatherings, and avoid taking public transportation
K15	Isolation and treatment of people who are infected with the Coronavirus disease (COVID-19) virus are effective ways to reduce the spread of the virus. The observation period is usually 14 days
K16	Not all persons with COVID-2019 will develop to severe cases. Only those who are elderly, have chronic illnesses, and are obese are more likely to be severe cases.
Risk Perception	
Please rate your chances of personal risk of infection with COVID-19 for each of the following?	
P1	Risk of becoming infected.
P2	Risk of becoming severely infected
P3	Risk of dying from the infection
P4	How much worried are you because of COVID-19?
P5	How likely do you think Coronavirus disease (COVID-19) will continue in your country?
P6	If Coronavirus disease (COVID-19) continues in your country, how concerned would you be that you or your family would be directly affected?
How do you feel about the Self-isolation?	
P7	I am worried about self-isolation.
P8	I am bored by self-isolation.
P9	I am frustrated by self-isolation
P10	I am angry because of self-isolation.
P11	I am anxious about self-isolation.
P12	I am angry because of the quarantine.
Attitude towards public health practices to mitigate the spread of COVID-19 (Compliance)	
A1	Are you currently or have you been in (domestic/home) quarantine because of COVID-19?
A2	Are you currently or have you been in self-isolation because of COVID-19?
A3	In recent days, have you gone to any crowded place including religious events?
A4	In recent days, have you worn a mask when leaving home?
A5	In recent days, have you been washing your hands with soap and running water for at least 20 seconds each time?
A6	Since the government gave the directives on preventing getting infected, have you procured your mask and possibly sanitizer?
A7	Have you travelled outside your home in recent days using the public transport
A8	Are you encouraging others that you meet to observe the basic prevention strategies suggested by the authorities?
See Supplementary Table for the full survey item with the response options	

Independent variables

These included demographic A) characteristics of the participants, which consists of age, gender, marital status, education, employment status, occupation (if employed), religion, if they lived alone, the number of people living together in the household and place of current residence. B), Knowledge about COVID-19 origin, symptoms and prevention. C), Feeling about the practice of self-isolation during COVID-19 lockdown. D) Attitude towards COVID-19 mitigation measures that included the practice of self-isolation, home quarantine (A1 and A2) as well as compliance questions (A3-A8)(see Table 1).

Sample size determination

The survey assumed a proportion of 50% with 95% confidence and 2.5% margin of error was based on a previous study[29]. This is because the main objective of this research was on COVID-19, and there are no previous studies from SSA that examined factors associated with risk perception of 2019-nCoV. An online sample size calculator was used, and we assumed a sample size of approximately 1921, including 20% non- response rate.

Statistical analysis

Scores for risk perception were calculated for each of the independent variables and treated as a continuous variable with mean (±standard deviation) risk scores. The risk perception scores ranged from 1 to 30. Risk scores by independent variables were summarized using a t-test for two categorical groups and a one-way analysis of variance (ANOVA) for more than two categorical groups. Univariate linear regression analyses were conducted to assess the unadjusted coefficients (B) with 95% confidence intervals among SSA residents and residents in the diaspora. The adjusted coefficients (β) with 95% confidence intervals obtained from the multiple linear regression model were used to measure the factors associated with the risk perception of COVID-19 among SSA residents and those in the diaspora. Only significant variables in the univariate analysis were used to build the regression model. Knowledge was included in the model because it is strongly related to attitude and practice, while knowledge and attitude have been reported to be associated with practice ([30]). Feeling about the practice of self-isolation during COVID-19 lockdown would help in identifying individuals who could develop mental health issue during the lockdown because past studies showed that longer duration of separation and restriction of people's movement due to SARS were associated with poorer mental health[31, 32]. Including attitude towards the mitigation practices in the model would influence action to reduce the spread of the infection. In our linear regression analyses, we checked for homogeneity of variance and multicollinearity, including Variance Inflation Factors (VIF) and the VIF < 4 was considered suitable [33]. All analysis was performed using Stata version 14.1 (Stata Corp. College Station United States of America), and a two- tailed p-value < 0.05 was considered statistically significant.

Results

Demographics of respondents in Africa and in the diaspora

Of 1,969 respondents (55.1% male and 44.9% female) that completed the survey, the majority were living in SSA (n=1855, 92.8%) and 143 (7.2%) in the diaspora at the time of data collection. The percentage distribution of the respondents by country of residence for local residents and those in Diaspora has been presented as a Supplementary figure. The majority of the local respondents lived in Ghana (28.2%), Nigeria (26.7%) and South Africa (21.7%), while many of those in diaspora were from the USA (19.6%), UK (18.2%) and

Australia (15.4%). Figure 1 presents the mean scores (out of 30) and the 95% CI of risk perception scores towards COVID-19 based on respondents region of residence. There was no significant difference in the mean risk perception scores between the two groups (p=0.117). Table 2 shows the demographics of SSA in Africa and in the diaspora with their mean (standard deviation) scores for perceived risk towards COVID-19. Compared to SSA residents, those living in the diaspora were younger, more often female, and less often married.

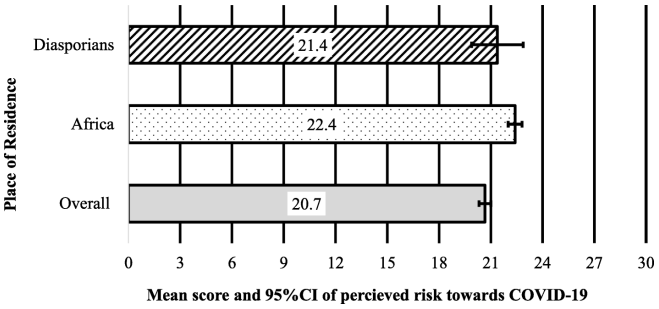

Figure 1. *Mean scores (/30) of risk perception towards COVID-19 among Sub-Saharan Africans living locally (Africa) and in the diaspora. Error bars are 95% confidence intervals of mean scores*

Perception of overall COVID-19-associated risk

For those in SSA, the risk perception score was significantly lower in the 18-28 years age group (p = 0.003, Table 2) than in older age groups. Again, employment (p = 0.040) and a higher level of education (p < 0.001, Table 2) had significantly higher risk perception scores than being unemployed with lower education, respectively. There was no significant difference in the risk perception scores based on gender, marital status, religion, occupation, and the number of people living together among SSA residents. The risk perception score did not significantly differ in sociodemographic characteristics among participants living in the diaspora.

Among those living in SSA and those in the diaspora, the mean scores for risk perception was similar between those who either practiced or did not practice self-isolation and home quarantine. Similarly, no significant differences in risk perception were observed between participants who reported being anxious, bored, frustrated, angry compared to those who did not report any of these symptoms in the two groups. Table 3 shows the unadjusted and adjusted coefficients for factors associated with risk perception of COVID-19 among Africans residing in SSA. In contrast, Table 4 shows the same information for those living in the diaspora. Table 3 shows that among the local SSA residents, working in the health care sector (adjusted coefficient, β = 0.61, 95% CI [0.09, 1.14]) was associated with high-risk perception towards COVID-19, as well as knowledge (β = 1.19, 95% CI [1.05, 1.34]) and attitude (β = 0.63, 95% CI [0.58, 0.69]) towards COVID-19 mitigation measures. Although, unemployment (B = -0.78, 95% CI [-5.53, -0.04]) and lower levels of education (primary/secondary education, B = -2.19, 95% CI [-3.32, -1.05]) were associated with lower risk perception towards COVID-19 in the univariate analysis, the significance was lost after adjusting for other potential cofounder factors. From Table 3, it can be seen that, among SSAs in the diaspora, knowledge (β = 1.79, 95% CI [1.16, 2.41]) and attitude (β = 0.30, 95% CI [0.02, 0.58]) were similarly associated with a high-risk perception of COVID-19. However, there was no significant association between the demographic variables and the risk perception scores in this group.

Table 2. Demographics of Sub-Saharan Africans living in Africa and in the diaspora with their mean (standard deviation) scores for the perceived risk of contracting COVID-19.

Variables	Local SSA	Scores	P-value	Diaspora SSA	Scores	P-value
Demography						
Age category in years, n =1818(b)						
18–28	722	20.0 (8.1)	**0.003**	52	20.7 (8.1)	0.371
29–38	476	21.3 (7.3)		47	20.2 (7.5)	
39–48	393	21.3 (7.7)		31	18.3 (8.9)	
49+	227	21.6 (7.1)		13	22.5 (5.6)	
Sex, n =1822						
Males	1002	21.0 (7.6)	0.394	80	21.0 (7.0)	0.118
Females	820	20.7 (7.9)		62	18.9 (8.8)	
Marital status, n =1825						
Married	793	21.1 (7.4)	0.293	70	20.1 (8.2)	0.929
Not married (a)	1032	20.7 (8.0)		73	20.2 (7.7)	
Education status, n =1827 (b)						
Postgraduate education	576	21.3 (6.8)	**<0.001**	56	20.4 (7.7)	0.918
(Masters /PhD)						
Bachelor education	861	21.1 (7.8)		64	20.1 (8.2)	
Secondary/Primary	390	19.1 (9.0)		23	19.5 (7.2)	
education						
Employment status, n =1830						
Employed	1200	21.1 (7.5)	**0.040**	97	19.8 (7.7)	0.462
Not employed	630	20.3 (8.2)		46	20.9 (8.3)	
Religion, n =1825						
Christianity	1605	20.8 (7.7)	0.510	136	20.2 (7.8)	0.802
Others	220	21.2 (7.6)		7	19.4 (9.6)	
Occupation, 1753						
Non-health care sector	1357	20.6 (7.8)	0.109	111	19.6 (8.1)	0.743
Health care sector	396	21.3 (7.8)		34	20.2 (8.9)	
Household factors						
Do you live alone during COVID-19, n=1826						
No	1483	20.8 (7.6)	0.864	117	20.0 (7.8)	0.86
Yes	343	20.9 (8.1)		26	20.3 (8.6)	
Number living together, n=1650 (b)						
1–3 people	466	20.9 (7.5)	0.866	36	18.9 (8.9)	0.249
4–6 people	870	20.7 (7.9)		37	17.5 (10.2)	
6+ people	314	21.0 (7.7)		26	21.3 (6.4)	
Public Attitude towards mitigation measures						
Practiced self-isolation, n=1644						
No	1141	22.8 (4.7)	0.390	83	21.9 (5.3)	0.871
Yes	503	23.0 (5.1)		50	21.8 (5.7)	
Practiced home quarantine, n =1641						
No	989	22.8 (4.7)	0.814	91	21.7 (5.3)	0.496
Yes	652	22.9 (4.9)		42	22.4 (5.9)	
Feeling about the self-isolation						
Anxious, n=1463						
No	592	20.8 (7.7)	0.865	50	21.0 (6.8)	0.213
Yes	871	20.7 (8.1)		62	19.0 (9.4)	
Bored, n=1493						
No	444	20.7 (7.9)	0.990	30	19.9 (8.1)	0.897
Yes	1049	20.7 (7.9)		87	20.1 (8.3)	
Frustrated, n=1467						
No	704	20.7 (7.8)	0.982	63	20.5 (8.4)	0.657
Yes	763	20.7 (8.2)		56	18.4 (8.2)	
Angry, n=1418						
No	1098	20.8 (8.0)	0.692	88	22.4 (9.5)	0.283
Yes	320	20.6 (7.8)		23	19.7 (9.2)	
Knowledge scores (c)	1855	7.2 (2.2)		150	7.2 (2.5)	
Attitude scores	1855	13.7 (5.2)		150	14.0 (5.5)	

Abbreviation: COVID-19 Coronavirus diseases 2019

For each variable, no of responses=1969 otherwise indicated P-values are results of independent t-test and analysis of variance

(a) single, divorced and widowed

(b) Analysis of variance (ANOVA) was used

(c) continuous variables

Table 3. Unadjusted and adjusted coefficients for factors associated with perceived risk of contracting Coronavirus diseases (COVID-19) among SSAs living in African countries.

Variables	Unadjusted Coefficient	95%CI	Adjusted Coefficent	95%CI
Demography				
Age category in years				
18-28	0.00		0.00	
29-38	**1.29**	**0.40, 2.18**	0.49	-0.06, 1.05
39-48	**1.3**	**0.35, 2.24**	**0.60**	**0.01, 1.19**
49+	1.59	0.44, 2.73	0.29	-0.43, 1.01
Sex				
Males	0.00		–	–
Females	-0.31	-1.02, 0.40		
Marital status				
Married	0.00		–	–
Not married	-0.38	-1.10, 0.33		
Education status				
Postgraduate education (Masters /PhD)	0.00		–	–
Bachelor education	-0.20	-0.98, 0.59		
Secondary/Primary education	**-2.19**	**-3.32, -1.05**		
Employment status				
Employed	0.00		–	–
Not employed	**-0.78**	**-1.53, -0.04**		
Religion				
Christianity	0.00		–	–
Others	0.37	-0.72, 1.45		
Occupation			–	–
Non-health care sector	0.00		0.00	
Health care sector	0.71	-0.16, 1.59	**0.61**	**0.09, 1.14**
Household factors				
Do you live alone during COVID-19				
No	0.00		–	–
Yes	0.08	-0.83, 0.99		
Number living together				
<3 people	0.00		–	–
4-6 people	-0.17	-1.05, 0.70		
6+ people	0.07	-1.04, 1.18		
Public Attitude towards COVID-19 Mitigation measures				
Practiced self-isolation				
No	0.00		–	–
Yes	0.22	-0.28, 0.72		
Practiced home quarantine				
No	0.00		–	–
Yes	0.06	-0.42, 0.53		
Feeling about the self-isolation				
Anxious				
No	0.00		–	–
Yes	-0.07	-0.90, 0.76		
Bored				
No	0.00		–	–
Yes	0.01	-0.87, 0.88		
Frustrated				
No	0.00		–	–
Yes	-0.01	-0.83, 0.81		
Angry				
No	0.00		–	–
Yes	-0.20	-1.19, 0.79		
Knowledge score‡	**2.38**	**2.26, 2.50**	**1.19**	**1.05, 1.34**
Attitude score‡	**1.08**	**1.08, 1.13**	**0.63**	**0.58, 0.69**

Coronavirus diseases 2019, COVID-19. ‡=continuous variables.
Confidence intervals (CIs) not including 0 are significant variables.

Table 4. Unadjusted and adjusted coefficients and 95% confidence intervals (CI) of factors associated with perceived risk of contracting Coronavirus diseases (COVID-19) among SSAs living in the diaspora.

Variables	Unadjusted Coefficent	95% CI	Adjusted Coefficent	95% CI
Demography				
Age category in years				
18-28	0.00		-	-
29-38	-0.54	-3.68, 2.60		
39-48	-2.45	-6.00, 1.09		
49+	1.75	-3.09, 6.59		
Sex				
Males	0.00		-	-
Females	-2.08	-4.70, 0.53		
Marital status				
Married	0.00		-	-
Not married	0.12	-2.50, 2.74		
Education status				
Postgraduate Degree (Masters /PhD)	0.00		-	-
Bachelor's degree	-0.35	-3.13, 2.44		
Secondary/Primary	-0.97	-5.81, 3.87		
Employment status				
Employed	0.00		-	-
Unemployed	1.04	-1.76, 3.84		
Religion				
Christianity	0.00		-	-
Others	-0.77	-6.84, 5.30		
Occupation				
Non-health care sector	0.00		-	-
Health care sector	0.53	-2.68, 3.75		
Do you live alone during COVID-19				
No	0.00		-	-
Yes	0.30	-3.09, 3.70		
Number living together				
<3 people	0.00		-	-
4-6 people	-1.43	-5.55, 2.70		
6+ people	2.38	-2.15, 6.92		
Public Attitude towards COVID-19 mitigation measures				
Self-isolation				
No	0.00		-	-
Yes	-0.16	-2.10, 1.78		
Home quarantined				
No	0.00		-	-
Yes	0.7	-1.32, 2.72		
Feeling about the self-isolation				
Anxious				
No	0.00		-	-
Yes	-1.98	-5.13, 1.16		
Bored				
No	0.00		-	-
Yes	0.23	-3.22, 3.67		
Frustrated				
No	0.00		-	-
Yes	-0.67	-3.65, 2.31		
Angry				
No	0.00		-	-
Yes	-2.11	-5.98, 1.77	0.00	
Knowledge score‡	**2.36**	**1.97, 2.75**	**1.79**	**1.16, 2.41**
Attitude score‡	**0.99**	**0.81, 1.17**	**0.30**	**0.02, 0.58**

Coronavirus diseases 2019, COVID-19. ‡=continuous variables.
Confidence intervals (CIs) not including 0 are significant variables.

From Table 4, it can be seen that, among SSAs in the diaspora, knowledge (β = 1.79, 95% CI [1.16, 2.41]) and attitude (β = 0.30, 95% CI [0.02, 0.58]) were similarly associated with a high-risk perception of COVID-19. However, there was no significant association between the demographic variables and the risk perception scores in this group.

Discussion

This study found comparable high-risk perception scores among residents living in SSA and those in the diaspora, which were associated with an increase in knowledge of COVID-19 and attitude towards the mitigation measures. Health care workers resident in SSA had higher risk perception scores compared to their counterpart non- healthcare workers. Although having lower education and not working during the pandemic was associated with significantly lower risk perception of COVID-19 among local residents, this was nullified after adjusting for other demographic variables.

The finding that older individuals felt at greater risk of COVID-19 was in line with past studies showing that older individuals have significantly higher COVID-19 related severe complications and deaths than young individuals[34]. Public awareness of this information may explain the finding of lower risk perception for contracting the infection among younger respondents in SSA. As highlighted by Dillard et al[35], having a perceived low risk of infection can make young people become less compliant to public health measures. This can in turn lead to higher COVID-19 infection[35], and ultimately passing the infection to the population more susceptible to COVID-19 related complications since young people were shown to be more likely to transmit the virus than others[36]. In line with these findings, some countries took stringent steps to limit the young population from transmitting COVID-19 infection to the older population [37-40] but recorded mixed success[40-42]. Rapid and proactive outreach programs targeted at young people in Australia and Canada might explain why the risk perception was similar between younger and older participants living in the diaspora in this study[43]. Such directed programs and policies should be implemented within the vulnerable groups in our local populations.

Studies have reported a high perceived risk of COVID-19 among African health workers[44-46] but did not compare between health and non-health workers. In a cross-sectional study conducted on 350 Ghanaians during the early stage of the outbreak, there was no difference in risk perception scores between health and non- healthcare workers[47] but healthcare worker reported a higher mean scores than non-healthcare workers. The higher mean reported by healthcare worker in this study may be attributed to the fact that healthcare workers had to work even if their individual risk perception would want to make them to comply with risk mitigation such as isolation[48, 46]. In this study, high-risk perception for contracting COVID-19 was associated with working in the health sector, but this was only significant among those who were living in SSA. Firsthand experience with the virus is often linked to high-risk perception[49], higher knowledge of the disease among health care workers compared to the non-health workers might explain their higher perception of risk for contracting the infection. The lack of proper training on protective measures reported in previous studies by health workers in SSA countries[46] may explain the significant association found among local health care workers but not among those living in the diaspora. Again, the implementation of targeted policies may as well account for the lack of association among respondents living abroad.

In this study, knowledge about COVID-19 and a positive attitude towards the mitigation measures were associated with a high-risk perception of contracting the disease, both in SSA and the diaspora. Similar findings have been reported in Ethiopia[50], showing that individuals who perceive higher risk are more likely to adopt protective measures, which in turn influences the probability of infection[50, 51]. However, the prevalence of misinformation about COVID-19 among SSA respondents[52], together with the immoderate psychological stress caused by this misinformation about COVID-19 due to the poor knowledge about the disease[28], are potential sources of reduced risk perception in this sub region. These would lead to increased transmissions and mortality. Hence, accurate information about the pandemic using the trusted media platforms can help in accurate risk judgement and proper adoption of public health measures to control the spread of infection [28, 53].

COVID-19 related morbidity and mortality vary disproportionately based on sociodemographic characteristics, for instance, males and older people have high mortality due to COVID-19 compared to females and the young population[54]. Individual's behaviours towards safety measures have been linked to their level of the perceived risk of disease[35]. Adopting public health measures such as the use of a nose mask in public areas and frequent hand sanitization can lead to successful control of air-borne infectious diseases like COVID-19[53]. Therefore, public health strategies for successful control of COVID-19 among SSAs may benefit from targeting the sub-population identified in this study. That is the unemployed, non-healthcare workers, the younger population and those with lower levels of education.

This study was limited by several factors: 1), assessed risk perception and comparing the perceptions from SSA residents in and outside Africa may be limited by the fact that those who felt they w ere at risk of COVID-19 infection were more likely to respond to recommended health behaviours [55]; 2), findings from this study cannot be generalizable to entire SSA regions; 3), it was an online survey made available only in English language thus restricting respondents without access to the internet where internet penetration remains relatively low and some from French-speaking SSA nations[56]. However, the use of an internet-based methodology was the only reliable means to disseminate information at the time of this study; 4), the survey items were self-administered and some of the questions for example, those on compliance require subjective responses, and has no answer that can be verified. If a respondent reported good behaviour but not practiced it, there is no way we can independently verify their response. Despite these limitations, this study from the SSA region provided insight into the role of residence in mitigating the factors that influence risk perception of COVID-19 among SSAs during the pandemic. The study used a robust analysis to control for potential confounders during the analysis in order to reduce the issue of bias.

Conclusions

In summary, this study explored the factors associated with the risk perception of contracting COVID-19 among SSAs, particularly looking at the role of residence in peoples' level of risk perception. The findings indicate that health communication and education strategies designed to promote the adoption of preventive behaviours among SSAs should focus on increasing knowledge about the disease and encouraging a positive attitude towards the mitigation measures. In addition, such programmes will benefit from targeting the unemployed, less educated, healthcare workers and the younger population, for optimum outcome. These findings can be helpful in policy implications in disaster risk management, including infection control of COVID-19, particularly in English speaking countries in the SSA region.

List of abbreviations

COVID-19: coronavirus SARS-CoV2

SSA: Sub-Sahara Africa

CI: Confidence intervals

EVD: Ebola Virus Disease

EPPM: Extended parallel process model

WHO: World Health Organization

SPRP: Strategic Preparedness and Response Plans

ANOVA: Analysis of variance

Declaration

Ethics approval and consent to participate

The Human Research Ethics Committee of the Cross River State Ministry of Health, Nigeria approved this study (#: CRSMOH/RP/REC/2020/116). Written informed consent was obtained from all respondents before participation, by asking respondents to voluntarily answer either a 'yes' or 'no' to the question inquiring whether they agreed to participate in the survey. Respondents could only proceed to complete the survey if they answered 'yes' to this question. All protocols are carried out in accordance in accordance with the Helsinki Declaration for Human Research.

Consent for publication

Not applicable

Availability of data and materials

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests

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Authors' contributions

K.E.A, U.L.O, R.O. conceptualized the study. K.E.A., E.K.A., B.N.E., K.P.M., P.C.G., U.L.O., G.O.O., O.N., R.O., T.I., T.C.G., D.D.C., C.A.M., R.L. and D.B. were involved in data collection and interpretation of the data. K.E.A., D.B. and U.L.O performed the formal analysis of the data. E.K.A., D.B., R.O. and .L.O. drafted the original manuscript. K.E.A., G.O.O., E.K.A., B.N.E., K.P.M., P.C.G., O.N., R.O., T.I., T.C.G, D.D.C., C.A.M, R.L. and D.B. reviewed and edited the manuscript. K.E.A., T.I., D.D.C., K.P.M. and U.L.O. supervised the project.

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12. Factors affecting willingness to comply with Public health measures during the Pandemic among Sub-Sahara Africans

Running title: Compliance to COVID-19 practices in Africa

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Keywords: Facemask; Handwashing; Self-isolation; Mitigation; Survey monkey; Pandemic; Lockdown; West Africa; Eastern Africa; South Africa; Nigeria

Abstract

Background: The unprecedented outbreak of coronavirus disease (COVID-19) drastically spread worldwide, resulting in extraordinary measures put in place in various countries including Sub Saharan Africa (SSA) countries.

Objective: To assess the factors associated with compliance to with the public health measures imposed by various SSA countries.

Method: Cross sectional study using self-administered surveys distributed on social media platforms between April 18th and May 16th, 2020, corresponding with the mandatory lockdown period in most SSA countries. Multivariate analysis examined the associated factors.

Results: The prevalence of hand hygiene, quarantine, self isolation practices, wearing of face mask and attending large gatherings during COVID-19 were 94%, 39%, 31%, 64% and 14%, respectively. In multivariate models, older age [49+ years: adjusted OR 2.13, 95%CI 1.22,3.71), females (OR 1.41,95%CI 1.03,1.93), Central Africans African countries (OR 3.73,95%CI 2.02,6.87) were associated with wearing face mask. Living alone (aOR 1.52,95%CI 1.04,2.24) during the lockdown was associated with avoiding large gatherings including religious events. Female respondents (aOR 1.61, 95%CI 1.30, 2.00), married (aOR 1.71,95%CI 1.33,2.21) and unemployed (aOR 1.62,95%CI 1.25,2.09) SSAs were more likely to practice self-quarantine measures.

Conclusion: The low prevalence of mitigation practices suggest the need for targeted education campaign programs to sensitise the population

Keywords: Facemask; Handwashing; Self-isolation; Mitigation; Survey monkey; Pandemic; Lockdown; West Africa; Eastern Africa; South Africa; Nigeria

Introduction

Since December 2019, a newly identified coronavirus (Severe Acute Respiratory Syndrome Coronavirus 2, SARS-CoV-2) was found to cause an out-break outbreak of coronavirus disease (COVID-19) in Wuhan, Hubei Province, China and spread to other countries by early mid-January 2020 1. A combination of cases detected outside Wuhan, with the detection of infection in at least one household cluster and the documented infections in healthcare workers car risk of much wider spread of the disease [2].

Globally, as of July 29, 2020, there have been 16,713,304 confirmed cases and in Africa, 789,226 cases have been confirmed[1]. The first confirmed case in Africa was reported in Egypt on Feb 14, 2020, with this prompting African preparedness efforts[3]. Currently, due to the lack of vaccines and effective pharmaceutical treatments, nonpharmaceutical interventions (NPIs) are the most effective for local and global control and mitigation of COVID-19[4]. way to curb the spread of COVID-19[4].

The WHO interim guidance document of 7th March 2020 provided guidance to countries for responding to community transmission of COVID-19 through implementation of some public health measures appropriate to them[5]. The various public health measures adopted were at the national, community and

individual levels. At the national level, governments introduced screening and quarantine of arrivals at airports and seaports as well as restriction of travels from countries highly affected by COVID-19 to finally suspending air travel into their countries [6, 7]. At the community and individual levels, governments introduced several measures some of which were considered draconian. These measures included strict lockdown policy, staying at home to save life campaigns, travel and movement restrictions and prohibition of mass gatherings, regular hand washing under running water, frequent cleaning of surfaces with soap, or disinfectants [8, 9].

Public education through combating information against rumors, combating misinformation and fake news about the pandemic formed part of the public health measures to minimize the spread of COVID -19 by educating the public on appropriate information for guidance of behaviors and practices[10]. In South Africa, a private firm Praekelt.org created a WhatsApp-based helpline that provided real-time date and automated responses in numerous languages to educate and sensitize people[11].

In spite of the good intentions of the governments, there were factors militating against citizens' compliance to these measures. Central to this was economic hardships resulting from these enforced restrictions. This appeared most impractical in densely populated informal settlements and in economies largely dependent on informal trading. Religious practices, misinformation, and incidents of unrest were other factors implicated in affecting compliances[3333333]. In another research article, knowledge was quoted to be a prerequisite for establishing prevention beliefs, forming positive attitudes, and promoting positive behaviours, and that individuals' cognition and attitudes towards disease affect the effectiveness of their coping strategies and behaviours to a certain extent [13]. This research was designed to assess the adherence to public health measures adopted in selected African countries on COVID-19 as well as to broadly evaluate the factors that influenced compliance to these measures in order to plan appropriately for the future. Findings from this study will enable public health researchers and policy makers to target sub-population not willing to comply with public health measures put in place by the respective SSA governments to contain and minimise the spread of COVID-19 infection in this region.

Methodology

Study population and design

This cross-sectional survey was conducted between the months of April and May 2020. During this time, most African countries were under the mandatory lockdown as implemented by their various governments. As it was not feasible to perform nationwide community-based sample survey during this period, the data were obtained electronically via survey monkey. A structured validated and pretested questionnaire was posted on social media platforms – Facebook and WhatsApp – to facilitate a better response. These platforms were chosen because they reflect the most commonly used social media platforms the locals in the participating countries engage with. Emails were also used. The questionnaire included a brief overview of the context, purpose, procedures, nature of participation, privacy and confidentiality statements and notes to be filled out.
The respondents were African nationals from different African countries living in

their countries of origin or overseas including Ghana, Cameroon (only distributed to the English-speaking regions), Nigeria, South Africa, Tanzania, Kenya, Uganda etc. To be eligible for participation, respondents had to be aged 18 years or older and be able to provide online consent.

Sample size determination

The study assumed a proportion of 50% of the population since similar study had not been carried out in Africa and with a desire precision of 2.5% and 5% significance level for a two-sided test. Assuming a non-response rate of 20%, the final sample size was calculated to be 1921 respondents, which was adequate to detect statistical differences in the analysis of this online cross-sectional study on COVID -19 in Africa. However 1801 respondents participated by completely answering questions on compliance to with public health measures during the COVID-19 pandemic.

Survey Questionnaire and study factors

The questionnaire used in this study is presented as Supplementary table 1. The survey tool for the COVID-19 was developed based on the guidelines from the WHO for clinical and community management of COVID-19[1,5]. The questionnaire was adapted with minor modifications to suit this study's objective. A pilot study was conducted to ensure clarity and understanding as well as to determine the duration for completing the questionnaire prior to dissemination. The questionnaire consisted of 53 items divided into four sections (demographic characteristics, knowledge, perception and practice). The demographic variables included questions on age, gender, marital status, education, employment and religion.

Outcome variables

Six questions addressed willingness to comply with COVID-19 public health measures. These questions are the subject of this paper, and their wordings were as follows: "During COVID-19, government authorities might request co-operation from the public in a number of ways. Please indicate …"

1. *Are you currently or have you been in (domestic/home) quarantine because of COVID-19?*
2. *Are you currently or have you been in self-isolation because of COVID-19?*
3. *In recent days, have you worn a mask when leaving home?*
4. *In recent days, have you been washing your hands with soap and running water for at least 20 seconds each time?*
5. *In recent days, have you gone to any crowded place including religious events?*

All responses except willingness to quarantine because of COVID-19 were coded on a five-point Likert-scale. Response options for all questions were 'Always', 'Not Sure', 'Not at all', 'Rarely' and 'Sometimes'. In addition, willingness to quarantine because of COVID-19 responses were coded as 'yes' and 'no'.

Ethics

The study adhered to the principles of the 1967 Helsinki declaration (WMA, 2013) and the protocol was approved by the Human Research Ethics Committee of the Ministry of Health Human Research Ethics Committee of the Cross River State Ministry of Health, Nigeria (number: CRSMOH/RP/REC/2020/116).
Participation was anonymous and voluntary. Informed consent was obtained from all participants prior to commencement of the study and after the

study protocol has been explained. Participants consented to voluntarily participate in this study by answering either a 'yes' or 'no' to the question inquiring whether they voluntarily agree to participate in the survey. A 'no' response meant that the participants could not progress to answering the survey questions and were excluded from the study.

Statistical analysis

Data analysis was performed using Stata version 14.1 (Stata Corp. College Station United States of America). Categorical variables were presented as frequencies and percentages. This was followed by estimation of the prevalence and 95% confidence intervals (CI) of each willingness to comply with COVID-19 public health measures.

The five-point Likert-scale response used in the question module were dichotomized, such that responses of 'Always' were coded as '1' and all other responses as 0. This was done to aid epidemiological interpretations and to describe the type of outcome under study (prevalence study and odds ratios). Additionally, it is very hard difficult to determine normality from a Likert-scale In addition, quarantine because of COVID-19 responses were coded as 1 for 'yes' and 0 for 'no'.

Univariable and Multiple logistic regression using a stepwise backwards model was used in order to identify the factors significantly associated with willingness to comply with health health measures during COVID-19. All variables with statistical significance of $p<0.05$ were retained in the final model.

Results

Of the 1801 respondents (males, n = 993, 56%) that completed the online questionnaire, about half (52.2%) were from West Africa and over 65% were aged below 39 years. Table 1 shows the demographic characteristics of the respondents as well as their knowledge of the origin/transmission of the disease, its symptoms and the compliance with government regulations to prevent the spread of the infection. Knowledge of COVID-19 origin/mode of transmission and its symptoms were inadequate in more than two- thirds (73.2%) and 64.5% of the respondents, respectively. A significant proportion (52.0%) had a low risk perception of contracting COVID-19. With regards to compliance, majority (73.5%) reported adherence to each of the government prescribed measures to control the spread of infection with respect to avoiding crowded places (86%) during the lockdown and practice of hand hygiene (94.0%).

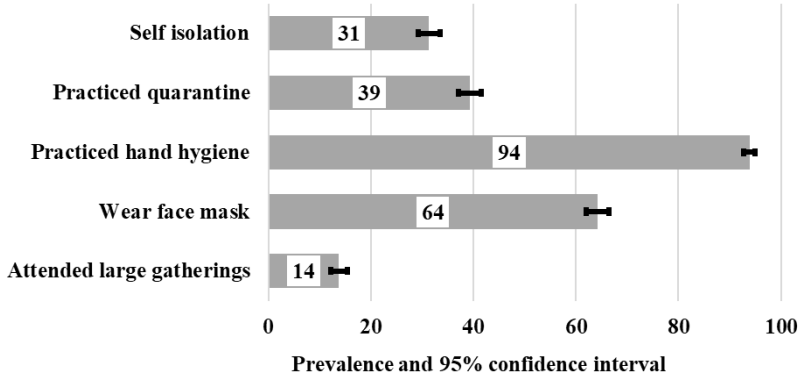

Figure 1. *Prevalence and 95% confidence intervals (CI) of mitigation practices to stop the spread of COVID-19 in Sub -Saharan Africa*

Table 1. Sociodemographics, knowledge and compliance of study sample (n=1801, except where indicated)

Demographic Variables	Frequency(n)	Percentage (%)
Region of residence, n=1777		
Africa	1,644	92.52
Diaspora	133	7.48
Sub-region, n=1747		
West Africa	982	56.21
East Africa	181	10.36
Central Africa	221	12.65
Southern Africa	363	20.78
Age category (years), n=1773		
18-28	676	38.13
29-38	482	27.19
39-48	390	22
≥49	225	12.69
Sex, n=1774		
Males	993	55.98
Females	781	44.02
Employment status, n=1782		
Employed	1,189	66.72
Unemployed	593	33.28
Marital Status, n=1778		
Married	790	44.43
Not married	988	55.57
Religion, n=1779		
Christianity	1,571	88.31
Others	208	11.69
Educational status, n=1782		
Postgraduate	592	33.22
Bachelor	971	54.49
Primary/Secondary	219	12.29
Occupation, n=1688		
Non-health care sector	1,300	77.01
Health care sector	388	22.99
Household factor		
Do you live alone during COVID-19, n=1781		
No	1,454	81.64
Yes	327	18.36
Number living together, n=1557		
< 3 people	452	29.03
4-6 people	802	51.51
6+ people	303	19.46
COVID-19 -related knowledge		
Knowledge of origin/transmission		
Inadequate	1,318	73.18
Adequate	483	26.82
Knowledge of Symptoms		
Inadequate	1,154	64.08
Adequate	647	35.92
Perception of risk		
Low	940	52.19
High	861	47.81

Factors associated with the attendance to of large gatherings and use of facemasks in Sub-Saharan Africa

Table 2 presents the unadjusted (OR) and adjusted odd ratios (aOR) for the factors associated with attending large gathering and use of face masks. Respondents living in the Central African region (OR 3.33, 95% CI 2.34, 4.75), those married (OR 1.39, 95% CI 1.06-1.84), those with university education (OR 1.42, 95% CI 1.04, 1.94) and those who live alone (OR 1.62, 95% CI 1.17, 2.23) were more likely to comply with the regulation on avoiding large crowds (including religious gatherings) while those aged 39 – 48 years (OR 0.52, 95% CI 0.34, 0.76) and non-Christians (OR 0.46, 95% CI = 0.27, 0.79) were less likely to comply with this directive. The respondents who had a perceived high-risk of contracting COVID-19 (OR 1.45, 95% Cl 1.11, 1.190) were more likely to avoid large gatherings compared to those with low perception of risk. After adjusting for the potential confounders, respondents that lived alone during the pandemic (aOR 1.52, 95%CI 1.04, 2.24), and those that reported high perception of risk of contracting the infection (aOR 1.27, 95%CI 1.05, 1.55) were more likely to avoid large gatherings during the lockdown.

In the unadjusted analysis, compliance with the recommendation to wear facemask when going out was associated with older age (49 years and over), living in diaspora, female sex, and respondents from the Eastern, Central and Southern African region. (Table 2). After adjusting for the potential cofounding variables, all the aforementioned factors except for place of residence (diaspora) remained significantly associated with the use of facemask in this cohort.

Table 2. Unadjusted (OR) and adjusted odd ratios (aOR) for factors associated with attending large gatherings, regular handwashing, self-quarantine and isolation during the lockdown. The 95% confidence intervals (CI) of the odd ratios are also shown

	Attended large gatherings				Worn mask in recent days			
Sociodemographic	OR	95%CI	aOR	95%CI	OR	95%CI	aOR	95%CI
Region of residence								
Local	1.00	-- --	--	--	1.00	-- --	--	--
Diaspora	1.51	[0.96, 2.39]		--	1.5	**[1.04, 2.29] --**		--
Age category (years)								
18-28	1.00	-- --	1.00	--	1.00	--	1.00	--
29-38	0.994	[0.72, 1.36]	0.9	[0.65, 1.36]	0.95	[0.74, 1.20]	0.69	[0.48, 1.00]
39-48	**0.52**	**[0.34, 0.76]**	**0.5**	**[0.33, 0.82]**	1.29	[0.99, 1.68]	1.34	[0.88, 2.04]
49+	**0.34**	**[0.19, 0.60]**	**0.3**	**[0.14, 0.51]**	**1.6**	**[1.17, 2.28]**	**2.13**	**[1.22, 3.71]**
Sex								
Males	--	--	--	--	1.00		1.00	--
Females	--	--	--	--	**1.6**	**[1.31, 1.95]**	**1.4**	**[1.03, 1.93]**
Employment status								
Employed	--	--	--		1.00	--	--	--
Unemployed	--	--	--		**0.76**	**[0.62, 0.93]**	--	--
Marital status								
not married	1.00	--	--		1.00	--	--	--
Married	1.39	**[1.06, 1.84]**	--	--	**0.79**	**[0.65, 0.96]**	--	--
Sub-region								
West Africa	1.00				1.00		1.00	
East Africa	1.53	[0.97, 2.39]	--	--	**2.7**	**[1.86, 3.89]**	**2.4**	**[1.37, 4.10]**
Central Africa	**3.33**	**[2.34, 4.75]**	--	--	**6.2**	**[4.00, 9.43]**	**3.7**	**[2.02, 6.87]**
Southern Africa	1.07	[0.73, 1.57]	--	--	**1.8**	**[1.38, 2.29]**	**1.9**	**[1.29, 2.89]**
Religion								
Christianity	1.00		1.00		1.00			
Others	0.46	[0.27, 0.79]	0.5	[0.27, 0.93]	1.1	[0.82, 1.50]		
Educational status								
Postgraduate	1.00				1.00			
Bachelor	**1.42**	**[1.04, 1.94]**	--	--	0.95	[0.76, 1.17]		
Primary/Secondary	1.21	[0.76, 1.94]	--	--	1.16	[0.84, 1.62]		
Occupational status								
Non-health care sector			1.00					
Health care sector	--		0.85	[0.68, 1.08]	--			
Household factor								
Do you live alone during COVID-19								
No	1.00		1.00		1.00			
Yes	**1.62**	**[1.17, 2.23]**	**1.52**	**[1.04, 2.24]**	0.87	[0.68, 1.11]		
Number living together								
< 3 people			1.00					
4-6 people	-	--	0.99	[0.77, 1.24] --		--		
6+ people	--	--	1.04	[0.77, 1.42] --		--		
COVID-19 -related knowledge								
Knowledge of origin/transmission								
Inadequate			1.00					
Adequate	--		1.25	[1.00, 1.56] --		--		
Knowledge of Symptoms								
Inadequate	--		1.00					
Adequate	--		1.04	[0.85, 1.28] --		--		
Perception of risk								
Low	1.00		1.00					
High	**1.45**	**[1.11, 1.90]**	**1.27**	**[1.05, 1.55] --**		--		

Bolded are significant differences with 95% confidence intervals of odd ratios that does not include 1.00. Values are derived from stepwise regression model with empty cells representing variables not included in the final model

Factors associated with practicing regular handwashing, self-quarantine and self isolation on recommendation among Sub-Saharan Africans

Table 3 presents the unadjusted and adjusted odd ratio for factors associated with practicing regular handwashing, self-quarantine and self-isolation during the lockdown. The table shows that compliance with the practice of hand washing was significantly associated with increasing age with 14.2 folds (95% CI of OR 3.42,57.57) increase in the odds of hand washing among older respondents (49 years and above) compared to younger ones (18-28years). This association was lost after adjusting for potential cofounders. Central Africans (aOR 0.30, 95%CI 0.15, 0.57), those who were unemployed (aOR 0.30 95%CI 0.21,0.51) and respondents that had adequate knowledge of COVID-19 origin/transmission (aOR 0.48, 95%CI 0.31, 0.76) were less likely to practice hand hygiene compared to West Africans, the employed and those that demonstrated inadequate knowledge. Being female (aOR 1.61, 95% CI 1.30, 2.00), being married (aOR 1.71, 95% CI 1.33,2.21) and being unemployed (aOR 1.62, 95% CI 1.25,2.09) were associated with more likelihood of practising quarantine measures. Although education level was associated with observing quarantine and isolation measures, in the unadjusted analysis, the adjusted odds ratio did not show any significance.

Table 3. Unadjusted (OR) and adjusted odd ratio (aOR) for factors associated with practicing regular handwashing, self-quarantine and isolation during the lockdown. The 95% confidence intervals (CI) of the odd ratios are also shown.

Sociodemographic	Practiced Hand washing				Practiced quarantine				Self isolation			
	OR	95% CI	aOR	95% CI	OR	95% CI	aOR	95% CI	OR	95% CI	aOR	95% CI
Region of residence												
Local	1				1				1			
Diaspora	0.61	[0.33, 1.14]			0.7	[0.48, 1.02]			**1.37**	**[1.95, 1.97]**	—	—
Age category (years)												
18-28	1				1				1		1	
29-38	**3.09**	**[1.84, 5.19]**			**0.5**	**[0.40, 0.64]**			**0.48**	**[0.37, 0.61]**	**0.7**	**[0.50, 0.88]**
39-48	**6.03**	**[2.88, 12.63]**			**0.4**	**[0.30, 0.51]**			**0.31**	**[0.23, 0.41]**	**0.5**	**[0.36, 0.72]**
49+	**14**	**[3.41, 57.57]**			**0.4**	**[0.26, 0.50]**			**0.26**	**[0.18, 0.39]**	**0.4**	**[0.28, 0.64]**
Sex												
Males	1				1		1		1			
Females	1.12	[0.75, 1.68]			**1.7**	**[1.41, 2.07]**	**1.6**	**[1.30, 2.00]**	**1.29**	**[1.06, 1.58]**	—	—
Employment status												
Employed	1		1		1		1		1			
Unemployed	**0.25**	**[0.16, 0.38]**	**0.3**	**[0.21,0.51]**	**2.4**	**[1.93,2.89]**	**1.6**	**[1.25,2.09]**	**2.33**	**[1.90, 2.87] –**		
Marital status												
Not married	1				1		1		1		1	
Married	**0.31**	**[0.19, 0.51]**	–	–	**2.3**	**[1.88, 2.80]**	**1.7**	**[1.33, 2.21]**	**3.03**	**[2.43, 3.77]**	**2**	**[1.51, 2.66]**
Sub-region												
West Africa	1		1		1		1		1			
East Africa	1.04	[0.51, 1.94]	0.6	[0.30, 1.29]	1	[0.72, 1.39]	1	[0.68, 1.37]	0.96	[0.68, 1.35]		
Central Africa	0.69	[0.40, 1.18]	**0.3**	**[0.15, 0.57]**	0.9	[0.63, 1.17]	**0.6**	**[0.44, 0.85]**	0.98	[0.71, 1.35]		
Southern Africa	1.52	[0.85, 2.71]	1.4	[0.73, 2.56]	1.1	[0.88, 1.43]	1	[0.74, 1.26]	1.18	[0.92, 1.53]		
Religion												
Christianity	1				1				1			
Others	0.61	[0.36, 1.04]	–	–	1.1	[0.79, 1.42] –		–	1.31	[0.97, 1.77]		
Educational status												
Postgraduate	1				1				1			
Bachelor	**0.39**	**[0.22, 0.68]**	–	–	**1.5**	**[1.19, 1.84] –**		–	**1.66**	**[1.31, 2.10]**		
Primary/Secondary	**0.23**	**[0.12, 0.44]**	–	–	**3.3**	**[2.38, 4.52] –**		–	3.27	[**2.35, 4.53**]		
Occupational status												
Non health care	1				1				1			
Health care	0.94	[0.58, 1.51]	–	–	1	[0.83, 1.31] –		–	1.02	[0.80, 1.30]		
Household factors												
Do you live alone during COVID-19												
No	1				1				1			
Yes	0.85	[0.52, 1.38]	–	–	1	[0.79, 1.28] –	–	**1.63**	**[1.28, 2.09]**			
Number living together												
< 3 people	1				1		1		1			
4-6 people	1.2	[0.76, 1.90] –	– –		1	[0.81, 1.31]	1.1	[0.82, 1.36]	1	[0.78, 1.29]		
6+	1.76	[0.91, 3.40]	– –		1.3	[0.98, 1.77]	**1.4**	**[1.03, 1.91]**	1.33	[0.98, 1.82]		
COVID-19 -related knowledge												
Knowledge of origin/transmission												
Inadequate	1		1		1				1			
Adequate	**0.53**	**[0.35, 0.79]**	**0.5**	**[0.31, 0.76]**	**1.3**	**[1.04, 1.58] –**		–	**1.44**	**[1.16, 1.80]**		
Knowledge of Symptoms												
Inadequate	1				1				1			
Adequate	1.03	[0.69, 1.55]	– –		1	[0.80, 1.19]		–	**1.23**	**[1.00, 1.51]**		
Perception of risk												
Low	1				1				1		1	
High	1.26	[0.85, 1.86]	– –		1.1	[0.87, 1.26] – –		–	**1.25**	**[1.02, 1.53]**	**1.3**	**[1.03, 1.56]**

Bolded are significant differences with 95% confidence intervals of odd ratios that does not include 1.00.
Values are derived from stepwise regression model with empty cells representing variables not included in the final model.

Discussion

This paper evaluated the public health measures at the individual and community levels enforced by African governments and considered the factors associated with compliance with these measures. The measures identified in this paper included personal measures like hand hygiene/hand washing, the use of face masks, physical and social distancing such as avoiding large crowds/mass gathering, isolation and quarantine. Respondents in SSA demonstrated a high level of compliance with avoiding crowded places, wearing of face masks and regular hand washing but varied between countries. Fewer respondents complied with the recommendation to self-isolate during the pandemic but knowledge of COVID-19 origin/mode of transmission and symptoms of the disease were inadequate. The factors associated with compliance with mitigation practices were age, marital status (being married), sex (female), central African residency as well as having adequate COVID-19 related knowledge and perceived high risk of contracting the infection.

The differences in compliance rate among SSA countries may suggest a direct link between the varying degrees of strictness of lockdown measures, sensitisation of the citizens and education, especially to the vulnerable groups. For example, there was a widespread reference to varying degrees of lockdown across SSA countries, such as 'total lockdown' and 'partial lockdown,' or 'tight lockdown' and 'loose lockdown.' Similar control measures were also important in successfully controlling SARS-CoV in 2003 and was substantially aided by important differences in the transmission dynamics of SARS-CoV compared with SARS-CoV-2[14]. As there is currently no effective pharmacological interventions or vaccines available to treat or prevent COVID-19, nonpharmacological public health measures such as isolation, social distancing, and quarantine remain the only effective ways to respond to the outbreak[15]. To discuss measures of controlling spread it is worth noting an established mode of transmission for COVID-19, particularly human-to-human transmission. This kind of transmission has been recognised with the major mode of respiratory tract transmission via droplets and indirectly from fomites and to a lesser extent via aerosols[16].

The respondents in this study who were unemployed were more likely to self-isolate and quarantine but less likely to practice handwashing relative to those who were employed. A major component of the government efforts towards containing the spread is self-quarantine [17], even though different studies have suggested that a major obstacle to compliance with household quarantine is concern over loss of income resulting from prolonged absence from work[18]. Around the world during the coronavirus outbreak, governments implemented economic relief plans to help the people [19-22], but this was not so in most SSA countries except for South Africa [19]. In Isreal compensation increased the compliance rate to with self-quarantine from 57% to 94% demonstrating that providing people with assurances about their livelihoods during self-quarantine is an important component of compliance with public health regulations[20]. Since the unemployed did not show any association with compliance to other measures, it could mean that their motivation for isolation and quarantine were 'partial'. They probably were motivated by lack of jobs to take them out or the fact that there was no associated cost. With a current mobile phone penetration rate of 75% in SSA[23], the use of novel mobile cash transfer options such as

mobile money should be considered by SSA governments. This channel can reach the informal sector with cash sustenance packages during a lock down, so as to improve on quarantine and self isolation in future pandemics or epidemics.

Our study found that practice of hand washing and avoiding large gathering were optimal while over two-third of the participants wear face mask and about on-third complied with quarantine. These findings are similar to the study published in the Centers for Disease Control and Prevention's Morbidity and Mortality Weekly Report presented data that showed that nearly two third of the people surveyed complied with the use of face masks, maintaining physical distancing (79.5%) and about 86% avoided gatherings of 10 or more[24]. However, more people reported practicing self-isolation in their study compared with our finding (77% versus 40%), which could be attributed to the relief measures/assistance from the US government which encouraged people to stay more at home compared to most African countries where little, or no help came from the governments.

Although compliance with measures showed no patterned association with the regions, Central Africans African counties were more likely to observe the government imposed measures which could be explained by the fact that they had experienced repeated outbreaks of the deadly Ebola virus since the seventies right up to recent times[25] and therefore this improved on their ability to take public health measures and messaging more seriously. Moreover, the Central African region was an early epicentre of the COVID-19 pandemic in Africa, with Cameroon for example confirming its first case as early as 5th of March 2020[26], thereby creating huge awareness and fear and thus encouraging early compliance with lockdown measures. In this study, females were more likely to comply with self-quarantine and isolation compared with males, which is similar to a recent study where females were more likely to take protective measures during the pandemic[24]. This finding may be related to the employment of more SSA women than males in the formal sector[27] and with the shut down of the formal sector during the lockdown, females likely stayed at home, thus reported self-isolation. Similar to a previous studies[28,29] age was associated with compliance with most of the public health measures examined, with older respondents more likely to wear face mask, practice handwashing but less likely to attend crowded gatherings, practice quarantine and self-isolation. This indicates that age is an important determinant of compliance with public health measures to control COVID-19.

This study has some limitations. First, the survey was only administered online and therefore may not have captured the opinion of non-internet users in the rural areas where the reach of the internet remains low [23]. This may also have excluded respondents from the older people in SSA countries who are less likely to use the internet compared to younger ones[30]. Also, the survey was available only in English such that it may have been impossible for some citizens of francophone countries in the SSA to participate. Hence, the results may not generalize to all Sub-Saharan African populations. It is also possible that respondents from some SSA countries like Tanzania may have been affected by the lockdown as the citizens were refrained from giving out information regarding the pandemic, hence the wide variation in the response rate per region. Another limitation was the lack of incentives and therefore no assistance from online

companies for distribution of the survey may have affected the reach to respondents. The strengths of this study include that, it is the first sub-regional analysis of African respondents with respect to the current COVID-19 pandemic and offers a unique perspective on the SSA countries' compliance with public health measures to contain and prevent the spread of the infection and thus provides a valuable contribution for future interventions across the region.

Conclusions

Sub-Saharan African respondents in this study were compliant with the public health measures put in place by the respective governments to control the spread of COVID-19, despite their inadequate knowledge of the disease. While individual/ community level control measures are as important as government actions, the governments of SSA will need to consider relief packages for their citizens in times like this to help improve on compliance during outbreaks of this nature. Overall, this study calls on the the SSA countries to consider certain sociocultural and economic solutions to help improve preparedness and response to future outbreaks.

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Paper context

What is known: Public health compliance in relation to other pandemic including influenza have been investigated in non-Sub-Saharan African population.

What the paper adds to the topic: This study provides first evidence on key factors associated with willingness to comply with the public health measures during COVID-19 in Sub-Saharan Africa.

What the implications of the paper: Findings will enable public health researchers to target sub-populations not willing to comply to public health measures for other COVID-19 waves and future pandemics.

Data availability statement. The data that support the findings of this study are available on request from the corresponding author, ULO.

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Supplementary table

Table 1: Sample of online-administered questionnaire

Do you think Coronavirus disease (COVID-19) outbreak is dangerous? Yes/ No/ I don't know
Do you think Public Health Authorities in your country are doing enough to control the Coronavirus disease (COVID-19) outbreak?

Yes/ No/ I don't know

Do you think Coronavirus disease (COVID-19) has little effects on Blacks than on Whites? Yes/ No/ I don't know
Do you think Hand Hygiene / Hand cleaning is important to control the spread of the Coronavirus disease (COVID-19) outbreak?

Yes/ No/ I don't know

Ordinary residents can wear general medical masks to prevent the infection by the COVID-19 virus? Yes/ No/ I don't know

Do you think antibiotics can be effective in preventing Coronavirus disease (COVID-19) outbreak? Yes/ No/ I don't know

If yes, have you purchased an antibiotic in response to COVID-19 disease outbreak? Yes/ No/ I don't know
Do you think there are any specific medicines to treat Coronavirus disease (COVID-19)? Yes/ No/ I don't know
Do you think there would be a vaccine for preventing Coronavirus disease (COVID-19) outbreak in the next 6 months? Yes/ No/ I don't know

The main clinical symptoms of COVID-19 are fever, fatigue, dry cough, and sore throat. True/ False/not sure
Unlike the common cold, stuffy nose, runny nose, and sneezing are less common in persons infected with the COVID-19 virus.

True/ False/not sure

There currently is no effective cure for COVID-2019, but early symptomatic and supportive treatment can help most patients recover from the infection True/ False/not sure

It is not necessary for children and young adults to take measures to prevent the infection by the COVID-19 virus. True/ False/not sure

COVID-19 individuals cannot spread the virus to anyone if there's no fever. True/ False/not sure
The COVID-19 virus spreads via respiratory droplets of infected individuals True/ False/not sure

To prevent the infection by COVID-19, individuals should avoid going to crowded places such as train stations, religious gatherings, and avoid taking public transportations True/ False/not sure

Isolation and treatment of people who are infected with the COVID-19 virus are effective ways to reduce the spread of the virus. The observation period is usually 14 days True/ False/not sure

Not all persons with COVID-2019 will develop to severe cases. Only those who are elderly, have chronic illnesses, and are obese are more likely to be severe cases. True/ False/not sure

Perception

Please rate your chances of personal risk of infection with COVID-19 for each of the following?

Risk of becoming infected. Very high/High/ low/very low/ unlikely
Risk of becoming severely infected. Very high/High/ low/very low/ unlikely
Risk of dying from the infection. Very high/High/ low/very low/ unlikely
How worried are you because of COVID-19? Very worried/worried/not worried

Are you currently or have you been in (domestic/home) quarantine because of COVID-19? Yes/No/not sure

Are you currently or have you been in self-isolation because of COVID-19? Yes/No/not sure

How do you feel about the self-isolation
I am worried/anxious/alarmed and frightened by self-isolation. Yes/No/not sure
I consider the self-isolation as necessary and reasonable. Yes/No/not sure
I am nervous about the self-isolation. Yes/No/not sure I am bored by the self-isolation. Yes/No/not sure
I am frustrated by the self-isolation. Yes/No/not sure

I am angry because of the self-isolation. Yes/No/not sure

Practices
In recent days, have you gone to any crowded place including religious events? Always/ sometimes/ rarely/not at all/not sure

In recent days, have you worn a mask when leaving home? Always/ sometimes/ rarely/not at all/not sure

In recent days, have you been washing your hands with soap for at least 20 seconds each time Always/ sometimes/ rarely/not at all/not sure

(Source: Revised and Adopted from WHO, 2020)

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13. Economic, Health and Physical impacts of COVID-19 Pandemic in Sub-Saharan African regions: A Cross sectional survey

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Abstract

Purpose: The key preventive measures adopted to minimise the spread of the coronavirus disease (COVID-19) had significant health, economic and physical impacts mostly in developing countries. This study evaluated the health, economic and physical impacts of COVID-19 lockdown measures among sub-Saharan African (SSA) population and associated demographic variations.

Methods: 1970 respondents took part in this web-based cross-sectional survey during the mandatory lockdown period in most SSA. The dependent variables were health (COVID-19 infection, hospitalisation), socioeconomic (lost job, closed down business) and physical impacts (separated from family) of COVID-19. Univariate and bivariate logistic regression analyses were used to explore the factors associated with each of the dependent variables by the four sub-regions (Southern, Western, Central and East Africa).

Results: The respondents were aged 34.1 ± 11.5 years (range: 18 – 75 years) and mostly men (1099, 55%). 25.9% (n = 511) reported an impact of COVID-19 pandemic with significant regional variations ($p<0.0005$, higher proportion were East 36.2% and Southern Africans 30.3%) but no gender ($p=0.334$) and age group variations ($p>0.05$). Among Central African respondents, more men than women lost their businesses (45.7% versus 14.3%, $p=0.002$) and COVID-19 infections (40.0% versus 18.2%, $p=0.024$) during the study period. Multivariable analysis revealed that respondents from East (Adjusted odds ratio [AOR] 1.95, 95% confidence interval [CI]: 1.42-2.69), Southern (AOR 1.46, 95% CI: 1.09-1.96) and Central Africa (AOR 1.47, 95% CI: 1.06-2.03) reported significantly higher impact of COVID-19. Those who reported family separation during the lockdown were more likely to be older participants (39-48 years, AOR 2.48, 95% CI: 1.11-5.57)

Conclusion: One in four SSA respondents, mostly East and Southern Africans were adversely affected by COVID-19 pandemic during the lockdown. Interventions in high- risk populations are needed to reduce the health, socioeconomic and gender disparities in the impacts of COVID-19.

Keywords: Job loss, infections, hospitalisation, family separation, lockdown, coronavirus infection, Africa.

Introduction

The coronavirus disease (COVID-19) pandemic has had significant health and economic impacts largely as a consequence of the key preventive measures adopted by most countries to minimise the spread of the virus[1, 2]. These measures include partial or complete lockdowns of economies resulting in temporary closures of airports, businesses, schools and social services. The pandemic was a profound shock to societies and economies, and underscores society's reliance on women both on the front line and at home[3]. The pandemic simultaneously exposed structural inequalities in health economy, security and social protection, and intensified gender inequality in Africa with many women having to work harder than before while earning even less than they normally would[4, 5]. In China, women make up more than 90% of health- care workers in Hubei province[6] and in Africa, about 70% of

nurses are women[7]; highlighting the gendered nature of the health workforce and the increased risk that female health workers are exposed to[8]. No policies and public health efforts have yet addressed the gendered impacts of disease outbreaks globally,[9] and this lack of action continues even in the response to coronavirus disease (COVID-19), worse still among SSA countries.

As noted in India where a majority of residents in rural areas depend on foreign remittances, in the month immediately after the lockdown announcement, weekly household local income dropped by 88% compared to the long-term average with another 63% reduction in foreign remittances.[10] The loss of jobs and income and the inability to access hospital services during the lockdown was also linked to psychosocial distress among respondents in India.[11] In a South African study on the economic impacts of the pandemic in the hotel industry[12], researchers reported that 99.7% of the hotels were negatively impacted by the COVID-19 pandemic. This included 67% that reported a decline in income, 30.2% stated they expected that 90-100% of their staff would lose their jobs during the lockdown and many of the hotels were at risk of bankruptcy (62.8%) and permanent business closure[12]. These studies highlighted the need for micro survey data showing the economic impacts of COVID-19 lockdowns on poor and vulnerable households living in other developing countries[10]. However, no study has examined the differential effects of COVID-19 impact by the different sub- regions.

SSA countries face many health and economic challenges, and the impact of COVID-19 in this region could be higher than that in developed economies[13, 14]. Although SSA countries were the last to register COVID-19 cases[15], the region has been reporting high infection rates while other regions[16], which have trade links with SSA such as China, have started to flatten out with economic stimulus and investment plans underway. In addition, while the rest of the world is emerging from the global slowdown and reopening businesses[17, 18], the trend in SSA economies seems to veer towards a deeper recession with further possibilities of production and trade related constraints if infection rate continues to rise[19].

In addition, demographic, political, cultural and health issues in the sub-regions of SSA are different, which implies that the impact of COVID-19 may be different[19]. For example, over nine percent of Mauritius' population was 60 years and older in 2005, making it the oldest country in SSA while other Southern African countries such as South Africa and Lesotho had approximately eight percent of their populations aged 60 and older. Countries such as Benin, Burundi, Kenya, Mauritania, Rwanda, Uganda, and Zambia, had the older population accounting for less than four percent of the total population[20]. In terms of HIV infections, Southern African countries of Botswana and Swaziland have the highest rates, while West Africa has been relatively less affected by HIV infection compared to other regions of SSA[21]. Furthermore, data from the World Health Organisation has shown that strata with lower socioeconomic status are more prone to the dangers of COVID-19[22].

The poor economic resilience and differences in socio-demographic variables among different sub-regions of SSA exposes the region to greater risks of serious negative impacts from the COVID-19 pandemic. For instance, in Ethiopia where there was no direct restrictions imposed on the agriculture sector (the primary means of livelihood for most people) during the pandemic, researchers projected that the

sector could face a 4.7% loss in output due to its linkages with the rest of the economy.[23] Therefore, this study was carried out to investigate the health, economic and physical impacts of COVID-19 and their associations with variables such as gender, age and region of origin, among respondents living in SSA countries. Recognising these impacts and their associations with gender and regional variations is an important step to understanding the primary and secondary effects of a health emergency on different individuals and communities, and for creating effective, equitable policies and interventions[24].

Material and methods

Study population

Respondents were from sub-Saharan African countries including those living abroad and in their countries of origin with origin from Ghana, Cameroun (only distributed to the English-speaking regions), Nigeria, South Africa, Tanzania, Kenya, Uganda etc. Respondents who were 18 years and older, and able to provide online consent were considered for the survey.

Study design

A cross-sectional descriptive study was conducted over a period of one month (April 18 to May 18, 2020) corresponding to the period of mandatory lockdown and restriction of movement in most of the countries surveyed. The data were obtained electronically via survey monkey with an e-link of the structured synchronised questionnaire posted on Facebook and WhatsApp which were commonly used by the locals in the participating countries and was sent via emails by the researchers to facilitate responses. Online survey was the only feasible way of reaching people as we could not perform nationwide community-based sample survey during this period.

Survey questionnaire

The questionnaire included a brief overview of the context, purpose, procedures, nature of participation, privacy and confidentiality statements and notes to be filled out. The items were developed based on COVID-19 knowledge questionnaire guidelines of the World Health Organization (WHO) for clinical and community management of COVID-19. A sample of the questionnaire has been reported previously[25] including the details of initial pilot. However, for the purpose of this study, the section utilised in the analysis is shown in Supplementary Table.

Outcome variables

The main outcome variable was any impact of COVID-19, which was coded as '1', if the participants reported that they or any family member was affected by COVID-19 and '0' if they did not report any impact of COVID-19. The secondary outcomes were five items on the impact of COVID-19 including whether or not the participant or a family member a) lost their job, b) closed down business, c) contracted COVID-19, d) hospitalised due to COVID-19, and e) were completely separated from their families during the lockdown period.

Independent variables

The independent variables included the demographic characteristics of the participants: age (divided into four age groups including 18-28, 29-38, 29-48 and 49+years based on the distribution), region of origin (West, East, Southern and Central Africa), religion (Christian and others), educational (Postgraduate including

masters and PhD, undergraduate University degree, primary/secondary school), marital (married/de facto and others including widowed, divorced, separated, and single), employment and occupational status (working in healthcare and non-healthcare sectors).

Data analysis

Demographic and the outcome variables were summarised as counts and percentages for categorical variables and two-way frequency table was used to obtain the proportion estimates for each sub-region. The level of association between gender and the impact of COVID-19 was tested using Fisher's exact test by sub-region. Having any impact of COVID-19 was considered as 'yes' if participants reported any of the following outcomes: lost job, closed business, contracted COVID-19, hospitalised and separated from family, and 'no' if they did not report any of the five impacts.

In the univariate and bivariate analyses, Odds ratios with 95% confidence intervals were calculated in order to assess the unadjusted risk of independent variables on the independent variables. Following the univariate logistic regression analysis, variables with a P-value <0.20 were retained and used to build a multivariable logistic regression model which examined the factors associated with the impacts of COVID-19 pandemic. We conducted bivariate logistic regressions to determine factors associated with 'any impact of COVID-19', and for each of the five impacts of COVID-19 during the pandemic at P <0.05. The significant factors in the univariate analysis were added to the regression model. The odds ratios with 95% confidence intervals were also calculated to assess the adjusted factors. All statistical analyses were performed using the Statistical Package for Social Sciences (SPSS, version 26, IBM, Armonk, NY, USA).

Ethical considerations

Ethical approval for the study was sought and obtained from the Human Research Ethics Committee of the Cross River State Ministry of Health (CRSMOH/HRP/HREC/ 2020/117). The study was carried out in accordance with the Helsinki Declaration for Human Research. The confidentiality of participants was assured in that no identifying information was obtained from participants. Participants were required to answer a 'yes' or 'no' to the consent question during survey completion to indicate their willingness to participate in this study.

Results

Of the 2032 completed surveys, data for 1970 (96.9%) participants from West Africa (56.1%), Southern Africa (20.4%), Central Africa (12.7%) and East Africa (10.8%) who responded to the items on the impact of COVID-19 were analysed. The respondents were aged 34.1 ± 11.5 years (mean ±standard deviation; range: 18 – 75 years) and mostly men (1099, 55%). Other demographic details showing the participants' characteristics by sub-regions are provided in Table 1.

Table 1. Demographic Characteristics of the Respondents (N = 1970) by Sub-Saharan African Sub Region. Values are Number (Percentages) Except for Age.

Characteristics	West Africa (n=1105)	East Africa (n=213)	Southern Africa (n=402)	Central Africa (n=250)	*P*-value
Demographic variables					
Age, mean (±SD)	35.6 (11.1)	33.8 (8.0)	34.1 (14.0)	28.2(9.2)	<0.001*
Gender					
Men	684 (62.2%)	122 (36.5%)	155 (38.6%)	124 (49.8.4%)	<0.001
Women	415 (37.8%)	90 (63.5%)	247 (61.4%)	123 (50.2%)	
Employment status					
Employed	995 (90.4%)	182 (86.3%)	364 (90.5%)	199 (80.6%)	<0.001
Unemployed	106 (9.6%)	29 (13.7%)	38 (9.5%)	48 (19.4%)	
Marital status					
Single	520 (47.2%)	90 (42.9%)	241 (60.0%)	178 (72.1%)	<0.001
Married	543 (49.3%)	119 (56.7%)	138 (34.4%)	66 (26.7%)	
Other	38 (3.5%)	1 (0.4%)	23 (5.6%)	3 (1.2%)	
Religion					
Christian	1031 (93.7%)	191 (90.5%)	286 (71.1%)	230 (93.5%)	<0.001
Other	69 (6.3%)	20 (9.5%)	116 (28.9%)	16 (6.5%)	
Level of education					
Postgraduate degree	417 (37.9%)	82 (38.9%)	93 (23.2%)	41 (16.6%)	<0.001
University degree	622 (56.5%)	120 (56.9%)	179 (44.6%)	149 (60.3%)	
High/Secondary/Primary School	62 (5.6%)	9 (4.2%)	129 (32.2%)	57 (23.1)	
Occupation					
Healthcare	270 (24.5%)	55 (26.1%)	72 (17.9%)	39 (15.8%)	0.001
Non-Healthcare	831 (75.5%)	156 (73.9%)	330 (82.1%)	208 (84.2%)	
Main Outcome variables					
Impact of COVID-19					
Lost job	152 (45.9%)	47(56.0%)	61 (37.9%)	41 (45.1%)	0.058
Closed down business	86 (26.7%)	26 (31.3%)	38 (25.0%)	27 (30.7%)	0.654
Contracted COVID-19	77 (23.6%)	24 (29.6%)	16 (10.5%)	26 (29.2%)	<0.001
Hospitalized due to COVID-19	121 (36.1%)	32 (39.0%)	64 (40.8%)	38 (41.3%)	0.682
Separated from family	80 (24.7%)	27 (32.1%)	40 (25.6%)	31 (35.2%)	0.162
Any effect	242 (21.9%)	77 (36.2%)	122 (30.3%)	70 (28.0%)	0.034

NOTES: P-values are results of comparison between regions, * results of univariate analysis of variance (ANOVA) for age, others are Chi Square association between regions and demographic characteristics.
P<0.05 are statistically significant.
Abbreviations: COVID-19, novel coronavirus; SD, standard deviation.

Respondents from West Africa were significantly older (17.7% aged 49 years and above) and those from Central Africa were significantly younger (p<0.04, 54.6% aged 18-28years) than those from other regions (Table 1). A total 510 (25.9%) respondents reported an impact of COVID-19 during the pandemic including economic (300 [45.0%] lost their jobs and 177 [27.5%] lost their businesses), health (143 [22.1%] contracted the virus and 255 [38.3%] were hospitalised due to COVID-19) and physical impacts (178 [27.4%] were completely separated from their families) of the pandemic. There was no significant effect of age group on any impact of COVID-19 across the regions (p=0.112), although the effect of age approached significance (p=0.071) among East Africans being slightly higher among 25-33 and 25-33 years age groups compared with the other age groups (Figure 1).

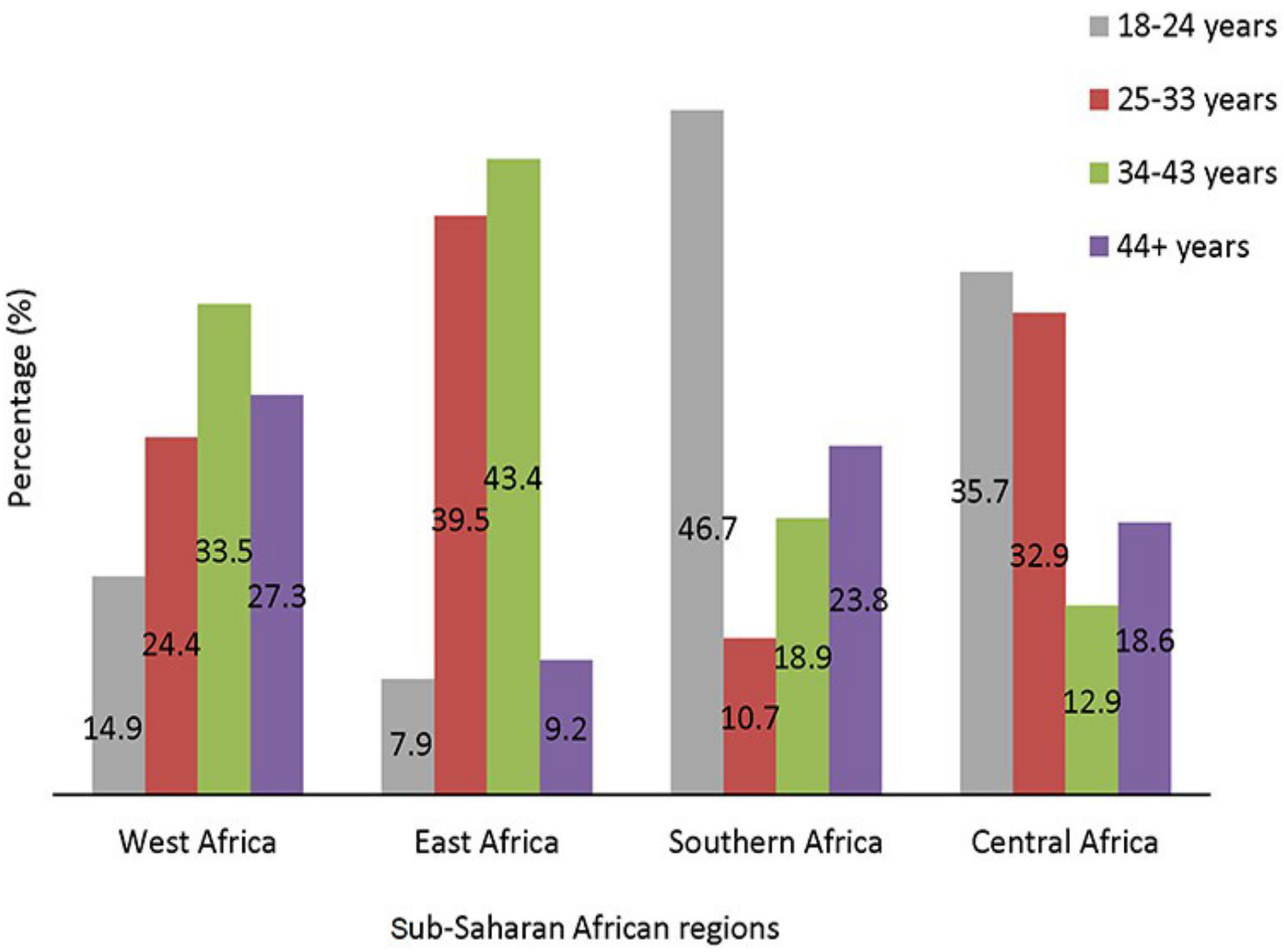

Figure 1. *Percentage distribution of any impact of COVID-19 during the lockdown in the sub-Saharan African regions by age group (n = 1970).*

Impact of COVID-19 according to gender in the four SSA regions

Using Chi-Square analysis, there was no statistically significant association between gender and any impact of COVID-19 (p=0.334) in the pooled analysis. Figure 2 shows the percentage breakdown of participants who reported any of the five impacts of COVID-19 for the four SSA sub-regions. Significant gender effects were found only among Central African respondents where more men than women suffered from business closure (45.7% versus 14.3%, p=0.002) and contracted COVID-19 infections (40.0% versus 18.2%, p=0.024). Proportionally, women were more impacted by COVID-19 than men in Southern Africa but this association did not reach statistical significance.

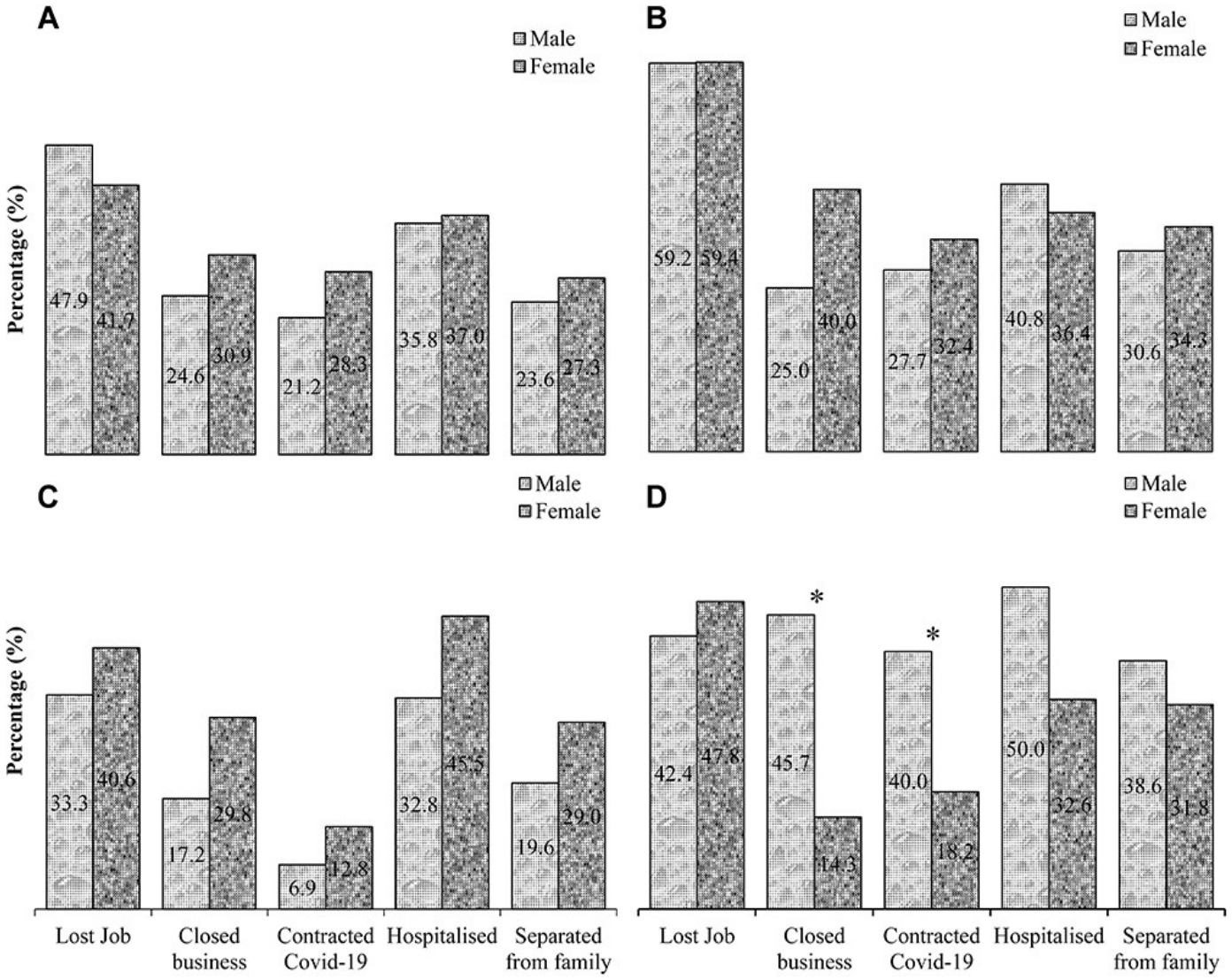

Figure 2. Percentage breakdown of the impacts of COVID-19 (lost jobs, closed down businesses, contracted COVID-19, hospitalized due to COVID-19 and physical separation from families) during the lockdown in the sub-Saharan African regions by gender: West Africa (A), East Africa (B), Southern Africa (C) and Central African (D) regions (n=1970).
**Indicates a significant difference in the impact of COVID-19 between men and women (p < 0.05, independent t-test).*

Impact of COVID-19 according to region

Figure 3 shows the percentage breakdown of respondents who experienced any impact of COVID-19 in each sub-region during the pandemic. There were statistically significant differences in the proportion of respondents who reported any impact of COVID-19 compared with those who did not report any impact of the pandemic within the sub-regions ($p<0.001$). East (36.2%) and Southern African (30.3%) respondents were more likely to report any impact of the pandemic compared with those from the other sub-regions

Multivariable analysis of factors associated with the impact of COVID-19 in the four SSA regions

After adjusting for the effects of gender, employment status, marital status, religion, level of education and occupation, which were significant in the previous analysis (see Table 1), multivariate logistic regression analyses revealed that the region of residence was the only factor associated with any impact of COVID-19 among the respondents. Those from East (Adjusted odds ratio [AOR] 1.95, 95% confidence interval [CI]: 1.42-2.69), Southern (AOR 1.46, 95% CI: 1.09-1.96) and Central Africa (AOR 1.47, 95% CI: 1.06-2.03) had higher odds of any impact of COVID-19 than West Africans.

Similar regression analysis conducted with each of the five impacts of COVID-19 (Figure 2) as a dependent variable showed that age was significantly associated with closure of business. Respondents aged 18-28 years (AOR 0.28, 95% CI: 0.11-0.72), 29-38 years (AOR 0.43, 95% CI: 0.19-0.99), 39-48 years (AOR 0.53, 95% CI: 0.29-0.99) had lower odds of closing their business than those aged 49+ years. Similarly, those aged 39-48 years had higher likelihood of separating from family during the lockdown (AOR 2.48, 95% CI: 1.11-5.57).

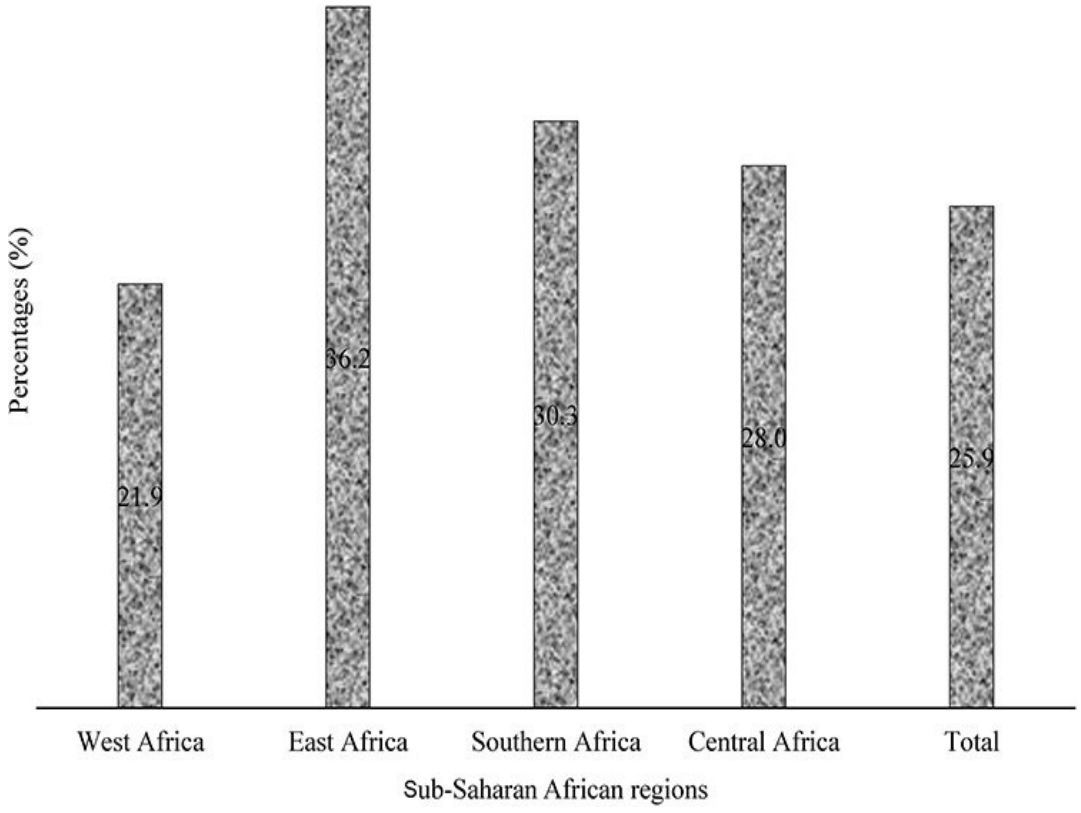

Figure 3. Percentage distribution of any impact of COVID-19 by sub-Saharan African sub-region (n = 1970).

Compared with West African respondents, Southern Africans reported a lower likelihood for contracting COVID-19 (AOR 0.21, 95%CI: 0.10-0.47) during the lockdown, while those who were employed were marginally less likely to contract COVID-19 (AOR 0.53 95%CI: 0.25-1.01) compared to those who were unemployed at the time of this study.

Discussion

The COVID-19 cases started in late 2019 in China and spread sporadically across the world presenting one of the most serious global health crises. While its impact on the world's economic and health systems including morbidities and mortalities continue to rise, the full extent of its toll in different SSA regions has not been investigated. We investigated the health, economic and physical impacts of COVID-19 and their associated demographic variations. The results showed that there were gender and regional variations on the impact of COVID-19 and these were in line with recent predictions[19]. East and Southern African respondents reported the highest impacts of COVID-19 (about one third of the respondents) followed by Central and the least impact was found among West African respondents. After adjusting for all potential cofounders, we found that East and Southern African respondents were more likely to report any impact of COVID-19 compared to West African respondents. During the lockdown, Southern African respondents reported lower likelihood of contracting COVID-19 compared with West Africans in this study. Overall, more people in SSA reported shutting their businesses during the pandemic, and the effects were mostly felt among persons older than 49 years. In this study, the effect of gender was depended on the variable used to measure the impact of COVID-19 and this varied between the sub-regions in SSA. For instance, in Central Africa, men were disproportionately impacted by COVID-19 and suffered greater business shut downs and contracting COVID-19 disease than the women. This could be a reflection of gender inequalities in most Central African countries. During humanitarian crises, such as pandemics, men and women are affected differently[7]. However, in Southern Africa, there was a tendency for greater impact of COVID-19 among women than men7. In addition, as the disease spreads in this sub region, there are also concerns over its impact on women and girls, whose vulnerabilities may worsen as it overwhelms the already poor health systems[7]. The impact of COVID-19 in West and Eastern Africans between males and females was the same, except for marginal differences in job losses among Western Africans and closure of businesses in both sub-regions. These results are different from what was generally observed during the Ebola outbreak, where gendered norms meant that women were more likely to be infected by the virus, given their predominant roles as caregivers within families and as front-line health-care workers[24]. Unlike their male counterparts, women were less likely to have power in decision making around the outbreak, and their needs remained largely unmet[26]. Further investigations are required to fully comprehend the contrasting regional variations on the influence of gender on the impact of COVID-19. The finding of higher impact of COVID-19 among East and Southern African respondents could have been influenced by the nature of lockdowns adopted during the time of the study in the different sub regions of SSA. For example, most countries in the East and Southern African countries adopted complete lockdowns, which may have resulted in low economic productivity and disruptions to key value trading chains in those regions[27]. Individuals in these countries were

restricted to their homes except under strict controlled circumstances such as seeking of medical care, buying food, medicine and other essential supplies or the collection of social grants. On the other hand, in Western African countries such as Ghana and Nigeria and many Central African countries, there was a partial lockdown and many businesses including small, medium and informal businesses that sustain the livelihoods of the majority of citizens, were still in operation during the time of this study. The informal sector carries a significant weight in most Sub Saharan African economies[28]. The reported lower likelihood of Southern Africans to contract COVID-19 during the lockdown compared with West Africans could be due to the relatively young mean age of the Southern African respondents in this study (34.1±14 years) who had a high proportion of their population between 18-24 years (Figure 1).The study found that persons aged 49 years and older were more likely to shut down their businesses during lockdown compared with those younger than 48 years. As reported, COVID-19 can lead to hospitalisation and death for young adults, however, it causes the most severe health issues in adults29. It has been shown that older adults (over 65 years of age) represent 80% of hospitalisations and have a 23-fold greater risk of death than younger adults (under 65 years)[29]. Although it is not known why SARS-CoV-2 infections are more severe and fatal in the aged[29], knowledge of this may have resulted in adult respondents taking the necessary precautions of shutting their businesses and staying at home to curtail their risk of contracting the virus. This assertion is further supported by the fact that those aged 39-48 years were more likely to be separated from their families during the lockdown compared with older respondents 49+ years in this study.

This study has some limitations. The cross-sectional design of this study made it impossible to determine causation. Given the inability to physically access respondents due to the pandemic, the survey tool was sent out to prospective respondents electronically using social media platforms and emails. This method of soliciting respondents may have inadvertently excluded some potential participants whose opinion may have differed, such as those without internet access, and people living in rural areas where internet penetration remains relatively low.[30] However, the use of an internet-based methodology was the only reliable means to disseminate information at the time of this study. Furthermore, the survey was presented in the English language and those from non-English speaking countries in SSA may not have participated. Notwithstanding these limitations, this was the first study from the SSA region to provide regional insight into some of the socioeconomic and health impact of the pandemic suffered by residents during the lockdown period. Although this subject is commonplace as it is expected to happen during pandemics, no study has demonstrated these impacts of COVID-19 in the way the present study did, particularly at a regional level among Africans. This makes our study a unique one, since it provided the first documented regional evidence showing the impacts of the lockdown on the ordinary citizen. The study was presented at the 9th Scientific Conference of the Epidemiological Society of Nigeria an affiliate of the International Epidemiological Association at which public health experts stated that the paper provided evidence for impacts that had hitherto been anecdotal. The use of a robust analysis to control for potential confounders during the analysis reduced the possibility of a bias.

Conclusion

This study showed that gender had an influence on the impact of COVID-19 in the Central African sub-region. The pandemic was reported to have a more significant impact on East and Southern Africans compared with West African respondents, possibly due to the differences in the nature of the lockdowns in these sub-regions. In addition, older adults (>49 years) were more likely to shut down their businesses during the pandemic. The findings of this study suggest that COVID-19 has an effect on health, economic and social fabric of society in this region. As the pandemic intensifies and communities suffer significant disruptions, ongoing efforts need to be intensified to prevent increased morbidity and mortality. SSA countries need to learn from each other during this recovery period, and policy instruments that include holistic approach should be implemented, to reduce human suffering and enhance the recovery of the economy in the different sub-regions. There is need for further studies examining other indices of economic and health impacts of the COVID-19 outbreak in the sub-Saharan African regions.

Disclosure

The authors report no conflicts of interest in this work.

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14. COVID-19 in sub-Saharan African Countries: Association between compliance and public opinion

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Abstract

Background: The outbreak of coronavirus disease (COVID-19) has created a global public health crisis and non-compliance with public health measures to contain the infection poses a challenge to Sub-Saharan African governments. This study investigated the associations between compliance and public opinion on COVID-19 public health containment measures across selected SSA countries.

Method: Anonymous online cross-sectional survey was administered to 1779 adults (18 years and older) during the mandatory lockdown period in most African countries (April 18 – May 16, 2020). Respondents were recruited via Facebook, WhatsApp, and authors' networks. Data on participants' socio-demographics, their opinions regarding the precautionary measures against COVID-19, and their compliance with preventive measures were collected. Multiple logistic regression analysis was used to examine the association between compliance and public opinions about COVID-19.

Results: Respondents who did not think that public health authorities in their countries were doing enough to control the CoVID-19 outbreak were more likely to attend crowded places (aOR 1.75, 95% CI 1.30-2.35). Those who thought COVID-19 would not remain in their countries (aOR 0.48, 95% CI 0.24 – 0.96) and those who thought self- isolation is not needed during the pandemic (aOR 0.29, 95% CI 0.13 – 0.65) were less likely to encourage others to comply with the strategies put in place to prevent the spread of the disease. Participants who thought the COVID-19 outbreak was dangerous and those wearing medical masks were found to wash their hands with soap under running water.

Conclusion: The study showed that public opinion influenced the compliance of individuals to public health measures for containment and mitigation of COVID-19. There is a need to improve compliance by the public.

Keywords: COVID-19, compliance, public opinion, public health measures, Sub- Saharan Africa

1. Introduction

The year 2020 had been a troubling year occasioned by the outbreak of the novel coronavirus disease (COVID-19). In less than six months following its outbreak in Wuhan, China, the condition, declared a global pandemic by the World Health Organization (WHO)(WHO, 2020a; Xiao & Torok, 2020), had ravaged the globe and caused fear, panic, economic disruption and deaths worldwide. COVID-19 had affected more than six million people worldwide as at the first week of June 2020, with a tremendous rising toll of deaths (Roser, Ritchie, Ortiz-Ospina, & Hasell, 2020).

Nations at the early stages of the disease outbreak, took it as the normal flu, a common respiratory-related disease or just another self-limiting viral infection that would resolve with time. As at March 2020, when WHO declared COVID-19 a pandemic, many countries were still not certain of actions to be taken or strategies to be adopted to prevent the spread of the infection (Cucinotta & Vanelli, 2020).
With the rapid global spread of the disease, the rising number of infections and

mortality, different countries had to institute strategies to control the spread of the infection. Self-Isolation, quarantine, and lockdowns were some of the measures taken by governments across different countries (Xiao & Torok, 2020). Furthermore, WHO provided guidelines including handwashing with soap under running tap, use of alcohol-based hand sanitizers, cough etiquette, wearing of the N95 mask (for medical professionals), observing the 1m – 1.5m social distancing and avoiding social gatherings among others (Lewnard & Lo, 2020; Liu, He, Rong, & Tang, 2020), to mitigate the spread of the infection. Despite the implementation of these measures, there were reports of increasing rates of infection.

Countries in the Sub-Saharan African (SSA) regions were dealing with the COVID-19 by adopting and modifying the measures mentioned above to suit their political, economic, social and development levels (Ataguba, 2020; Ekpenyong et al., 2020). However, there were fears of increasing infections and so much uncertainty as to the future of this viral infection coupled with the fatalistic perception about the outcome of the disease (Zhao et al., 2020).

Compliance meant the acceptance and effective application of the measures that were put in place by governments to curb the spread of the COVID-19 disease (Ekpenyong et al., 2020; Ovenseri-Ogbomo et al., 2020; Plohl & Musil, 2020). This study sought to examine the associations between compliance with the measures put in place and public opinions on COVID-19 in sub-Saharan Africa. If the government directives were to be well-coordinated, it is important that they be initiated more efficiently. Through the findings of this study, the factors associated with compliance were identified, and for which the understanding of the interplay of these factors is useful when planning future interventions in future pandemics.

2 Methods

2.1 Ethics and consent

The study adhered to the principles of the Helsinki declaration (WMA, 2001), and the protocol was approved by the Human Research Ethics Committee of the University of Calabar. Participation was anonymous and voluntary. Informed consent was obtained from all participants prior to commencement of the study and after the study protocol has been explained. Participants consented to voluntarily participate in this study by answering either a 'yes' or 'no' to the question inquiring whether they voluntarily agree to participate in the survey. A 'no' response meant that the participants could not progress in answering the survey questions and were excluded from the study.

2.2 Study design

This cross-sectional descriptive study was carried out during the mandatory lockdown period (27 April – 17 May 2020) for most African countries. Data was obtained electronically via survey monkey with a survey link posted on the commonly used and easily accessible social media platforms – WhatsApp and Facebook – to elicit a better response. In addition, survey links were shared through the authors' emails and direct short message services.

To be eligible for participation, respondents had to be Sub-Saharan Africans aged 18 years or older; and be able to provide online consent by answering a

'yes' or 'no' response before starting the survey to indicate their willingness to participate in this study. Survey distribution covered SSA countries such as Ghana, Cameroon (only distributed to the English-speaking regions), Nigeria, South Africa, Tanzania, Kenya and Uganda.

2.3 Survey questionnaire

The questionnaire included a brief overview of the context, purpose, procedures, nature of participation, privacy and confidentiality statements and statements to be responded to. The survey tool was developed based on the guidelines from the WHO for clinical and community management of COVID-19 (WHO, 2020a, 2020b), and adapted with modifications to suit the objectives of this study. A pilot study was conducted to ensure clarity and understanding as well as to determine the duration for completing the questionnaire prior to distribution. This self-administered online questionnaire consisted of 17 items of two sections (demographic characteristics and practice/compliance). The demographic variables included questions on age, gender, marital status, education, employment and religion. The questions included closed- ended questions with "Yes" (score 1) to "No" (score -1) and a five-point 'Likert-type scale' to score participants' responses. A 'Not Sure' response was scored as 'zero'. For responses utilizing Likert scale, the scores ranged from '0" for 'Always/A great deal'; "1" for 'Sometimes/A lot'; "2" for 'Rarely/A moderate amount'; "3" for 'Not at all/A little' and "4" for 'Not Sure/ Not at all'.

Respondents were asked about their compliance towards the public health measures put in place by the various SSA countries to mitigate and contain the spread of COVID-19. The compliance score ranged from 5–20 points and was divided into 3 categories. The bottom <5.0% of scores was arbitrarily referred to as 'poor compliance', the next 12.5% as 'moderate compliance', and the top ≥20.0% as 'good compliance'.

2.4 Dependent variables

The outcome variable was compliance to the eight government policies designed to contain and mitigate the spread of COVID-19: attendance at crowded places, handwashing with soap under running water, self-isolation, quarantine, use of facemask when going out, no outside travels, purchase of hand sanitizers and encouraging others to comply with government guidelines, which are shown in Supplementary Table S1.

2.5 Exposure variables

The exposure variables for this study were the public opinion, which included six variables that were associated with the government policies to prevent the spread of the disease. The public opinion variables used in the analysis were; if the respondents thought the COVID-19 outbreak was dangerous, If they thought public health authorities in their countries were doing enough to control the CoVID-19 outbreak, If they thought hand hygiene or hand-cleaning was important in the control of the spread of COVID-19; and if they considered the self-isolation as necessary and reasonable.

2.6 Independent variables

The independent variable was the demographic factors, which included age group, gender, SSA region, country of residence, employment status, marital status, religion, level of education, occupation and whether they lived alone or not.

2.7 Statistical analysis

Data analysis was performed using Stata version 14.1 (Stata Corp. College Station United States of America). Categorical variables were presented as frequencies and percentages. This was followed by the estimation of the proportion of each compliance response or public opinion response, and the differences between proportions were evaluated using 95% confidence intervals (CI). The outcome variable was compliance, which was categorized into 'poor, moderate and good compliance'. All the independent variables shown in Table 1 were then entered into a multivariate model to estimate the associated factors by adjusted ORs and 95% CIs.

3 Results

3.1 Characteristics of the population

Table 1 shows the characteristics of all study participants and summary of responses used in the predictive modelling of compliance and public opinion. A total of 1779 (male to female ratio of 1.3:1) completed the survey. From the table, most of the respondents had at least a university degree n=1563(87.6%), were younger than 38 years n=1158(65.3%) and employed n=1189(66.7%). Nearly all participants n=1644(92.5%) were residing in their respective countries of origin at the time of this study.

Table 1. Demographic characteristics of the respondents in this study (n=1779)

Characteristics	Frequency	Percent
Region		
West Africa	982	56.21
East Africa	181	10.36
Central Africa	221	12.65
South Africa	363	20.78
Country of residence		
Africa	1,644	92.52
Outside of Africa	133	7.48
Age classification		
18-28 years	676	38.13
29-38	482	27.19
39-48	390	22
49+ years	225	12.68
Sex		
Males	993	55.98
Females	781	44.02
Working status		
Employed	1189	66.72
Unemployed	593	33.28
Marital status		
Married	790	44.43
not married	988	55.57
Religion		
Christian	1571	88.31
Others†	208	11.69
Level of Education		
Master's Degree or more	592	33.22
Bachelor's Degree	971	54.49
Secondary/primary	219	12.29
Occupation		
Non healthcare	1,300	77
Healthcare	388	23
Household factors		
Lived alone during COVID		
No	327	18.4
Yes	1,454	81.6
How many live together		
< 3 people	452	29
4-6 people	802	51.5
6 or more people	303	19.5

† includes Muslims (5.0%) and African traditionalist (1.4%), others (5.3%).

Result present as frequencies (percentages).

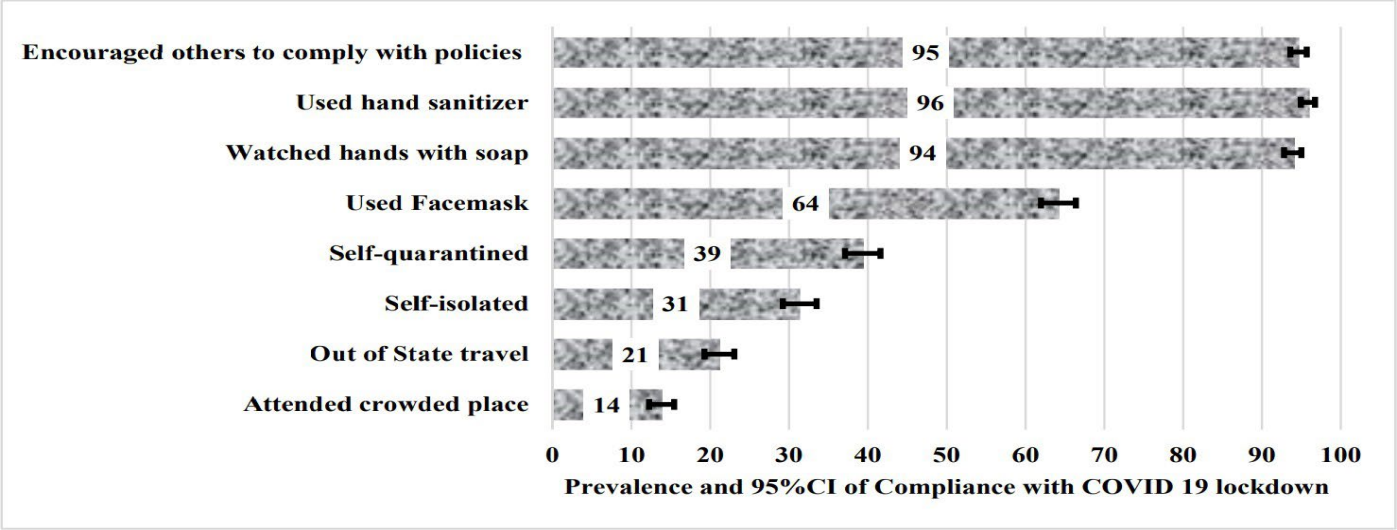

Figure 1. *Compliance with COVID-19 public health measures. Result presented prevalence a 95% confidence interval (CI)*

Figure 1 presents the outcome variables of compliance with public health measures put in place to control the spread of the virus in SSA. From this figure, there was good compliance with encouraging others to comply with government policies and washing hands with soap under running water, average/moderate compliance with the use of facemasks and poor compliance with self-isolation, quarantine as well as avoiding large gatherings, whereas one in every seven respondent attended a crowded place during the lockdown.

3.2 Multivariable analysis

Figure 2 presents the adjusted odds ratio and confidence interval for the association between public opinion and compliance with government policies to stop the spread of COVID-19. After adjusting for all demographic variables, respondents who reported that the public health authorities in their countries were not doing enough to minimize the spread of the disease were more likely to go to crowded places during the pandemic (aOR 1.75, 95% CI 1.30-2.35). Supplementary Table S2 shows the factors associated with the public health measures put in place to contain and mitigate the diseases. The practice of self-isolation and quarantine were associated with the thought that COVID-19 would be gone after the lockdown, whereas washing hands with soap were associated with the opinion that COVID-19 was dangerous and could be prevented by wearing of the facemask.

Respondents who thought that COVID-19 would not remain in their countries (aOR 0.48, 95% CI 0.24 – 0.96) and those who thought self-isolation was not needed during the pandemic (aOR 0.29, 95% CI 0.13 – 0.65) were less likely to encourage others to comply with the preventive strategies put in place to stop the spread of the disease.

3.3 Associated factors with compliance with government policies

In addition to the factors identified in Figure 2, other factors that were associated with compliance to government policies to stopping the spread of the disease in SSA were old age, being resident in East and Central Africa, living alone during the lockdown, female sex, being employed, and marital status (unmarried). See Supplementary Table 2 for details.

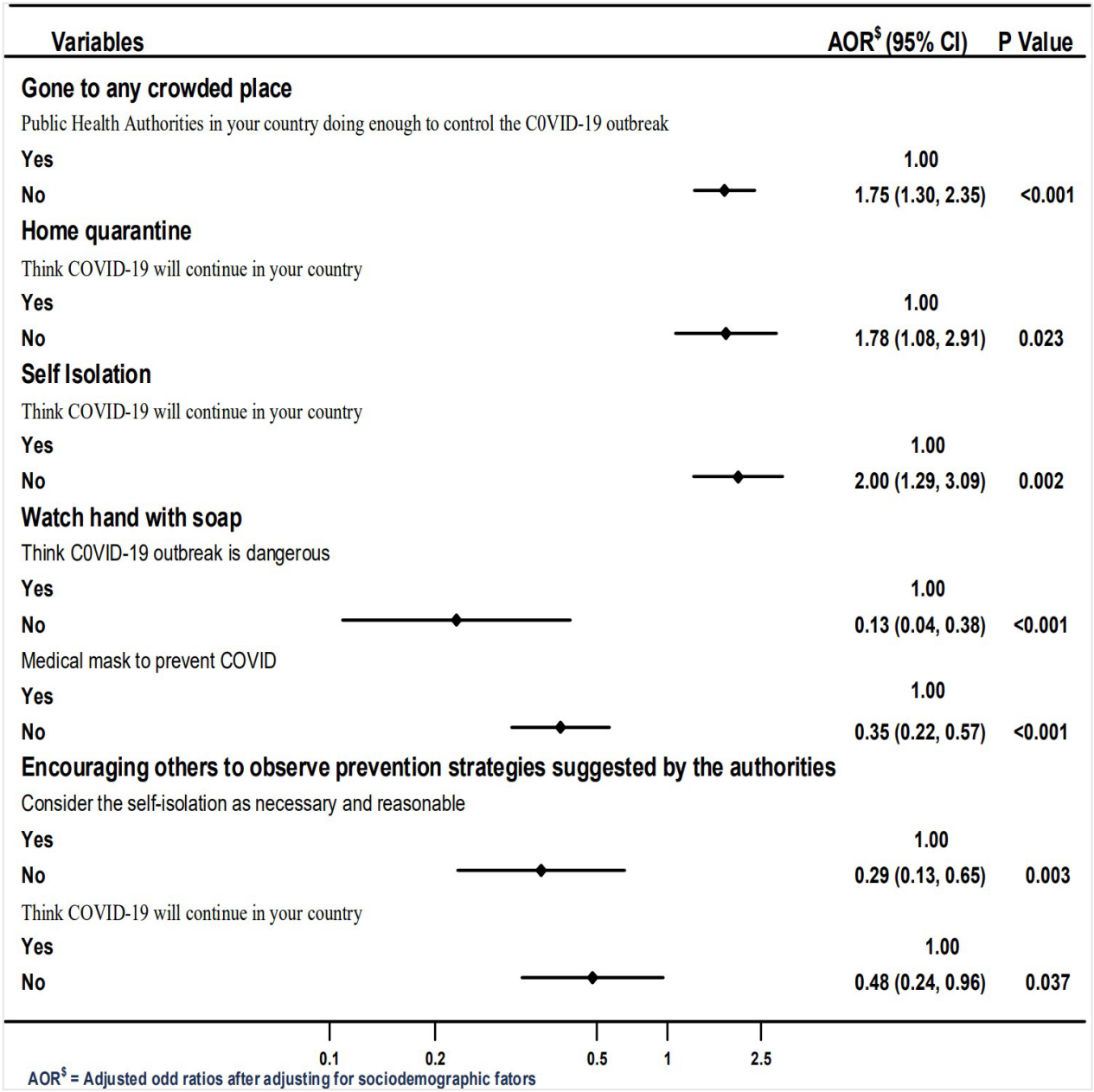

Figure 2. *Association between public opinion and compliance with government policies. Showing variables with significance in the multivariable analysis*

Result presented as adjusted Odds ratio at 95 % confidence interval and p value at significance p = 0.05

4 Discussion

In this study, we investigated the association between compliance and public opinion toward measures taken during the COVID-19 in Sub-Saharan African countries. The results indicated that there was generally good compliance with the measures recommended for the mitigation of the spread of COVID-19 amongst the respondents with hand hygiene recording the highest compliance level while out-of-state travel and avoidance of crowded gathering complied with the least. However, the level of compliance varied from one SSA region to another. The results further showed that opinion on how respective governments were handling the pandemic and whether the pandemic would be curtailed influenced respondents' compliance to

prescribed measures to address the spread of infection and hence deal with the pandemic.

The opinion that the public health authorities in the respective SSA countries were not doing enough to minimize the spread of the diseases was associated with attending public gatherings during the pandemic and poor compliance to social distancing. In an opinion poll, (Ipsos, 2020) it was asserted that the public was divided on whether self-isolation, travel restrictions and social distancing could contain the spread of the coronavirus disease and thus were reluctant to comply with these measures. A broadcast by Gallup Pakistan reported that the public had the belief that government was not actually doing enough through the public health authorities which is in agreement with the findings of this study (Pakistan, 2020). An Israeli study argued that the citizens' refusal to comply with public health measures to control the spread of COVID-19 is expectedly a characteristic of human behaviour and concluded that the escalation of the disease was thought to come from individual behaviour and may not be related to activities of public health authorities (Mansdorf, 2020). From the psychological front, humans are predisposed to refusal and denial. In this case, they are referred to as refusers, since they are in denial, and this opposes the containment measures (Mansdorf, 2020). Public health activity slacking in implementation is also a threat to the people, and there is a need to ensure that public health activities are made to reach the populace. This could be achieved effectively by concerted efforts at educating the populace on the containment and mitigation measures in place as set out by the governments of these countries.

Respondents who thought that COVID-19 would remain in their countries after the lockdown were less likely to comply with the mitigation practices, including self-isolation and self-quarantine. Starting as a conspiracy theory, most people believe that COVID-19 has come to stay (Ahmed, Vidal-Alaball, Downing, & Seguí, 2020; Aiyewumi & Okeke, 2020; Bierwiaczonek, Kunst, & Pich, 2020; Bruder & Kunert, 2020; Coë; Durkee, 2020; Ovenseri-Ogbomo et al., 2020). Cultural practices in most SSA countries tend to influence beliefs that the COVID-19 issue is a phase that will disappear as it appeared (Aiyewumi & Okeke, 2020; Ovenseri-Ogbomo et al., 2020). Reports from the US death toll conspiracy theory set divided views on the duration and death toll of the COVID-19 (Durkee, 2020). The child welfare department in the US has accepted the permanency of the COVID-19 and thus are concerned on how to live through and with evolving variants and socio-economic fluctuations associated with COVID-19 (Tierney, Stevens, & Armbrust, 2020). This report is in line with the findings of this study with the spark of interest in finding solutions on the trending of the Coronavirus disease.

An important dimension to the compliance challenges according to the belief of the permanency of the pandemic is the religious propagation of the disease as an act of divinity to check the activities of men. It is stated that about 63% of Christians in American believe the pandemic is a message from God with Evangelical Protestants the most likely to believe that strong compared to mainline Protestants and Catholics (Schor & Fingerhut, 2020). This is in agreement with the finding of significant associations between religion and compliance with the government directives were respondents in this study (Schor & Fingerhut, 2020). We found that Christians were more likely to attend crowded events and embark on out of state travel during the lockdown period compared to those who were Muslims. SSA

countries demonstrate an affinity for the religion and so much expression of this is seen on the way countries in these regions had strong oppositions from religious leaders at the beginning of the pandemic and even having these leaders promote some conspiracy theories on COVID-19 pandemic including the 5g myth and that vaccination for COVID-19 is the mark of the beast (Files, 2020).

The workplace policies of working from home, as set out by many countries during the pandemic tend to give credence to the belief that COVID-19 is here to stay (Tang et al., 2020). The passing into law stringent measures that are perceived could become permanent in some countries (Cormacain, 2020; Van Natta et al., 2020) agrees with the findings of this study. In trying to map a road ahead for Indians in small villages, rural and urban settlements, the challenges encountered as a result of the global pandemic remains a thing of uncertainty regarding its permanency as shown in studies in this Indian settlement (Ananth, 2020). This calls for thorough governmental and individual investigations to ascertain the actual dimensions of the COVID-19 and its evolving trends with respect to educating all appropriately on adoption and compliance to the containment and mitigation measures in order to save and preserve lives following the rising numbers in global infections and deaths.

Another interesting finding of this study was the fact that respondents who disagreed that COVID-19 was dangerous and those who thought that the use of medical facemask was not preventative during COVID-19 were less likely to comply with the public health practices. Furthermore, many respondents reported compliance with wearing facemask when going out to the public, and this was associated with being resident in East and Central Africa. Also, people aged older than 29 years, being female, being unemployed and not married were associated with compliance to differing degrees in SSA. The findings are consistent with a study conducted in Malaysia whereby more than half of the participants reported wearing a face mask when going out in public (51.2%) and this was significantly associated with gender, age group, region, occupation, and income group (Azlan, Hamzah, Sern, Ayub, & Mohamad, 2020). Azlan et al. (2020), reported similar findings of good compliance in the practice of proper hand hygiene at the time the study was conducted in late March and found that this was associated with gender, age group, region, and occupation.

In this study, encouraging others to observe the public health measures put in place during the pandemic was associated with the perception of the disease duration and as such the lack of need to self-isolate during the pandemic. In the present study, almost a quarter of the respondents embarked on out of state travel despite recommendation not to do so. This low compliance may be due to the belief that social distancing measures such as travel bans, and self-isolation would not prevent the spread of the virus (Seale et al., 2020). This study went further to assess compliance in practicing self-isolation and quarantine. Those living in Central Africa, aged older than 39 years, being Muslims and living with others were significantly associated with being quarantined except for those who were unemployed and lived in East Africa. On the other hand, those older than 29 years old that were unmarried and held a bachelor's degree were significantly associated with self-isolation. There was no change in being quarantined and practicing self-isolation in East Africa, but the practice reduced in Central Africa.

Similar to this study, Bodas and Peleg

(2020) stated that being assured of household incomes during times of quarantine and self-isolation are important determinants of compliance. However, noncompliance was more observed in males, those who were married and less educated. In a study (Seale et al., 2020), the most common avoidance behavior adopted was keeping away from crowded places generally (67%). The opinion and compliance of the respondents among SSA countries play a vital role in enhancing the effective implementation of the measures provided by WHO to eliminate the spread of COVID-19 disease (WHO, 2020a). Those who believed that the COVID 19 disease was dangerous were more complying to government policies. Furthermore, the process of encouraging other people to comply with government directives was more practiced by those who believed that there was a need for self-isolation. As we continue fighting the spread of this pandemic, programs should focus on younger ones, unemployed and those who are living in West and Southern Africa. In addition, sex and marital status should be vital components that can help reduce effects on compliance, seeing that male respondents are more non-compliant and married people more compliant. This area needs to explore it further to ascertain the actual rate of influence of these factors.

This study had some limitations. Given the inability to physically access respondents due to the pandemic, the survey tool was sent out to prospective respondents electronically using social media platforms and emails. This method of soliciting respondents may have inadvertently excluded respondents who may not have access to the internet from participating in the study. Thus, it may not be a true reflection of the opinion of those living in rural areas where internet penetration remains relatively low (Hjort & Poulsen, 2019). However, the use of an internet-based methodology for this study, allowed for the rapid acquisition of responses from wide geographical distribution and this was the only reliable means to disseminate information at the time of this study. Furthermore, the survey was presented in the English language, thus excluding non-English speakers from the study area from participating. It was also noted that the sample of this study is biased towards West Africans, literates, and English speaking SSAs. These unintended biases should be noted when interpreting and applying the results because the findings cannot be generalized in all SSA countries. The low participation of respondents from other sub-regions like East Africa may have been occasioned by the lockdown as citizens from Tanzania were asked to refrain from giving out information regarding the pandemic. Notwithstanding these limitations, this study is the first SSA regional study that provides evidence on the impact of public opinion about the pandemic on compliance status on mitigation practices. The confounders were held constant at each step of the analysis in order to reduce the issue of bias. In addition, the study provides useful information for reducing the additional burden associated with non-compliance to these practices.

5 Conclusion

From the study, it is seen that there was good compliance with the public health measures set out by the different governments to contain and mitigate the spread of the coronavirus infection. The opinion held by respondents with respect to the handling of the pandemic by various governments in SSA and whether the pandemic will abate had a significant influence on the compliance with the public health measures. There was a vast regional variation in compliance and

opinion held by respondents with respect to the public health measures put in place to control the COVID-19 pandemic.

What is already known on this topic?

- The multiple dimensional approaches to formulating measures aimed at mitigating the COVID-19 spread and infection created more fear among the public.
- Rapid response committees were set up in sub-Saharan African countries who responded to calls on the control of the infection and spread of the coronavirus.
- There were demonstrated scepticisms in the uptake of the measures set out by countries in SSA, particularly among the rural dwellers and confusion on which measures will serve best to stop the disease entirely among the urban dwellers.

What this study adds

- The findings of this study showed good compliance with measures recommended for the mitigation of the spread of COVID-19 amongst the respondents with high compliance with hand hygiene and low compliance with out-of-state travel and avoidance of crowded gathering.
- Compliance to the mitigation practices was mostly driven by people's opinion on how respective governments were handling the pandemic and whether the pandemic will be curtailed.
- The unfulfilling role of public health protocols in the SSA countries and the need to institute implementation measures to the stipulated control measures was highlighted.

Declarations Competing interests

The authors declare no competing interest.

Authors' contributions

All authors made substantial contributions to the conception or design of the work; or the acquisition, analysis, or interpretation of data for the work; TC, DC, LO and KA drafted the work; KA, MC, RO, RL, ON, CP, EA, GO, CT, DC, TI, KM, BE, revised it critically for important intellectual content; all authors approved the final version to be published; and TC, DC, LO, and KA agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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Appendix Supplementary tables

Table S1 Sample of online administered questionnaire for main outcomes

In recent days, have you worn a mask when leaving home?
Always/ Sometimes/ Rarely/Not at all/Not sure
In recent days, have you been washing your hands with soap under running water for at least 20 seconds each time?
Always/ Sometimes/ Rarely/Not at all/Not sure
Are you currently or have you been in (domestic/home) quarantine because of COVID-19?
Yes/ No
Are you currently or have you been in self-isolation because of COVID-19?
Yes/ No
Since the government gave the directives on preventing being infected, have you procured your mask and possibly sanitiser?
Yes/ No
Have you travelled outside your home in recent days using the public transport?
Yes/ No
Are you encouraging others that you encounter to observe the basic prevention strategies suggested by the authorities?
Yes/ No
How much have you changed the way you live your life because of the possibility of continuing of Coronavirus disease (COVID-19)?
A great deal/ A lot/ A moderate amount/A little/Not at all

Supplementary Table 2

Table S2 Adjusted odds ratio (aOR) and Confidence interval (CI) of demographic factors associated with compliance with the public health measures.

Final model variables	Attended crowded place	Used Facemask	Self-quarantined	Self-isolated	Hand Sanitiser	Encouraged others	Hand washing	Out of state travel
	aOR[95%CI]	aOR[95%CI]	OR[95%CI]	aOR[95%CI]	aOR[95%CI]	OR[95%CI]	aOR[95%CI]	aOR[95%CI]
SSA Region								
West Africa	Reference	Reference	Reference	Reference				Reference
East Africa	1.59 [0.99, 2.54]	2.65 [1.83, 3.85]	1.01 [0.71, 1.43]	1.04 [0.72, 1.50]				1.83 [1.25, 2.69]
Central Africa	3.13 [2.16, 4.54]	6.62 [4.25, 10.31]	0.60 [0.43, 0.83]	0.76 [0.54, 1.06]				2.61 [1.87, 3.63]
South Africa	1.03 [0.70, 1.52]	1.82 [1.40, 2.37]	0.95 [0.73, 1.25]	1.09 [0.84, 1.43]				0.94 [0.68, 1.30]
Residence								
Local		Reference	Reference					
Diaspora		1.37 [0.90, 2.08]						
Age grouping								
18-28 years	Reference		Reference	Reference		Reference	Reference	Reference
29-38	0.83 [0.56, 1.21]		0.67 [0.49, 0.90]	0.65 [0.49, 0.87]		3.68 [2.05, 6.63]	2.27 [1.19, 4.34]	1.05 [0.80, 1.38]
39-48	0.42 [0.26, 0.69]		0.56 [0.38, 0.80]	0.48 [0.33, 0.69]		3.80 [1.98, 7.29]	3.16 [1.28, 7.77]	0.43 [0.30, 0.61]
49+ years	0.31 [0.16, 0.58]		0.47 [0.31, 0.72]	0.43 [0.28, 0.65]		12.31 [2.99, 50.65]	7.44 [1.71,32.32]	0.18 [0.10, 0.32]
Sex								
Male		Reference	Reference			Reference		
Female		**1.60 [1.29, 1.97]**	**1.59 [1.28, 1.98]**			**9.06 [7.04, 11.66]**		
Employment								
Employed	Reference	Reference					Reference	
unemployed	**0.63 [0.43, 0.92]**	**0.73 [0.57, 0.95]**					**0.44 [0.25, 0.77]**	
Marriage status								
Marriage		Reference	Reference	Reference	Reference			
Not married		**0.76 [0.60, 0.97]**	**1.51 [1.13, 2.01]**	**2.02 [1.52, 2.70]**	**0.48 [0.27, 0.85]**			
Religion								
Christian	Reference							Reference
Muslim	**0.45 [0.25, 0.80]**							**0.61 [0.40, 0.94]**
Education								
Postgraduate					Reference			
Bachelor					**0.44 [0.22, 0.88]**			
Secondary/Primary					0.56 [0.23, 1.38]			
Live alone								
No	Reference							
Yes	1.41 [1.01, 1.98]							
Number living together			Reference					
< 3 people			1.07 [0.83, 1.38]				Reference	
4-6 people			1.41 [1.03, 1.92]				1.16 [0.72, 1.86]	
6+							1.89 [0.96, 3.70]	
Occupation								
Not health related								
Health care related								

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15. The impact of information sources on COVID-19 vaccine hesitancy and resistance in sub-Saharan Africa

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Abstract

Background: Vaccination remains the most powerful weapon against the emergence of new variants of coronavirus (COVID-19). However, false information about COVID-19 vaccines through various platforms including social media remains a major threat to global public health. This study examined the impact of information sources on COVID-19 vaccine hesitancy and resistance in sub-Saharan Africa (SSA).

Methods: A validated web-based cross-sectional study was conducted from 14 March to 16 May 2021, and was administered in both French and English to 2572 participants aged 18 years and over. Data on sociodemographic characteristics, medical and vaccination history, and the information sources (mainstream media and social media) used by the participants during the pandemic were obtained. There were three main outcomes: The vaccinated group were those who responded in the affirmation (Yes) to the question of whether they have been vaccinated against COVID-19. Those who responded 'not sure' or 'no' to the question were then asked if they were willing to be vaccinated when the vaccine became available in their home countries. The responses to this follow-up question were used to derive the second and third outcome variables of 'vaccine hesitancy' and 'vaccine resistance', respectively. A series of logistic regression analyses were used to examine the impact of information sources on the three main outcomes.

Results: The prevalence of COVID-19 vaccine hesitancy among the participants was lowest among newspaper readers (42%) and highest among TV (72%) and social media users (73%). The prevalence of COVID-19 vaccine-resistance was also lowest among newspaper readers (37%) but highest among social media users (87%). Multivariate analyses revealed that compared to those who did not use these information sources, SSA participants who relied on the radio (aOR 0.83, 95%CI =0.70, 0.99), TV (aOR 0.80, 95%CI =0.65, 0.97) and social media (aOR 0.79, 95%CI =0.65, 0.97) for information during the pandemic were less likely to be hesitant towards taking the vaccines. However, social media users (aOR 2.13, 95%CI = 1.62, 2.80), those who watched TV (aOR 1.40, 95%CI =1.08, 1.80), relied on healthcare workers (HCWs: aOR 1.32, 95%CI =1.07, 1.63) and families/friends (aOR 1.31, 95%CI =1.06, 1.61) for COVID-19 related information during the pandemic were more likely to resist taking the COVID vaccines in this study. Participants who relied on the newspaper for information during the pandemic were less likely to resist the vaccines (aOR 0.77, 95%CI =0.62, 0.95) compared to non-readers of a newspaper.

Conclusion: We found that all six information sources except radio were strong predictors of the resistance towards COVID-19 vaccination. Further research on how these channels can be used to improve the availability of reliable healthcare information is needed. Investments in these resources will protect people and empower them to make appropriate choices about their health.

Keywords: Coronavirus; Facebook; Media; Africa; Television; Misinformation; Survey; Radio; Healthcare workers; Lockdown.

Background

The COVID-19 pandemic has significantly impacted economic, health and living conditions on the African continent and elsewhere [1, 2]. The impact on individuals, families and communities across Africa has been unprecedented. While the global economic loss is still unfolding, it is projected to be quite huge particularly in African countries [3]. The risk of COVID-19 resurgence remains high in several African countries due to poor adherence to public health measures, mass gatherings, low testing and low vaccination rates [4]. This resurgence creates more demands on an already depleted and struggling healthcare system thereby leaving many of the citizens in a dilemma. Governments are also overburdened with balancing the provision of care regarding the presence of other viral infections and diseases that have sprung up again due to all attention being diverted to the COVID-19 pandemic as is seen in countries like the Democratic Republic of Congo (Ebola), Lassa fever in Guinea, Liberia, Kenya (Rift valley Fever), Nigeria and Sierra Leone, Republic of Guinea (Marburg virus disease), among other African countries [5-8]. Furthermore, residents have purchased and stored some medications commonly used for treating other infectious diseases causing scarcity, and rising costs due to an increase in demand [9].

Vaccination remains the most powerful weapon against the emergence of new variants [10] as well as reaching herd immunity[11]. However, compared with the rich European and North-American countries, COVID-19 vaccination remains very low among African countries with only 11% of the adult population fully vaccinated[10]. This lack of adequate and complete vaccination of the populace, among other factors, is brought about by the state of the economy in African countries. Most African countries are in the low-middle income strata. High income economies, purchase and hoard vaccines immediately or even before they are mass produced by paying pharmaceutical companies huge deposits for these vaccines before production which affects the vaccine distribution globally. This also limits effective control of the widely spreading disease, particularly among African countries and thus the emergence of various variants of the virus as seen in South Africa (omicron), Brazil (delta) and India[12]. This act of hoarding vaccines could be directly attributable to the non-achievement of disease control and its resurgence in other variants in low-middle-income countries. As such the inability to attain community immunity globally since people are still travelling, more so, with most of these countries lowering their guard on the earlier preventive measures[12].

The African continent has witnessed four waves of COVID-19 over the last two years and has improved its capacity to manage COVID-19 cases [10]. The supply of COVID-19 vaccines across the region has also increased with approximately 672 million doses distributed across the region, mostly facilitated by COVAX (65%) and the rest through bilateral deals (29%) and the African Union's Vaccines Acquisition. Despite this improvement, there are concerns that the rapid spread of 'false or misleading information' in digital and physical environments causes confusion and risk-taking behaviours that can harm health and lead to mistrust in health authorities and undermine the public health response[13]. For instance, in Pakistan, vaccine hesitance and resistance fuelled by fear of the unknown, country of manufacture of the vaccine, religious and cultural ideologies, have made it almost impossible to reach the people [14]. Yet, despite the widespread concern about the potential impacts of misinformation on vaccination, little is known about the magnitudes of those impacts nor their differential effects across various countries in sub-Saharan Africa (SSA).

Exposure time to COVID-19-related news increased over time during the pandemic [15] and more exposures to the news have direct implications on people's actions such that receiving timely and informative communication during a time of uncertainties promotes public cooperation [16]. Infodemic affects the hesitance and resistance to uptake of new products across the market, and it becomes worse in a pandemic as seen with the coronavirus disease and its management and supposed consequences [13]. Vaccine hesitancy (reluctance to receive vaccines) is one of the top ten threats to global health [17] and this is fuelled by health information obtained from the news media, internet and social media platforms [18-21]. Vaccine hesitancy is also high among certain population groups [22, 23] probably due to the previous medical experiment amongst these population groups [24] and poor messaging [25]. Misinformation regarding the benefits, medicinal composition, and adverse effects of vaccination, limits patient understanding and overall buy-in [18]. Although access to technology has improved during the pandemic, and the use of social media has increased [18], there are concerns about the spread of misinformation across different social networks propagated via the contemporary anti-vaccination movement, to fuel vaccine hesitancy [26, 27]. This has the potential to compromise public confidence in the COVID-19 vaccine for the prevention of the disease [28]. However, where social media platforms were used to propagate healthy messages, by nurses and doctors, a significant improvement in compliance with public health messages and subsequent COVID-19 infections has been reported [21].

Sources of vaccination information have different effects on people's coping appraisal of COVID-19 vaccination [20]. Unlike mainstream media, social media such as Facebook, Twitter, Instagram, WhatsApp, and Pinterest allow individuals to rapidly create and share content globally without editorial oversight [29, 30]. These are complex and fluid ecosystems, in which anti-vaccination viewpoints can be amplified and represented as mainstream, and vaccine-hesitant parents can encounter compelling narratives from other parents dissuading vaccination [31]. Misinformation and unsubstantiated rumours regarding COVID-19 and potential vaccination against SARS-CoV-2 have already begun emerging on social media platforms, threatening to erode public confidence as the vaccines are rolled out in African countries [32]. Information spread through social media directly or indirectly increases hesitancy toward COVID-19 vaccination, while the opposite effect was observed for institutional websites [27]. Since social media platforms may self-select content streams, contributing to ideological isolation, owners must ensure that social media platforms provide access to accurate information on the safety and efficacy of vaccinations [29].

The uptake of COVID-19 vaccination in SSA may be impeded by the rapid spread of misinformation on social media leading to belief in false rumours about the pandemic [29], which has been associated with poor health-seeking behaviour [33, 34]. The recent mixed international messages about the efficacy of the different COVID-19 vaccines, their side effects beyond the local and systemic effects [35, 36] and the lack of clarity regarding the required dosage [37] may further reduce the confidence of African populations in the safety of the vaccines [21]. In addition the halting of the AstraZeneca vaccine in South Africa, which showed less protection against the new variant SARS-CoV-2 that can evade key antibodies [21], may have contributed to

lower people's confidence in the vaccine efficacy. Healthcare workers are among the most trusted experts [38-40].

Intensive global efforts for continued physical distancing and isolation to curb the spread of new strains of SARS-CoV-2 may intensify the use of social media as individuals try to remain connected while apart [41]. In a randomized controlled trial to understand the impact of social media in the United States, researchers found that messages spread by nurses and doctors on social media led to a significant reduction in holiday travel and subsequent COVID-19 infections [21]. Therefore, identifying, understanding, and addressing how information sources affect vaccine acceptance [42], hesitancy and resistance [43] is potentially important to increase vaccine uptake.

Therefore, this study was designed to, a) determine the proportions of SSA participants that were dependent on the different sources of information (social media and mainstream media sources) for COVID-19-related information; b), profile individuals who use the mainstream media outlets (TV and radio, newspaper) to obtain COVID-19 related information by identifying the key socio-demographic, and health-related factors that are associated with the different information sources; and c), determine the sources of information about the COVID-19 pandemic among vaccine-hesitant and resistant individuals across SSA countries as well as identify the association between sources of information and vaccine hesitancy. By identifying the distinguishing characteristics, public health officials may be better able to target a sub-population at greater risk of exposure to misinformation about the COVID-19 vaccine. Findings will also offer a greater understanding of how public health officials can effectively tailor health behaviour messaging to align with the socio-demographic profiles of vaccine- hesitant or resistant individuals, while also considering their consumption of COVID-19 information and the predominant sources. In addition, the study findings will help to provide steps on how social media may be used to improve health literacy and build public trust in vaccination.

Materials and methods

Survey design

This was a cross-sectional study that recruited participants across SSA countries between March 14 and May 16, 2021. The questionnaire was initially developed and used for a similar study[44]. The questionnaire was tested for the internal validity of the items, and Cronbach's alpha coefficient score ranged from 0.70 and 0.74, indicating satisfactory consistency [44]. The questionnaire was adapted with minor modifications to suit this study's objective and was made available in English and French languages to allow for residents residing in the Anglophone and Francophone SSA countries to participate. This was also necessary to increase the reach of the survey, one of the past study limitations [33, 34]. Moreover, a pilot study was conducted on 10 participants who were not included in the final study and were not part of the research group to ensure clarity and understanding as well as to determine the duration of completing the questionnaire before dissemination. The final questionnaire is presented as Supplementary Table S1.

Participants

Eligible participants were adults of SSA origin, living in or outside of Africa, aged 18 years and older, who were able to provide informed consent at the time of this study. Since this was an online survey, it is possible that participants were those who had access to the internet and those who were on their respective social media platforms and used them. Participants were excluded if they were not from SSA countries, were younger than 18 years, were unable to provide informed consent, and participated in the initial pilot study. The supplementary Figure S1 shows the distribution of the participants by their countries of origin.

Using a snowball sampling technique, participants were recruited online after the survey was created in survey monkey (SurveyMonkey Inc, San Mateo, California, USA, www.surveymonkey.com) and was administered in two languages. An e-link to the survey was disseminated via emails and posted on social media platforms (Facebook and WhatsApp). The distribution of the survey was strongly reliant on the snowballing or chain-referral approach using virtual networks to reach the population who used social media and other online formats, thus saving time and cost for data collection[45-47]. Authors were also encouraged to share the e-link of the survey through personal emails and social network groups in their respective countries. The use of an online survey ensured that a large spectrum of prospective participants across SSA could be reached in limited time and resources.

The sample size calculation was based on a single population proportion formula by the World Health Organization (WHO) as well as previous studies[33, 34, 48]. Assuming a 20% attrition rate for a proportion of 50% of the population and using the desired precision of 2% and the 5% significance level for a two-sided test to detect statistical differences between groups at 80% power, a sample size of 2502 was considered adequate for this study aims.

Dependent variables

The main outcomes were the three COVID-19 vaccine indicators of the participants. The vaccinated group was formed by those who responded in the affirmation (Yes) to the question of whether they have been vaccinated against COVID-19. Those who responded 'not sure' or 'no' to the question were then asked if they were willing to be vaccinated when the vaccine became available in their home countries. The responses to these follow-up questions were used to derive the second and third outcome variables of 'vaccine hesitancy' and 'vaccine resistance', respectively, similar to a previous study [49]. In this study, vaccine acceptance refers to a position ranging from passive acceptance to active demand [42], whereas hesitancy and resistance, respectively, were used to define the reluctance to receive vaccines (i.e. positions of being unsure about taking a vaccine) and being absolutely against taking a vaccine [43].

Exposure variables

The exposure variables were derived from the question of how the participants obtained information on the COVID-19 vaccine. The participants responded 'yes' or 'no' to whether they obtained the information from the mainstream media (Radio, Television, Newspaper), Social media (such as Facebook, WhatsApp, Twitter) or healthcare workers (HCWs), or family and friends.

Independent variables

The questionnaire included demographic data (age group, sex, country of origin, religion, marital status, educational level, employment status, occupational status), health indicator factors (smoking status, presence of pre-existing conditions including diabetes, lung disease, heart disease, hypertension, obesity, asthma) and previous immunisations/vaccines history. These constituted the independent variables.

Statistical Analysis

Analyses were performed using STATA/MP version 14 (Stata Corp, College Station, TX, USA) and categorical data are shown as counts and percentages. The proportion of participants who used each of the sources of information was conducted using cross-tabulation. The proportion of participants who used each of the sources of information was conducted using cross-tabulation. The associations between sources of information and vaccine hesitancy and resistance were determined in a series of logistic regression analyses that included sources of information as exposure variables after controlling for demographic factors, and health indicator factors. There is no unique statistical test for multicollinearity for binary logistic regression but in our analysis, we treat the binary outcome variables as a continuous variable and used the "Logit" command and then 'collin' command in Stata to determine multicollinearity including Variance Inflation Factors (VIF) because collinearity is driven by the characteristic of the independent variables and no the type of regression used[50] and the VIF < 4 was considered suitable[51]. The odds ratios with 95% confidence intervals (CI) were calculated to assess the adjusted odds of exposure and independence variables.

Ethical consideration

This self-administered web-based cross-sectional study was approved by the Humanities and Social Sciences Research Ethics Committee (HSSREC 00002504/2021) of the University of KwaZulu-Natal, Durban, South Africa. The study adhered to the principles of the 1967 Helsinki declaration (as modified in Fortaleza 2013) for research involving human subjects. Before the study, an explanation detailing the nature and purpose of the study was provided to all participants using an online preamble. Informed consent was obtained from the participants who were required to answer either a 'yes' or 'no' to a question on whether they were willing to voluntarily participate in the survey. The confidentiality of participant responses was assured, and anonymity was maintained. Participation in the study was voluntary without any incentive, inducement, or obligation from the researchers. To ensure that only one response per participant was included in the study, participants were instructed not to take part in the survey more than once, and during analysis, we also restricted the data by the IP address of the participants.

Results

The socio-demographic characteristics of the 2572 participants who took part in this study are reported in Table 1. Of these participants, 1390 were males (54%), mostly educated (80% of the participants had completed a bachelor's or higher education degree), about one-third were aged 18-28 years (929, 36.1%), and more than half of them were not married (1440, 56.0%) and resided in West African countries (1446, 56.2%). About 80% of the participants were employed in non-healthcare sectors and of health indicators, there were few smokers (177, 6.9%) and people who reported that they had a pre-existing condition (880, 34.2%).

Television and social media were the main sources of information for more than two-thirds (n=1897 and 1879, respectively) of the participants in this study during the pandemic, while less than half relied on the newspaper (n=1067, 41.5%) for such information (Table 1). This was consistent across regions, age groups and gender. More than half of the Central African participants reported that they sought COVID-19-related information from HCWs, whereas East African participants relied less on this source of information. Fifty-five percent of those with a pre-existing health condition and those that had previous vaccination reported that they relied on HCWs for COVID-19-related information.

Percentage of vaccine acceptance, hesitance, and resistance by the information sources

The proportion of COVID-19 vaccinated, hesitant and resistant participants at the time of this study was 14.9%, 17.8%, and 67.3%, respectively. Figure 1 displays the proportion of participants who reported COVID-19 hesitancy and resistance, across the different media sources used by the participants during the pandemic. A total of 17% of mainstream listeners and 13% of social media users were vaccinated at the time of this study. Irrespective of the participants' source of information during the pandemic, the proportion who resisted the vaccine was significantly higher and ranged from 37% among newspaper readers to 85% among social media users. In comparison, the proportion who were hesitant to take the vaccine ranged from 42% among newspaper readers to 73% among those who watched TV during the pandemic.

The Chi-square test found significant associations between the participants' vaccination status and their reliance on social media ($p<0.0001$), TV ($p=0.004$), HCWs ($p<0.0001$) and friends/families ($p=0.001$) for COVID-19–related information, during the pandemic.

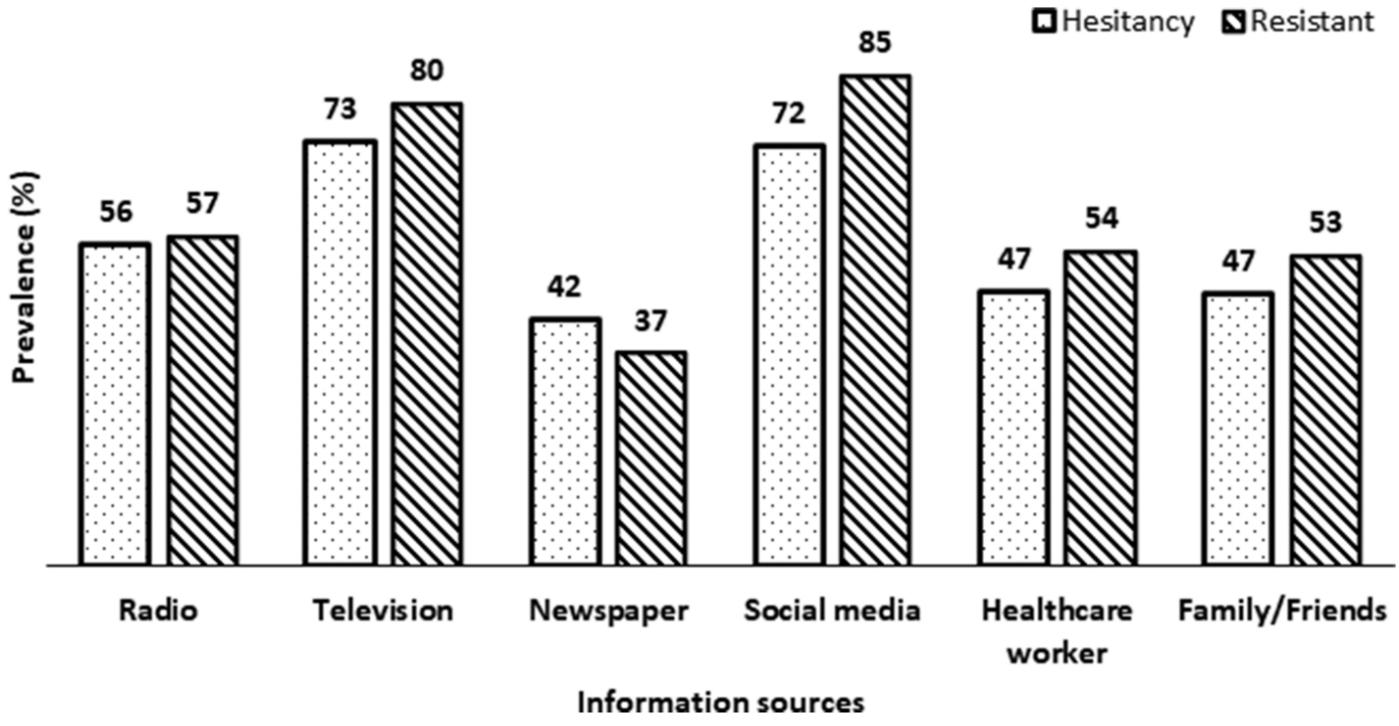

Figure 1. Prevalence of COVID -19 vaccination, hesitancy, resistance by information sources in sub-Saharan Africa, during the pandemic (n = 2572)

Table 1. Distribution (n, %) of the socio-demographic characteristics of the participants and their main sources of COVID-19 related information during the pandemic

Variables	All	Radio	TV	Newspaper	Facebook	HCW	Family/friends
n, %	**2572 (100)**	**1449 (56.3)**	**1897 (73.8)**	**1067 (41.5)**	**1879 (73.1)**	**1289 (50.1)**	**1215 (47.2)**
Demography							
Age category in years‡							
18-28	929 (36.1)	497 (54.0)	656 (70.6)	347 (37.4)	682 (73.4)	437 (47.0)	461 (49.6)
29-38	720 (28.0)	415 (57.6)	532 (73.9)	293 (40.7)	523 (72.6)	363 (50.4)	321 (44.6)
39-48	502 (19.5)	293 (58.4)	390 (77.7)	212 (42.2)	364 (72.5)	271 (54.0)	228 (45.4)
49+	346 (13.5)	201 (58.1)	271 (78.3)	177 (51.2)	265 (76.6)	178 (51.4)	164 (47.4)
Sex							
Males	1390 (54.0)	829 (59.6)	1047 (75.3)	629 (45.2)	1028 (74.0)	690 (49.6)	623 (44.8)
Females	1182 (46.0)	620 (52.4)	850 (71.9)	438 (37.1)	851 (72.0)	599 (50.7)	592 (50.1)
SSA region of origin‡							
West Africa	1446 (56.2)	800 (55.3)	1054 (72.9)	597 (41.3)	1077 (74.5)	755 (52.0)	668 (46.2)
East Africa	124 (4.8)	50 (40.3)	82 (66.1)	48 (38.7)	96 (77.4)	48 (38.7)	45 (36.3)
Central Africa	314 (12.2)	184 (58.6)	251 (79.9)	145 (46.2)	225 (71.7)	176 (56.1)	162 (51.6)
Southern Africa	667 (25.9)	409 (61.3)	500 (75.0)	269 (40.3)	472 (70.8)	303 (45.4)	332 (49.8)
Marital status							
Married	1132 (44.0)	648 (57.2)	866 (76.5)	472 (41.7)	821 (72.5)	590 (52.0)	505 (44.6)
Not married§	1440 (56.0)	801 (55.6)	1031 (71.6)	595 (41.3)	1058 (73.5)	699 (49.0)	710 (49.3)
Highest level of education							
Postgraduate degree	757 (29.4)	406 (53.6)	598 (79.0)	335 (44.3)	567 (74.9)	378 (49.9)	349 (46.1)
Bachelor's degree	1309 (50.9)	750 (57.3)	955 (73.0)	551 (42.1)	969 (74.0)	707 (54.0)	614 (46.9)
Secondary	448 (17.4)	262 (58.5)	312 (69.6)	158 (35.3)	314 (70.1)	181 (40.4)	234 (52.2)
Primary or less	58(2.3)	31 (53.5)	32 (55.2)	23 (39.7)	29 (50.0)	23 (39.7)	18 (31.0)
Employment status							
Employed/self employed	1890 (73.5)	1095 (57.9)	1428 (75.6)	827 (43.8)	1393 (73.7)	991 (52.4)	872 (46.1)
Unemployed/retired	682 (26.5)	354 (51.9)	469 (68.8)	240 (35.2)	486 (71.3)	298 (43.7)	343 (50.3)
Religion							
Christianity	2301 (89.5)	1,324 (57.5)	1,736 (75.4)	957 (41.6)	1,699 (73.8)	1170 (50.9)	1112 (48.0)
Others	271 (10.5)	125 (46.1)	161 (59.4)	110 (40.6)	180 (66.4)	119 (43.9)	103 (38.0)
Occupation							
Non-healthcare sector	1771 (68.9)	1017 (57.4)	1314 (74.2)	760 (42.9)	1301 (73.5)	801 (45.0)	908 (51.3)
Healthcare sector	801 (31.1)	432 (53.9)	583 (72.8)	307 (38.3)	578 (72.2)	488 (60.9)	307 (38.3)
Health indicators							
Smoking status							
Ex-smoker	160 (6.2)	82 (51.3)	108 (67.5)	66 (41.3)	118 (73.8)	70 (44.0)	63 (39.4)
Current smoker	177 (6.9)	114 (64.4)	132 (74.6)	65 (36.7)	133 (75.1)	75 (42.4)	102 (57.6)
Non-smoker	2235 (86.9)	1,253 (56.1)	1657 (74.1)	936 (41.9)	1,628 (72.8)	1144 (51.0)	1050 (47.0)
Any pre-existing condition							
No	1692 (65.8)	1184 (55.0)	1568 (72.9)	880 (40.9)	1555 (72.3)	1056 (49.0)	1008 (46.9)
Yes	880 (34.2)	265 (63.0)	329 (78 .2)	187 (44.4)	324 (77.0)	233 (55.0)	207 (49.2)
History of previous vaccination							
No	1692 (65.8)	910 (53.8)	1,229 (72.6)	661 (39.1)	1,237 (73.1)	803 (47.0)	793 (46.9)
Yes	880 (34.2)	539 (61.3)	668 (75.9)	406 (46.1)	642 (72.9)	486 (55.0)	422 (47.9)

HCW Healthcare workers
[a] Items have some missing responses
[b] Includes widowed, divorced and never married people. Postgraduate degree includes Masters /PhD

Socio-demographic, and health indicators associated with COVID-19-related information sources

The full set of findings from the multinomial logistic regression analyses for the characteristics of those that relied on the various sources of information during the pandemic, after adjusting for the potential cofounders, is presented in Table 2. In this study, reliance on the mainstream media for information during the pandemic was more likely to be observed among Central and Southern African participants, whereas social media was less likely to be used for COVID-19 information retrieval in those with primary education (aORs = 0.36, 95%CI = 0.20, 0.62) and non-Christians (aORs =0.74, 95%CI = 0.56, 0.97). Central African participants and those who worked in health sectors were more likely to rely on HCWs for COVID-19-related information as compared to West African participants and those who worked in non-healthcare sectors, during the pandemic. Compared with males, female participants were less likely to listen to the radio, watch TV and read the newspaper but more likely to rely on friends and family (aOR = 1.23, 95%CI = 1.05, 1.45), for COVID-19-related information, during the pandemic. Current smokers were also more likely to rely on friends and family (aOR = 1.97, 95%CI = 1.26, 3.10), while those with primary or no education as well as non-Christians were less likely to rely on social media for information, during the pandemic.

Associations between COVID-19 vaccine hesitancy, resistance, and sources of information used by participants in SSA during the pandemic

The aORs and their 95%CI for factors associated with vaccine hesitancy and vaccine resistance are presented in Table 3 and Table 4, respectively. After adjusting for the potential confounders, in this study, participants who listened to the radio, those who watched TV, and social media users, during the pandemic, were less likely to report COVID-19 vaccine hesitancy. As shown in Table 4, age (29-38 years), SSA region of origin (East Africa), educational level (primary education or less), religion and occupation of the participants were associated with resistance towards COVID-19 vaccination. Except for those who listened to the radio, reliance on other media sources for COVID-19–related information was significantly associated with vaccine resistance, with the strongest association found among social media users (aOR=2.13 95%CI=1.62, 2.80) Table 4. Also, those who watched TV and people who relied on HCWs and friends/family for COVID-19-related information were more likely to resist COVID-19 vaccination, whereas reading the newspaper reduced the likelihood of vaccine hesitancy (aOR =0.77, 95%CI 0.62, 0.95) among the participants.

Table 2. Adjusted odd ratios (AORs) of factors associated with information sources used by participants in sub-Saharan Africa during the pandemic

Variables	Radio	Television	Newspaper	Social media	HCW	Family/Friends
Demography	**AORs [95% CI]**	**AORs [95% CI]**	**AORs [95% CI]**	**AORs [95% CI]**	**AORs [95% CI]**	**AORs [95% CI]**
Sex						
Males	Reference	Reference	Reference			Reference
Females	0.72 [0.81, 0.84]	0.81 [0.68, 0.98]	0.73 [0.62, 0.86]	-	-	1.23 [1.05, 1.45]
SSA region of origin						
West Africa	Reference	Reference	Reference	Reference	Reference	Reference
East Africa	0.53 [0.37, 0.78]	0.74 [0.50, 1.10]	0.88 [0.60, 1.29]	1.18 [0.76, 1.83]	0.56 [0.38, 0.82]	0.66 [0.45, 0.97]
Central Africa	1.16 [0.90, 1.50]	1.69 [1.24, 2.29]	1.20 [0.93, 1.54]	0.92 [0.70, 1.22]	1.37 [1.07, 1.77]	1.12 [0.87, 1.44]
Southern Africa	1.49 [1.22, 1.81]	1.44 [1.14, 1.81]	1.11 [0.91, 1.36]	0.89 [0.72, 1.11]	0.89 [0.73, 1.08]	1.03 [0.84, 1.27]
Highest level of education						
Postgraduate degree		Reference	Reference	Reference	Reference	Reference
Bachelor's degree		0.71 [0.57, 0.88]	0.97 [0.81, 1.17]	0.95 [0.77, 1.17]	1.20 [1.00, 1.45]	1.01 [0.84, 1.21]
Secondary		0.53 [0.40, 0.70]	0.73 [0.55, 0.96]	0.82 [0.62, 1.08]	0.86 [0.67, 1.11]	0.96 [0.74, 1.24]
Primary or less		0.34 [0.19, 0.61]	0.96 [0.54, 1.69]	0.36 [0.20, 0.62]	0.83 [0.47, 1.46]	0.44 [0.25, 0.80]
Employment status						
Employed/self employed	Reference		Reference			
Unemployed/retired	0.72 [0.60,0.88]		0.72 [0.59, 0.89]			
Religion						
Christianity	Reference	Reference		Reference		
Others	0.57 [0.44, 0.74]	0.45 [0.34, 0.59]		0.74 [0.56, 0.97]		0.65 [0.50, 0.85]
Occupation						
Non-healthcare sector	Reference		Reference		Reference	Reference
Healthcare sector	0.82 [0.69,0.99]		0.71 [0.59, 0.86]		1.81 [1.51, 2.17]	0.58 [0.48, 0.69]
Smoking status						
Ex-smoker						Reference
Current smoker						1.97 [1.26, 3.10]
Non-smoker						1.35 [0.96, 1.89]

Confidence intervals (CI) that does not include 1.00 are significant variables
Postgraduate degree includes Masters /PhD
HCW Healthcare workers

Table 3. Adjusted odd ratios for factors associated with media sources and vaccine hesitancy among participants in sub-Saharan Africa during the pandemic

Variables	Total	Radio	TV	Newspaper	Social media	HCWs	Friends
Demography	AORs [95% CI]	AORs [95% CI]	AORs [95% CI]	AORs [95% CI]	AORs [95% CI]	AORs [95% CI]	AORs [95% CI]
Age category in years							
18-28	Reference	Reference	Reference	Reference	Reference	Reference	Reference
29-38	0.85 [0.66, 1.10]	0.86 [0.66, 1.11]	0.85 [0.66, 1.10]	0.85 [0.66, 1.10]	0.85 [0.66, 1.10]	0.84 [0.65, 1.09]	0.85 [0.66, 1.10]
39-48	0.88 [0.64, 1.19]	0.88 [0.65, 1.20]	0.88 [0.67, 1.99)	0.88 [0.64, 1.19]	0.87 [0.64, 1.19]	0.88 [0.65, 1.20]	0.88 [0.65, 1.20]
49+	0.86 [0.61, 1.20]	0.86 [0.61, 1.21]	0.86 [0.61, 1.21]	0.85 [0.60, 1.19]	0.86 [0.61, 1.21]	0.86 [0.61, 1.21]	0.86 [0.61, 1.21]
Sex							
Males	Reference	Reference	Reference	Reference	Reference	Reference	Reference
Females	0.83 [0.70, 0.99]	0.82 [0.69, 0.98]	0.83 [0.69, 0.99]	0.84 [0.70, 0.99]	0.83 [0.70, 0.99]	0.84 [0.70, 0.99]	0.84 [0.70, 1.00]
SSA Region of Origin							
West Africa	Reference	Reference	Reference	Reference	Reference	Reference	Reference
East Africa	1.10 [0.73, 1.64]	1.07 [0.71, 1.60]	1.08 [0.72, 1.62]	1.10 [0.73, 1.64]	1.10 [0.74, 1.65]	1.06 [0.71, 1.58]	1.08 [0.72, 1.62]
Central Africa	0.86 [0.66, 1.13]	0.87 [0.66, 1.13]	0.88 [0.67, 1.15]	0.86 [0.66, 1.12]	0.86 [0.66, 1.12]	0.88 [0.68, 1.16]	0.87 [0.66, 1.13]
Southern Africa	1.24 [0.98, 1.56]	1.26 [1.00, 1.59]	1.26 [1.00, 1.58]	1.23 [0.98, 1.55]	1.23 [0.97, 1.54]	1.23 [0.98, 1.55]	1.24 [0.98, 1.56]
Marital Status							
Married	Reference	Reference	Reference	Reference	Reference	Reference	Reference
Not married	0.73 [0.58, 0.90]	0.73 [0.58, 0.90]	0.73 [0.58, 0.90]	0.72 [0.58, 0.90]	0.73 [0.59, 0.91]	0.73 [0.58, 0.90]	0.73 [0.59, 0.91]
Highest level of education							
Postgraduate Degree	Reference	Reference	Reference	Reference	Reference	Reference	Reference
Bachelor's degree	0.89 [0.72, 1.10]	0.90 [0.73, 1.11]	0.88 [0.71, 1.09]	0.89 [0.72, 1.10]	0.89 [0.72, 1.09]	0.90 [0.73, 1.12]	0.89 [0.72, 1.10]
Secondary	0.84 [0.61, 1.16]	0.85 [0.62, 1.18]	0.83 [0.60, 1.14]	0.85 [0.61, 1.17]	0.83 [0.60, 1.44]	0.84 [0.61, 1.16]	0.84 [0.61, 1.16]
Primary or less	0.59 [0.32, 1.12]	0.61 [0.32, 1.14]	0.57 [0.30, 1.07]	0.59 [0.32, 1.12]	0.56 [0.30, 1.06]	0.58 [0.31, 1.10]	0.58 [0.31, 1.09]
Employment status							
Employed/self employed	Reference	Reference	Reference	Reference	Reference	Reference	Reference
Unemployed/retired	1.28 [1.00, 1.63]	1.26 [0.99, 1.61]	1.26 [0.99, 1.61]	1.28 [1.01, 1.64]	1.28 [1.00, 1.63]	1.27 [0.99, 1.61]	1.28 [1.00, 1.63]
Religion							
Christianity	Reference	Reference	Reference	Reference	Reference	Reference	Reference
Others	1.29 [0.96, 1.73]	1.26 [0.94, 1.69]	1.24 [0.93, 1.67]	1.29 [0.96, 1.73]	1.27 [0.95, 1.71]	1.28 [0.95, 1.71]	1.28 [0.95, 1.71]
Occupation							
Non-healthcare sector	Reference	Reference	Reference	Reference	Reference	Reference	Reference
Healthcare sector	0.59 [0.48, 0.72]	0.58 [0.48, 0.71]	0.58 [0.48, 0.71]	0.59 [0.48, 0.72]	0.58 [0.48, 0.71]	0.61 [0.50, 0.75]	0.58 [0.47, 0.71]
Smoking status							
Ex-smoker	Reference	Reference	Reference	Reference	Reference	Reference	Reference
Current smoker	0.88 [0.54, 1.42]	0.90 [0.55, 1.45]	0.90 [0.55, 1.45]	0.88 [0.54, 1.42]	0.89 [0.55, 1.43]	0.88 [0.54, 1.42]	0.90 [0.56, 1.45]
Non-smoker	1.04 [0.73, 1.50]	1.06 [0.74, 1.52]	1.07 [0.74, 1.53]	1.04 [0.72, 1.49]	1.04 [0.73, 1.50]	1.06 [0.74, 1.53]	1.05 [0.73, 1.52]
Any pre-existing condition							
No	Reference	Reference	Reference	Reference	Reference	Reference	Reference
Yes	0.81 [0.64, 1.03]	0.82 [0.65, 1.04]	0.82 [0.64, 1.04]	0.81 [0.64, 1.03]	0.82 [0.64, 1.04]	0.82 [0.65, 1.05]	0.81 [0.64, 1.03]
Previous vaccine as a child							
No	Reference	Reference	Reference	Reference	Reference	Reference	Reference
Yes	0.90 [0.75, 1.08]	0.91 [0.76, 1.09]	0.90 [0.75, 1.08]	0.84 [0.75, 1.07]	0.90 [0.75, 1.08]	0.91 [0.76, 1.10]	0.90 [0.75, 1.08]

Confdence intervals (CI) that does not include 1.00 are signifcant variables
Postgraduate degree includes Masters /PhD
HCW Healthcare workers

Table 4. Adjusted odd ratios for factors associated with media sources and vaccine resistance among participants in sub-Saharan Africa during the pandemic

Variables	Total	Radio	TV	Newspaper	Social media	HCWs	Friends
Demography	AORs [95% CI]	AORs [95% CI]	AORs [95% CI]	AORs [95% CI]	AORs [95% CI]	AORs [95% CI]	AORs [95% CI]
Age category in years							
18-28	Reference	Reference	Reference	Reference	Reference	Reference	Reference
29-38	1.58 [1.16, 2.15]	1.58 [1.16, 2.15]	1.58 [1.16, 2.15]	1.59 [1.17, 2.17]	1.60 [1.17, 2.19]	1.59 [1.17, 2.17]	1.58 [1.16, 2.15]
39-48	1.13 [0.78, 1.66]	1.13 [0.77, 1.66]	1.13 [0.77, 1.65]	1.15 [0.78, 1.68]	1.15 [0.78, 1.68]	1.13 [0.77, 1.65]	1.13 [0.77, 1.66]
49+	1.30 [0.86, 1.96]	1.30 [0.86, 1.96]	1.29 [0.85,1.95]	1.34 [0.89, 2.04]	1.29 [0.85, 1.95]	1.30 [0.86, 1.97]	1.29 [0.85, 1.96]
Sex							
Males	Reference	Reference	Reference	Reference	Reference	Reference	Reference
Females	1.11 [0.89, 1.37]	1.11 [0.90, 1.37]	1.12 [0.91, 1.39]	1.09 [0.88, 1.35]	1.12 [0.90, 1.38]	1.10 [0.89, 1.37]	1.09 [0.88, 1.35]
SSA Region of Origin							
West Africa	Reference	Reference	Reference	Reference	Reference	Reference	Reference
East Africa	1.65 [1.07, 2.53]	1.65 [1.07, 2.54]	1.69 [1.10, 2.59]	1.64 [1.07, 2.53]	1.63 [1.06, 2.51]	1.71 [1.11, 2.63]	1.70 [1.10, 2.61]
Central Africa	0.73 [0.52, 1.04]	0.73 [0.52, 1.04]	0.72 [0.51, 1.02]	0.74 [0.52, 1.05]	0.75 [0.53, 1.07]	0.72 [0.51, 1.02]	0.73 [0.51, 1.03]
Southern Africa	1.02 [0.77, 1.33]	1.01 [0.77, 1.33]	0.99 [0.75, 1.31]	1.03 [0.78, 1.35]	1.05 [0.79, 1.38]	1.02 [0.78, 1.32]	1.01 [0.77, 1.33]
Marital Status							
Married	Reference	Reference	Reference	Reference	Reference	Reference	Reference
Not married	1.20 [0.92, 1.55]	1.19 [0.92, 1.55]	1.20 [0.92, 1.56]	1.22 [0.94, 1.59]	1.17 [0.90, 1.52]	1.19 [0.91, 1.55]	1.19 [0.91, 155]
Highest level of education							
Postgraduate Degree	Reference	Reference	Reference	Reference	Reference	Reference	Reference
Bachelor's degree	0.86 [0.67, 1.11]	0.86 [0.67, 1.11]	0.88 [0.68, 1.13]	0.86 [0.67, 1.11]	0.87 [0.68, 1.13]	0.85 [0.66, 1.10]	0.87 [0.67, 1.11]
Secondary	0.86 [0.58, 1.26]	0.86 [0.58, 1.26]	0.88 [0.60, 1.30]	0.84 [0.58, 1.24]	0.89 [0.61, 1.32]	0.86 [0.59, 1.26]	0.86 [0.58, 1.26]
Primary or less	0.27 [0.08, 0.91]	0.27 [0.08, 0.91]	0.29 [0.09, 0.98]	0.27 [0.08, 0.91]	0.30 [0.09, 1.02]	0.28 [0.08, 0.92]	0.28 [0.09, 0.95]
Employment status							
Employed/self employed	Reference	Reference	Reference	Reference	Reference	Reference	Reference
Unemployed/retired	0.84 [0.63, 1.13]	0.84 [0.63, 1.13]	0.85 [0.64, 1.14]	0.83 [0.62, 1.11]	0.85 [0.63, 1.14]	0.85 [0.63, 1.14]	0.84 [0.63, 1.13]
Religion							
Christianity	Reference	Reference	Reference	Reference	Reference	Reference	Reference
Others	0.57 [0.38, 0.84]	0.57 [0.38, 0.84]	0.60 [0.40, 0.89]	0.56 [0.38, 0.84]	0.60 [0.40, 0.88]	0.58 [0.39, 0.85]	0.59 [0.40, 0.87]
Occupation							
Non-healthcare sector	Reference	Reference	Reference	Reference	Reference	Reference	Reference
Healthcare sector	0.64 [0.50, 0.82]	0.64 [0.50, 0.82]	0.65 [0.51, 0.83]	0.63 [0.49, 0.81]	0.65 [0.51, 0.83]	0.62 [0.48, 0.79]	0.66 [0.52, 0.85]
Smoking status							
Ex-smoker	Reference	Reference	Reference	Reference	Reference	Reference	Reference
Current smoker	1.65 [0.92, 2.96]	1.65 [0.92, 2.96]	1.61 [0.90, 2.90]	1.64 [0.91, 2.94]	1.62 [0.90, 2.91]	1.65 [0.92, 2.96]	1.58 [0.88, 2.83]
Non smoker	1.29 [0.81, 2.05]	1.29 [0.81, 2.04]	1.25 [0.79, 1.99]	1.31 [0.82, 2.07]	1.30 [0.82, 2.06]	1.27 [0.80, 2.01]	1.26 [0.79, 2.00]
Any pre-existing condition							
No	Reference	Reference	Reference	Reference	Reference	Reference	Reference
Yes	0.97 [0.72, 1.30]	0.97 [0.72, 1.30]	0.95 [0.71, 1.28]	0.97 [0.72, 1.31]	0.93 [0.69, 1.26]	0.95 [0.71, 1.28]	0.96 [0.71, 1.29]
Previous vaccine as a child							
No	Reference	Reference	Reference	Reference	Reference	Reference	Reference
Yes	0.82 [0.66, 1.03]	0.82 [0.66, 1.03]	0.82 [0.65, 1.02]	0.84 [0.67, 1.05]	0.82 [0.65, 1.03]	0.81 [0.64, 1.01]	0.82 [0.65, 1.03]

Confidence intervals (CI) that does not include 1.00 are significant variables
Postgraduate degree includes Masters /PhD
HCW Healthcare workers

The forest plots showing the adjusted odd ratios for the association between the media sources used by the participants in SSA countries during the pandemic and vaccine hesitancy and resistance are shown in Figures 2 and 3, respectively. Figure 2 shows that COVID-19 vaccine hesitancy was significantly associated with four of the six media sources examined in this study. Reliance on HCWs, social media and traditional sources (TV and radio) for COVID-19-related information during the pandemic reduced the odds of COVID-19 vaccine hesitancy by 27%, 21%, 20% and 17%, respectively.

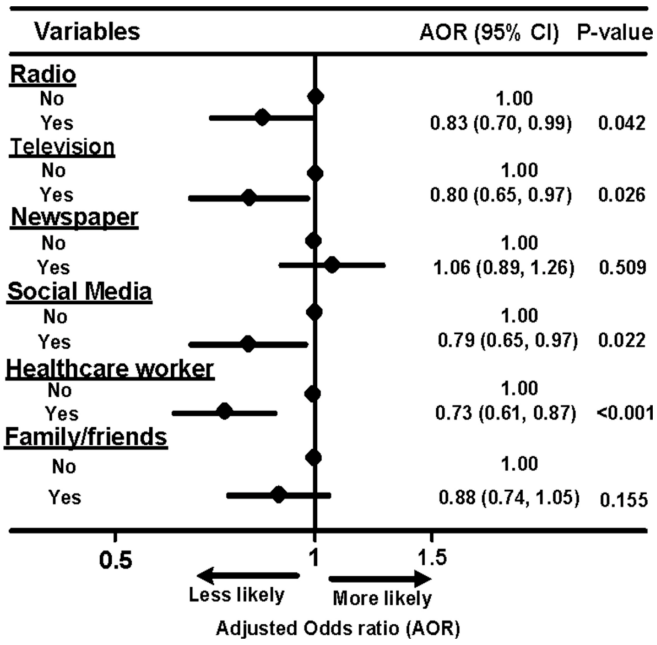

Figure 2. *Forest plot of association between main information sources and vaccine hesitancy and resistance among the participants in sub-Saharan Africa, during the pandemic*

There was a strong association between the use of social media and resistance towards COVID-19 vaccination (aOR=2.13, 95%CI 1.62, 2.80) as seen in Figure 3. Other factors such as watching TV and reliance on friends/families for information related to COVID-19 were also associated with COVID-19 vaccine resistance among the participants. Those who relied on the newspapers for information during the pandemic were less likely to be resistant towards taking the COVID-19 vaccines compared to those who did not (Figure 3).

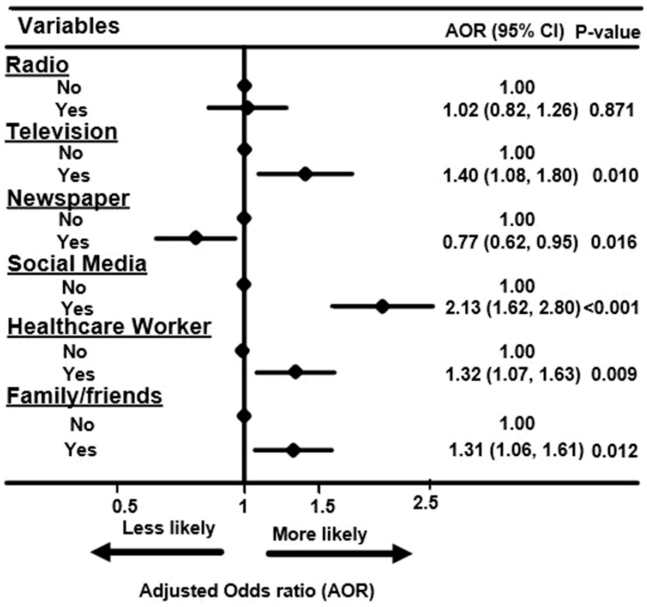

Figure 3. *Forest plot of association between main information sources and vaccine resistance among the participants in sub-Saharan Africa, during the pandemic*

Discussion

This study was undertaken to determine the role of different information sources on COVID-19 vaccine hesitancy and resistance in SSA. Consistent across age groups, gender and regions, television and Facebook, were the main sources of up-to-date information for participants in SSA during the pandemic. However, information from these sources, particularly those obtained from social media platforms, can be misleading, and as shown in the present study, social media users were twice more likely to resist the COVID-19 vaccines compared with non-users. Those who relied on the TV, HCWs, friends, and family members for their up-to-date information had a higher likelihood of vaccine resistance than their counterparts. In contrast, the odds for vaccine resistance were significantly reduced among those who reported that the newspaper was their main source of information during the pandemic.

Although the finding of a strong independent association between social media use and vaccine resistance was contrary to previous studies on smaller samples in Saudi Arabia [52, 53], this is important considering the wide utilisation of Facebook as the main source of information by many participants during the pandemic. A Facebook IQ survey revealed that more than 95 million people in SSAs access Facebook, with 97% of these doing so on handheld and mobile devices each month. Therefore, these popular sources of information (Television and Facebook) must be used to convey reliable, science-based information about COVID-19 vaccines and future pandemics to the millions of SSA people.

Smokers and females were more likely to rely on family and friends for COVID-19-related information, but less likely to rely on mainstream media (such as TV) than their male counterparts. There was a lower likelihood for non-Christians and those with lower education to rely on social media for information during the lockdown. Of the information sources, reliance on social media showed the strongest association with COVID vaccine hesitancy and resistance. After adjusting for potential covariates, information sources played a significant role in vaccine hesitancy and resistance among SSAs. Those who relied on information obtained from watching TV and family/friends were more likely to resist the COVID vaccine when compared to those who did not rely on those media sources. Listening to the radio and obtaining information from HCWs had a positive influence on intent towards vaccination because it reduced their likelihood of being resistant and hesitant towards COVID-19 vaccination. The negative influence of TV and social media use on COVID-19 vaccination reported in this study was not surprising as some emerging anti-vaccine television and social media campaigns are responsible for generating and perpetuating vaccine hesitancy and resistance. The high prevalence of inaccurate and negative information on social media regarding COVID-19 may predict a greater likelihood of negative vaccine intent in this case as well [54, 55]. In addition, social media is generally unregulated and has enabled people with anti-vaccine beliefs to generate and disseminate information freely [56]. The findings of this study are consistent with a previous study which found that, relative to social media and the internet, there was a positive association between reliance on traditional news sources and intention to uptake a COVID-19 vaccine in the United States [57]. Another previous work also highlighted the role of negative information on social media in shaping individual perceptions regarding human

papillomavirus (HPV) vaccination intent [58].

Central and Southern African participants showed greater reliance on mainstream media for COVID-19-related information, particularly watching TV, and this increased their likelihood of not taking the vaccine. This finding could, in part, be related to the nature of lockdowns in different sub-Saharan countries. For instance, South Africa went into Level 5 (hard lockdown) quite early in the pandemic (March 2020), and residents were mostly confined to their homes, watching TV [59]. Reliance on social media platforms for COVID-19-related information was associated with higher educational levels, which agreed with a study from South Africa [59] which found that education-related inequalities were visible in the use of COVID-19 preventive measures in South Africa.

The finding that the participants with pre-existing medical conditions or those who had a prior history of vaccinations were more reliant on HCWs for COVID-19-related information during the pandemic suggests that HCWs are trusted to have a better understanding of COVID-19 information, and as such, they can be a source of essential care and information in future pandemics. In a previous study, participants rated health information from doctors and other health workers as highly reliable [60]. This assertion is supported by a recent study that showed that HCWs are essential front liners, working to ensure the health of older adults and those with chronic conditions or disabilities during the COVID-19 pandemic[61]. The high vaccination and low hesitancy rates reported among participants who relied on HCWs for information were consistent with a previous study, which showed that HCWs have adequate information on vaccines and have the ability and confidence to communicate such information effectively [62]. This finding supports the idea that HCWs, can positively influence the use of vaccines and have the potential to impact COVID-19 vaccination in SSA. However, recent literature has also warned of the inadequate capacity of HCWs to deal with anti-vaccine messages on social media [63].

One interesting finding of this paper is the resistant effect of information derived from HCW reported by participants. Studies among Africans have shown that HCWs themselves are resistant to the vaccine with their information being obtained from unreliable sources such as social media, friends and family[64, 65]. Safety concerns, insufficient or inaccurate information, lack of trust in the government's capacity to manage, and personal beliefs are factors that have been reported to influence the acceptance or resistance of HCWs to the vaccine[66-68]. The likelihood of such health workers passing on information to the populace with content that may be tainted with their own beliefs and inaccuracies can contribute to making those who interact with them resistant to the vaccine.

Females were less likely to listen to the radio, watch TV and read newspapers but more likely to rely on friends and family, and this increased their likelihood of vaccine hesitancy. This finding may suggest that women expressed interest in COVID-19 issues with their friends and family (leaving very little room for individual proactive decision- making) while men were significantly more likely than women to get such information from the radio, TV and newspapers. The study also showed differences in behaviour, such that the less educated, non-Christians were not more reliant on social media platforms for information during the pandemic than their counterparts. For those who were more likely to be resistant (such as those who watched TV and those who relied on their

families and friends for information), additional vaccine promotional efforts would be required.

Limitations and strengths

Some limitations should be considered when interpreting the findings of this study. First, this was a cross-sectional study, and as such, we cannot determine causation. Second, like previous studies conducted during COVID-19 in SSA[34, 48, 69, 70], we utilized an internet-based methodology which was the only reliable means to disseminate information at the time of this study. The survey was distributed electronically using social media platforms and emails because it was difficult to physically access some participants in some places due to the protective measures still in place at the time of the study. This method of soliciting participants may have inadvertently excluded some potential participants whose opinions differed, such as those without internet access and people living in rural areas, where internet penetration remains relatively low[71]. Third, the survey was presented in English and French and thus inadvertently excluding non-English and non-French speaking countries in SSA from participating. Fourth, although the study showed satisfactory internal validity, its generalization or transferability to all SSA countries may be limited. Notwithstanding these limitations, this was the first study from the SSA region to provide insight into some of the impacts of information sources on the acceptance of COVID-19 vaccines which has been a worry to the international community. Although this topic is commonplace as reliance on online information sources is expected to happen during pandemics, no study has demonstrated the impacts of these sources of information on COVID vaccination in the way the present study did, including the use of a robust analysis to control for potential confounders during the analysis and reduce the possibility of a bias. This makes our study a unique one since it provided the first documented evidence from SSA showing the impacts of the lockdown on the behaviour of ordinary citizens.

Implications of our findings

This study provides an understanding of how the exposure of SSAs to various media sources during the pandemic, influences their attitude toward the COVID-19 vaccination program. Our focus on COVID-19 vaccine hesitancy and resistance is important because of the need to stem the pandemic by vaccinating enough people in the face of the recent rise in infections[11]. The findings are important because people's negative attitudes toward vaccination in general, and their hesitancy or resistance to the COVID-19 vaccine, is a growing public health problem. This study provides insight into how the various media outlets commonly used by the participants living in different SSAs regions to obtain COVID-19-related information affect their attitude towards vaccine uptake. This finding underlines the importance of media exposure, suggesting that the media can be used to improve vaccine literacy across the region[72]. In addition, this study contributes to our understanding of the interplay between SSA regions and media exposure during the pandemic. For example, the study found greater reliance on the mainstream media for COVID-19-related information among those from Central and Southern Africa, which negatively influenced vaccine uptake. This insight has important practical implications by informing us about the dynamics of individuals' attitudes and would help researchers understand the underlying factors that influence the acceptance of

vaccination during a pandemic. This study will help public health and health promotion officers in various SSA countries design more effective communications and interventions.

Furthermore, the very low vaccination rate observed in this study raises the concern of vaccine nationalism with challenges of vaccine inequity in low and middle-income countries which was shown to be counterproductive during the pandemic[5, 12, 73]. High-income countries prioritized investment in the stock of vaccinations over immediate capacity building and delivery of such life-saving vaccines by healthcare systems. These lessons are important in tackling future pandemics. Although vaccinations are the only effective means of tackling viral diseases, prior studies have demonstrated that many people do not believe in their safety and effectiveness[14]. There is also the possibility that previously eradicated infections may re-emerge in some regions. People need to be educated about vaccines, their safety and their efficacy. The media can be used to boost people's confidence in taking the vaccine [14, 74, 75].

Conclusions

The findings of this study suggest that healthcare organizations and governments of SSA fight misinformation by providing factual messages countries need to utilise social media platforms, television, and healthcare workers to provide reliable information to influence vaccine hesitancy and encourage uptake of the COVID-19 vaccination. Failure to access and apply reliable healthcare information, whether for the public or health workers, has always been a major cause of avoidable deaths. More research and investment are needed to improve the availability of reliable healthcare information, protect people from misinformation, and empower people with education on how to identify misinformation. The ongoing trajectory of misinformation – from vaccine hesitancy to previous infectious diseases to COVID-19 – calls for global action as the 'infodemic' of the next public health emergency may be worse than the current COVID infodemic.

List of abbreviations

COVID-19: Coronavirus disease

SSA: sub–Saharan Africa

OR: Odds ratio

AOR: Adjusted odds ratio

CI: Confidence interval

TV: Television

HCW: Healthcare worker

WHO: World Health Organization

Declarations

Ethics approval and consent to participate

The study was conducted following the Declaration of Helsinki involving human subjects and was approved by the Humanities and Social Sciences Research Ethics Committee (approval #: HSSREC 00002504/2021) of the University of KwaZulu-Natal, Durban, South Africa. Informed consent was obtained from all participants involved in the study.

Consent for publication

Not applicable

Availability of data and materials

The dataset supporting the conclusions of this article is included within the article (and its additional files). Data is also **available on request from the corresponding author OUL.**

Competing interests

The authors declare that they have no competing interests

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Authors' contributions

All authors were involved in the conceptualization of the study; K.E.A, U.L.O., and K.P.M performed the methodology; Software, K.E.A., ULO; Validation, T.I., R.O., E.E., B.N.E., O.A., K.P.M., E.K.A., M.C. and T.C.; Formal Analysis, K.E.A., and U.L.O.; Investigation, all authors; Resources, all authors; Data Curation, K.E.A., O.M.A, and U.L.O.; Writing – Original Draft Preparation, P.C.G., G.O., R.O.; E.E., U.L.O., E.A.; Writing – Review & Editing, K.P.M., G.O., O.A., E.A., K.E.A., K.P.M., R.L., D.D.C., and M.C.; Visualization,
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16. Acceptance and Risk Perception of COVID-19 Vaccination among Pregnant and Non pregnant Women in Sub–Saharan Africa: A Cross–Sectional Matched–Sample Study

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Abstract: This study aims to evaluate the acceptance and risk perception of pregnant and non pregnant women towards COVID-19 vaccines using a cross-sectional matched-sample study approach. A web-based questionnaire with closed– and open- ended questions was administered to adults older than 18 years in the sub–Saharan African (SSA) region. Respondents (n = 131) were grouped based on their pregnancy status (54 pregnant and 77 non pregnant women) and matched for comparison by age. The matched groups were compared using the chi-square test and the t-test where appropriate. Compared to non pregnant women, pregnant women reported significantly lower risk perception scores of COVID-19 infection (3.74 vs. 5.78, $p < 0.001$) and were less likely to take the COVID-19 vaccine (odds ratio = 0.12, 95% confidence interval (CI) 0.06–0.27, $p < 0.001$). A similar proportion of pregnant and non pregnant women believed in false information about the COVID-19 vaccine, and 40% of unvaccinated pregnant women (n = 40) were concerned about the safety of the vaccine. After adjustment, women's education, marital status, belief in misconceptions and risk perception were associated with non-vaccination among pregnant women. The content analysis revealed that pregnant women refused the vaccine due to mistrust of their countries' health systems, concerns about the country where the vaccines were manufactured and a lack of confidence in the production process of the vaccines. This study shows the poor acceptance of COVID-19 vaccines among pregnant women in SSA, who perceived a lower risk of COVID-19 infection. Understanding the reasons for non-acceptance and the motivation to accept the COVID-19 vaccine could guide the development of health education and promotion programmes, and aid governments and policymakers in implementing targeted policy changes.

Keywords: pregnancy; COVID-19 vaccines; acceptance; risk perception; sub–Saharan Africa; misconception

1. Introduction

To reduce the continuous spread of COVID-19, which puts everyone at risk of severe complications and mortality, a large proportion of the population, including pregnant women and children, should be vaccinated [1]. Compared to the general population, pregnant women are at a higher risk of contracting COVID-19, and their overall risk of severe illness from the infection and adverse pregnancy outcomes is greater [1–3]. Pregnant women who contract the virus have a higher risk of needing hospitalisation and intensive care [4]. This is partly because pregnancy suppresses the immune response [5] and the growing baby compresses the lungs, causing women to take in less air with each breath [6]. Contracting COVID-19 during pregnancy has also been associated with an increased risk of preterm birth and hospitalisation for the baby [7]. Considering these elevated risks, preventing serious COVID-19 infection is important [8], and various health organisations, including the US Centers for Disease Control and Prevention (CDC), recommend that pregnant women be vaccinated against coronavirus with the assurance of their safety and that of the baby during pregnancy [9–11].

Despite the reassurance that vaccination during pregnancy is not associated with any additional pregnancy, birth or new-born complications [12–14], many pregnant women are unwilling to be vaccinated due to concerns about the side effects on pregnancy outcomes. These concerns are a result of a lack of data about the safety of the vaccines for the baby and the mother during

pregnancy [15–18]. The results obtained from a qualitative interview of 31 pregnant women across the UK [18] suggested that most participants perceived receiving the vaccine as more dangerous than being infected with COVID-19. Furthermore, the results obtained from a recent review of COVID-19 uptake among pregnant women [19] have revealed that, among over 7000 pregnant women, only 27.5% have been vaccinated against the virus. From their review, the reasons for refusing the vaccines were attributed to a lack of confidence in the government, a confirmed diagnosis during pregnancy and concerns about the vaccines' side effects and safety. On the other hand, the factors that have been found to improve COVID-19 vaccine acceptability included the woman's age, race and ethnicity, the fear of being infected with the virus during pregnancy and the trust that the vaccines would prevent them from being infected [19]. However, in the SSA region, one study conducted among pregnant women in northern Nigeria [20] found that primigravid women who are Christian, have a primary level of education, have a higher monthly income, have an earlier gestational age, have received tetanus toxoid in the current pregnancy and have self-assessed their health status as good or better are more likely to accept the COVID-19 vaccine.

Providing adequate information has been suggested as one method of improving COVID-19 vaccine uptake among women [16,21–24], especially if more safety data on pregnancy become available [25]. Nonetheless, the acceptance rate of COVID-19 vaccines among pregnant women and mothers of young children has been found to differ between geographic locations, with the lowest rates reported for Russia, the USA and Australia. As a result, country-specific vaccination campaigns have been recommended for greater impact [22].

There is a paucity of information on the perception of pregnant women about COVID-19 vaccination programmes, particularly among low-income countries and, especially, those in the sub-Saharan African (SSA) region. Considering the low uptake of COVID-19 vaccines among pregnant women, previous findings from a review study suggested different strategies to increase vaccination among pregnant individuals, including promoting evidence-based information on vaccine safety among pregnant women [26]. Therefore, the present study was designed to evaluate the acceptance and risk perception of pregnant and non pregnant women towards COVID-19 vaccines using a cross-sectional matched-sample study approach. The findings of this study may be important to enhance the uptake of already-available vaccine programmes and guide the dissemination of newly developed vaccines.

2. Materials and Methods

2.2 Study Design

Existing data from a web-based cross-sectional study carried out between March and May 2021 were analysed for this study. The initial study, designed to evaluate the acceptance of COVID-19 vaccines in SSA, used a convenient sampling method. An e-link to a validated self-administered questionnaire was distributed through e- mails and posted on social media platforms such as Facebook and WhatsApp, inviting participants from all SSA countries, aged 18 and older, to participate. This questionnaire was designed in English and translated into a French version by scholars at the linguistic department of the University of Bamenda, Cameroon, for wider coverage of Anglophone and Francophone SSA countries.

Initially, 2572 participants (male: 1390 (54.0%); female: 1182 (46.0%)) took part in the study, including pregnant and non pregnant women. For this study, a sample size calculation was conducted. We determined that at least 50 pregnant and 50 non pregnant women were required to detect any statistical differences. In consideration of that, the study had a power of 80% to detect statistical differences, assuming a 10% attrition rate. Subsequently, 54 pregnant women were matched for comparison by age with 77 non pregnant women. Their responses were analysed as illustrated in Figure 1. The distribution of the women by their countries of origin is shown in Figure 2, which indicates that the majority were from Nigeria (32.8%), followed by South Africa (28.2%).

2.2. Ethics

Ethical approval was obtained from the Humanities and Social Sciences Research Ethics Committee of the University of KwaZulu-Natal, Durban, South Africa (reference number: HSSREC 00002504/2021). The study adhered to the principles of the 1967 Helsinki Declaration for research involving human participants. An anonymous, voluntary, informed consent was sought from each participant before administering the questionnaire, and participants were instructed to fill out the questionnaire only once. In addition, we ensured single participation from each respondent by utilising IP addresses during analysis.

2.3. Data Collection

The questionnaire included quantitative and qualitative sections. There were questions to ascertain the respondents' socio-demographic variables (age group, sex, country of origin, religion, marital status, educational level, employment status, occupational status), knowledge of COVID-19 vaccination and their COVID-19 vaccination status. The questions asked were to determine if participants believed in the efficacy of the vaccines to prevent COVID-19 and its complications and if they had been tested or ever tested positive for COVID-19. The respondents were also asked to indicate if they 'Agree' or 'Disagree' with the following common misconceptions about COVID-19 vaccines: "COVID-19 vaccines cause infertility in women", "COVID-19 vaccine is a means to digitally implant microchips" and "COVID-19 vaccines alter DNA". Other questions included their perception of the risk of becoming infected with COVID-19, the risk of dying from the infection and whether they thought the recommendations for vaccination by the health authorities in their countries were appropriate, with responses on a Likert scale from 0 to 4. The total risk perception score ranged from 0 to 12.

The vaccination status of the participants (vaccinated and non-vaccinated) was derived from two questions. The vaccinated group responded with an affirmative 'Yes' to the question, "Have you been vaccinated against COVID-19?". The second question was a follow-up to determine the participants' willingness to get vaccinated when it becomes available in their countries. This question was necessary considering that some SSA countries might not have commenced vaccine distribution to all residents at the time of this study. The responses 'No' and 'Not sure' to this follow-up question were merged and used to derive the estimate for the non-vaccinated group.

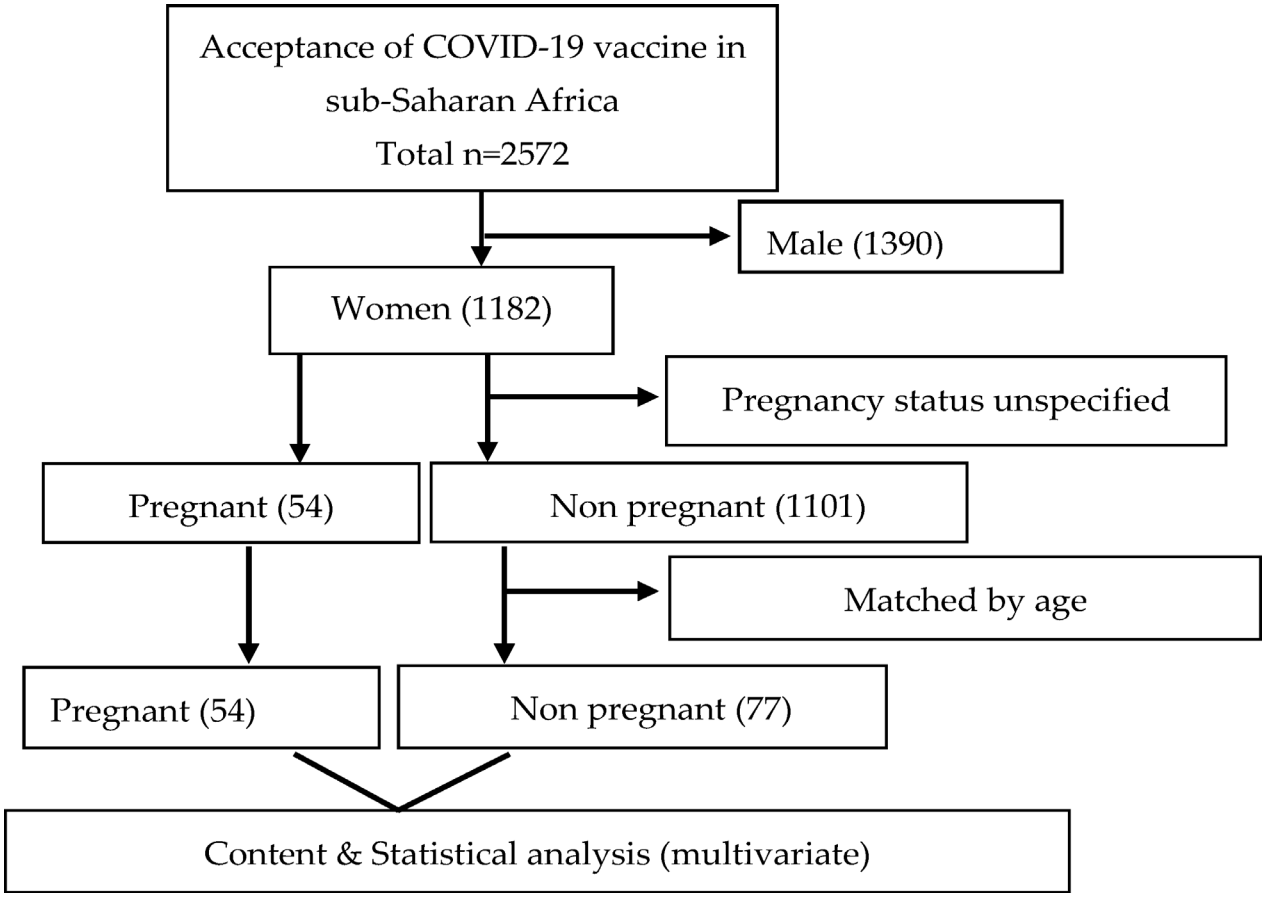

Figure 1. *Flowchart of pregnant and non pregnant women in sub-Saharan Africa.*

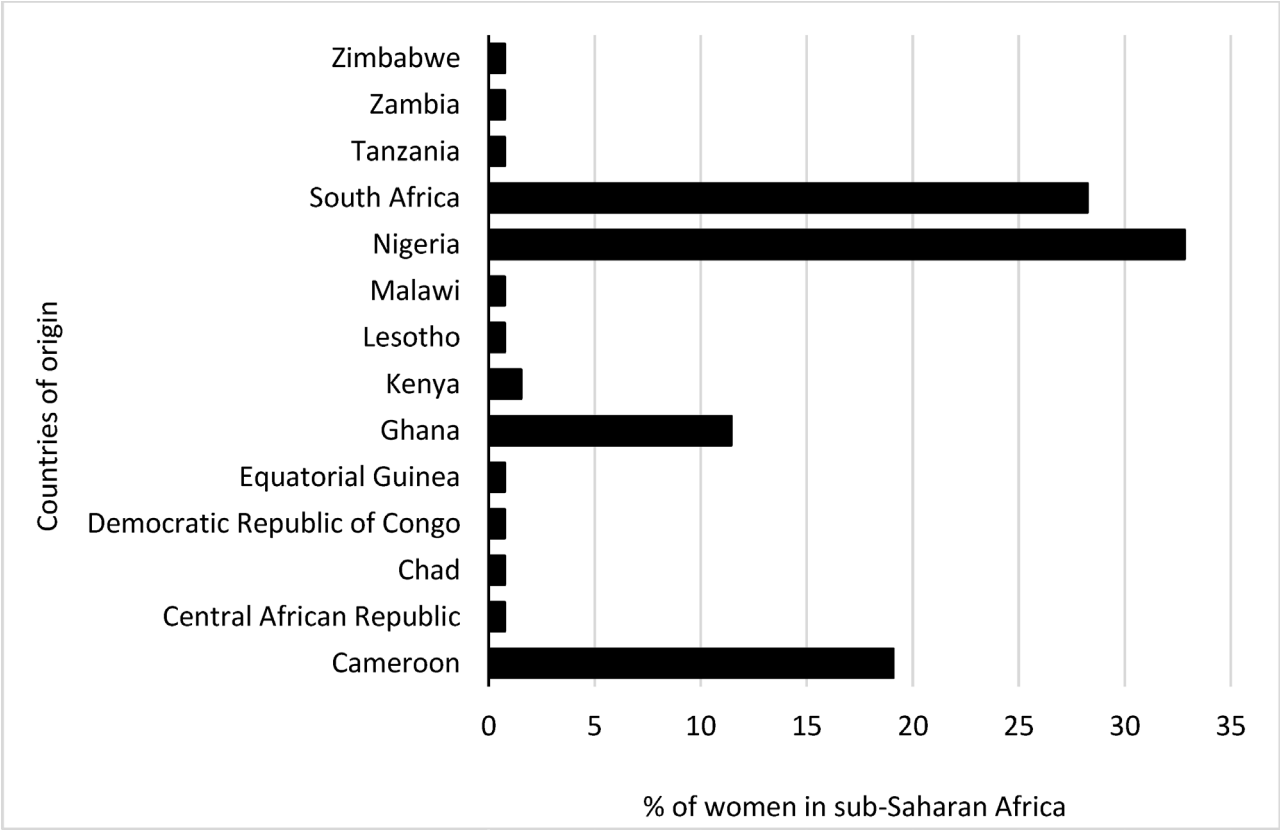

Figure 2. *The proportion of women in sub-Saharan Africa by country of origin.*

2.4. Content Analysis

Two follow-up questions were posed to the non-vaccinated participants, and their responses to these questions were analysed qualitatively. The first question was, "Which of the following factors contributed to your decision not to accept a COVID-19 vaccine?". For this question, there were ten options, including (1) advice from religious leaders, (2) advice from politicians, (3) mistrust for the pharmaceutical company, (4) mistrust of the health system in my country, (5) mistrust in the medical process for developing the vaccine, (6) mistrust for the country where the vaccine was produced, (7) personal beliefs or past historical experiences with vaccines, (8) concern about the safety of the COVID-19 vaccine, (9) not enough information from healthcare providers and (10) information from the media.

The second question was, "What can be done to encourage you to take the vaccine?". For this question, there were eight response options, which included: "I am more likely to accept the COVID-19 vaccine (1) if financial incentives are given to everybody; (2) if monetary rewards are given to healthcare providers involved in the vaccination; (3) if it is given for free; (4) if there is adequate information regarding the specific vaccine; (5) if I can get more education on the vaccines, their side effects, and how effective they are; (6) if it is a travel condition; (7) if it is an employment condition; (8) if many people start receiving the vaccine; (9) if I get positive feedback from those who have been vaccinated". The open-ended responses were grouped into major codes and analysed. The significant recurrent and salient points were reported using quotations.

2.5. Statistical Analysis

Statistical analysis was conducted using IBM SPSS Statistics for Windows, version 27 (IBM Corp., Armonk, NY, USA). The frequency and percentage of categorical variables were reported. The proportions of vaccinated women who were pregnant, not pregnant and uncertain about vaccination were determined. The association between hesitancy towards the COVID-19 vaccine and the demographic variables was determined using the t-test, the chi-square test and Fisher's exact test, where applicable. Logistic regression analysis was used to determine the factors associated with COVID-19 vaccination among women in SSA after adjusting for potential confounders. The results were presented as adjusted odds ratios and their 95% confidence intervals. A p-value less than 0.05 was considered statistically significant.

3. Results

3.1. Comparison of Sociodemographic and COVID-19 Test Factors between Pregnant and Non pregnant Women

The demographic characteristics of the women based on their pregnancy status are shown in Table 1. The majority of the pregnant women were young (18–34 years, 60%), from West Africa, married and had a tertiary education. In contrast, the non pregnant women were spread across three SSA regions, evenly split between two age groups, with the majority being unmarried (83%) and about 48% having a tertiary education. Among the cases and controls, there were predominantly more working women in non-healthcare professions.

Table 1 . Socio-demographic and COVID-19 testing among pregnant and non pregnant women.

Variable	Pregnant Women (n = 54, 41.2%)	Non Pregnant Women (n = 77, 58.8%)	*p*-Value
Demography			
Region of origin			
West Africa	30 (56.6)	28 (36.36)	0.037
East Africa	4 (7.55)	2 (2.60)	
Central Africa	8 (15.09)	20 (25.97)	
Southern Africa	11 (20.75)	27 (35.06)	
Age			
18–34 years	32 (60.38)	35 (50)	0.252
35 and older	21 (39.62)	35 (50)	
Marital status			
Unmarried	15 (27.78)	64 (83.12)	<0.001
Married	39 (72.22)	13 (16.88)	
Education			
Tertiary	50 (92.59)	37 (48.05)	<0.001
Secondary	4 (7.41)	40 (51.95)	
Employment status			
Unemployed	14 (25.93)	28 (36.36)	0.208
Employed	40 (74.07)	49 (63.64)	
Occupation			
Non-healthcare worker	36 (66.67)	59 (76.62)	0.209
Healthcare worker	18 (33.33)	18 (23.38)	
Place of residence	*n = 53*		
Africa	52 (98.11)	73 (94.81)	0.335
Diaspora	1 (1.89)	4 (5.19)	
COVID-19 test factors			
COVID-19 vaccine can prevent COVID-19 infection and its complications			
Disagree	11 (20.37)	26 (33.77)	0.492
Agree	43 (79.63)	51 (66.23)	
Have you ever been tested for coronavirus disease (COVID-19)?			
No	35 (64.81)	59 (76.62)	0.139
Yes	19 (35.19)	18 (23.38)	
Have you ever tested positive for coronavirus disease (COVID-19)?			
No	48 (88.89)	72 (93.51)	0.348
Yes	6 (11.11)	5 (6.49)	
Common misconceptions about the COVID-19 vaccine			
COVID-19 vaccines cause infertility in women			
Disagree	29 (53.70)	46 (59.74)	0.492
Agree	25 (46.30)	31 (40.26)	
COVID-19 vaccine is a means to digitally implant a microchip			
Disagree	31 (57.41)	53 (68.83)	0.094
Agree	23 (42.59)	24 (31.17)	
COVID-19 vaccines alter DNA			
Disagree	11 (20.37)	26 (33.77)	0.18
Agree	43 (79.63)	59 (66.23)	
Perception of risk of COVID-19 infection			
Mean (SD)	3.74 (2.26)	5.78 (2.89)	< 0.001

Tertiary = Diploma, university or postgraduate degree; unmarried = widowed, divorced, separated or single.

Even though more women agreed that COVID-19 vaccines could prevent COVID-19 infection and its complications, most of them (65% pregnant and 77% non pregnant) non pregnant had not been tested for COVID-19 infection (Table 1). The results, which are shown in Table 2, revealed that, compared to non pregnant women (23%), a higher proportion of pregnant women (35%) had taken a COVID-19 test at the time of this study, and twice as many pregnant women as non pregnant women had tested positive for the virus (11% vs. 6%). The mean risk perception score determined from the three items in the survey was 3.74 (SD = 2.26) for pregnant women and 5.78 (SD = 2.89) for non pregnant women.

3.2. Factors Associated with Non-Vaccination against COVID-19

Table 2 presents the significant variables in the logistic regression. Participants who completed tertiary education, were married, and had the belief that the COVID-19 vaccine is a means to implant digital microchips in one's body, as well as women who felt at a higher risk of contracting or dying from the virus, were significantly more likely to hesitate or refuse to take the COVID-19 vaccines when they become available in their countries.

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Table 2. Multiple logistic regression analysis of factors associated with non-vaccination among pregnant women in sub-Saharan Africa.

Variable	AOR [95%CI]	p-Value
Education		
Tertiary	1	
Secondary	0.04 [0.01, 0.18]	<0.001
Marital status		
Unmarried	1	
Married	37.54 [9.30, 151.56]	<0.001
COVID-19 vaccine is a means to implant a digital microchip		
No	1	
Yes	3.63 [1.12, 11.79]	0.032
Perception of risk of COVID-19 infection	1.58 [1.24, 2.01]	<0.001

AOR—adjusted odds ratio; CI—confidence interval; COVID-19—coronavirus 2019.

3.3. Common Misconceptions about the COVID-19 Vaccine

Table 1 also shows the number of pregnant and non pregnant women who held common misconceptions about COVID-19 vaccines. Overall, more women in both groups did not believe the common misconceptions about the vaccine. However, a significant proportion believed that the COVID-19 vaccine alters people's DNA (79.6% of pregnant women and 76.6% of non pregnant women). Approximately half of the pregnant women and 40% of the non pregnant women believed that the vaccine causes infertility. These beliefs were not dependent on the vaccination status of the participants.

The percentage of pregnant women and their past vaccinations is depicted in Figure 2. Overall, a higher proportion of pregnant women reported having been vaccinated in the past for other conditions compared to non pregnant women, especially against yellow fever (57% vs. 42%) and polio (54% vs. 43%).

In the univariate analysis, there was a significant difference in the likelihood of receiving the COVID-19 vaccines between pregnant and non pregnant women (odds ratio: 0.12, 95% Cl: 0.06–0.27). At the time of this study, 26% of pregnant women and 74% of non pregnant women had been vaccinated against COVID-19 (Figure 3).

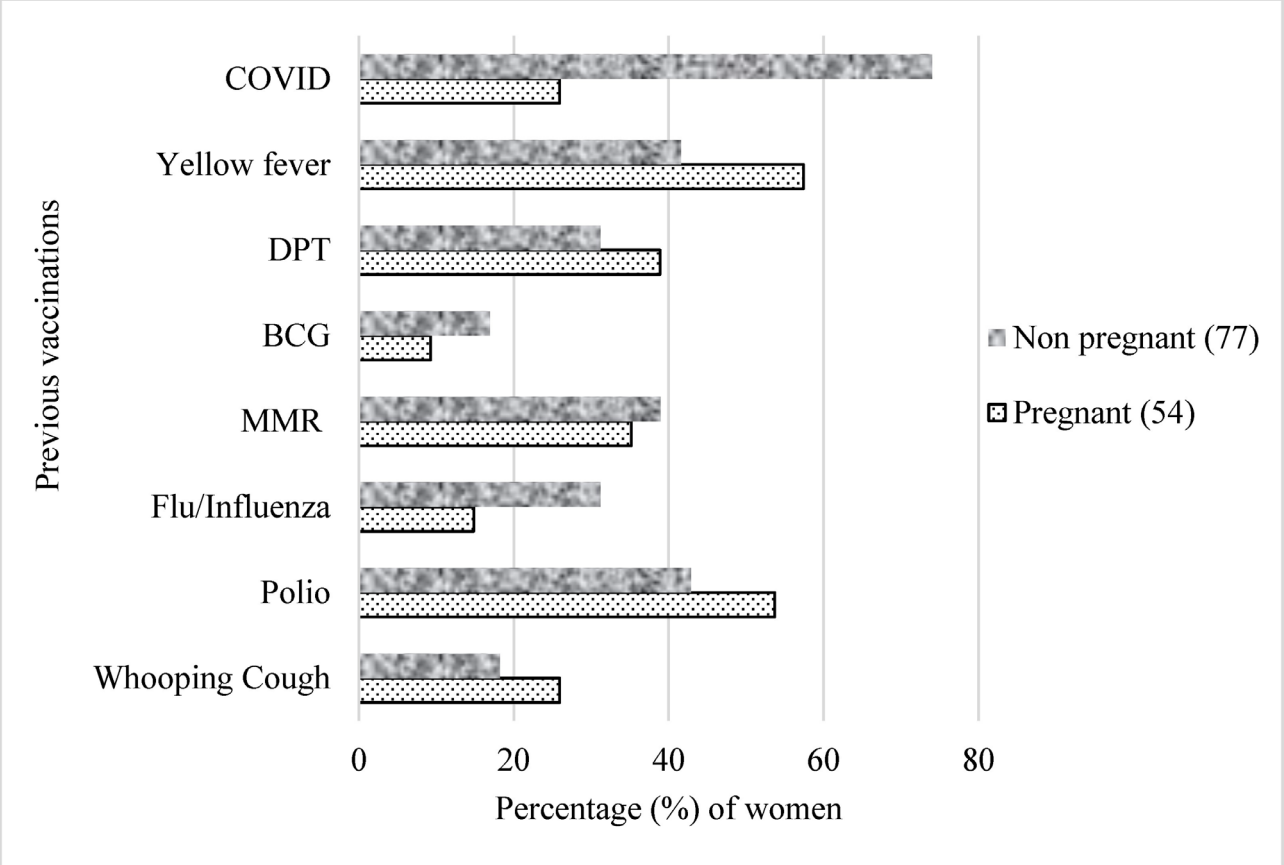

Figure 3. *Previous vaccinations based on pregnancy status. Participants selected multiple responses.*
MMR*—measles–mumps–rubella combination vaccine;*
DPT*—diphtheria, pertussis and tetanus;*
BCG*—Bacille Calmette–Guérin.*

3.4. Reasons for Not Getting Vaccinated against COVID-19

Figure 4 presents the breakdown of the reasons for not getting the COVID-19 vaccine among unvaccinated pregnant women. The most frequently cited reason by pregnant women for not taking the COVID-19 vaccines was mistrust of the health system in their countries (n = 19), while others (n = 16) cited the safety of the vaccines as their main reason for not receiving them. Information from the media and advice from religious leaders contributed the least to the reasons why pregnant women were hesitant towards the COVID-19 vaccines (n = 5), whereas the views of politicians about the vaccines did not influence the women's decision regarding COVID-19 vaccination.

Participants were also asked to indicate other reasons why they were not vaccinated. This was an open-ended question. Figure 5 presents the common themes that emerged as reasons for not being vaccinated. Apart from a few pregnant women who indicated that the unavailability of vaccines contributed to their not being vaccinated, most women who had not received the COVID-19 vaccine said it was mainly because of their suspicions about the countries where the vaccines were produced and the uncertainty of the vaccine production. Others reported concerns about the safety of the vaccines as the main reason for not taking them at the time of this study.

Below are some of the quotations from the women who said they would not take the COVID-19 vaccine when it became available to them:

"Concerned about the effects after taking the vaccine. There are many myths concerning it, like, it can make a woman not fertile to depopulate us. Most importantly, our COVID strain in Africa is not that dangerous. They should make available the vaccine to be given to the developed countries like us and not another product".

"I rather prefer self-protection for prevention purposes than trust the vaccine".

"Personal conviction that the vaccine is not necessary for Africa, especially for young people who are not at risk. It could be a birth control procedure to reduce world population".

"Vaccines have been used against black people for far too long-Kenya infertility, Tuskegee, etc. This vaccine is as questionable and its benefits for politicians far outweigh its care to manage this self-limiting bug".

Many respondents stated that they did not take the vaccines due to a dearth of information from healthcare providers about them. Others, however, said they refused the vaccines following advice from their religious leaders and their personal beliefs. Lastly, others reported that it was out of fear from their experience with other vaccines and their health, as can be seen from the quotes below:

"Risk to my health as I have SLE with a severely compromised immune system".

"I have a diagnosed allergy, which is the main cause of asthma and skin reactions, conjunctivitis. I am scared I might react to the vaccine".

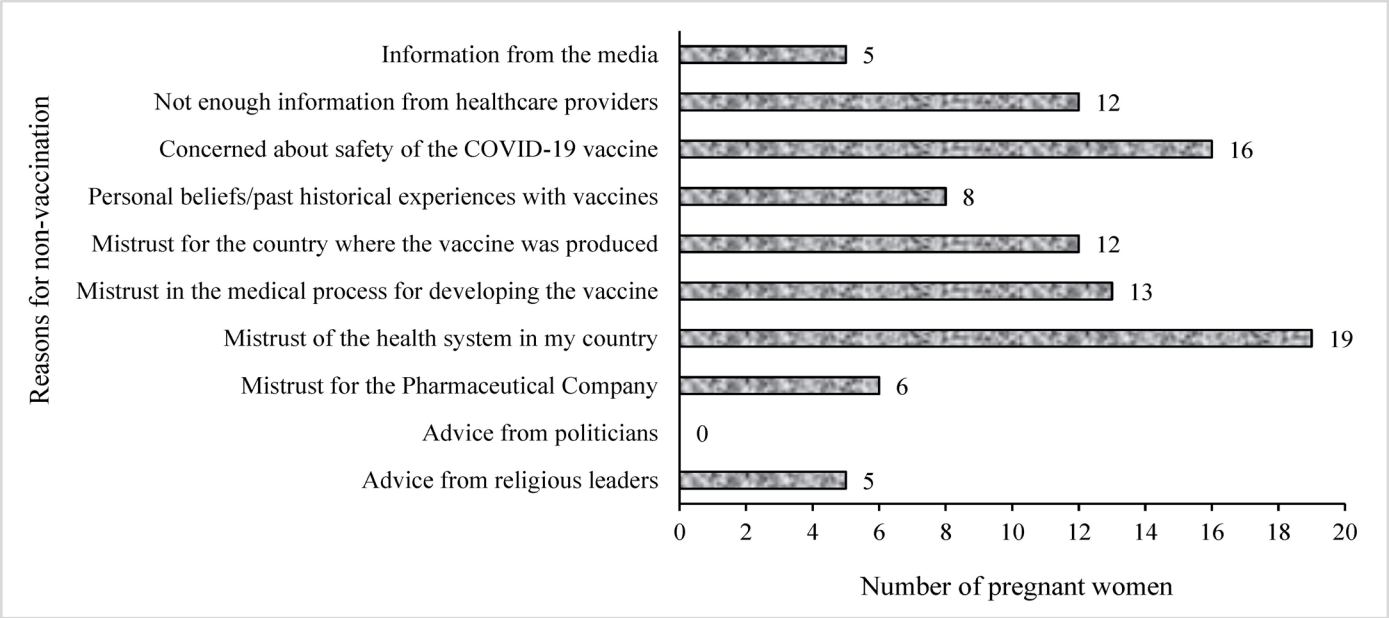

Figure 4. *Reasons for non-vaccination against COVID-19 among pregnant women. Participants selected multiple responses.*

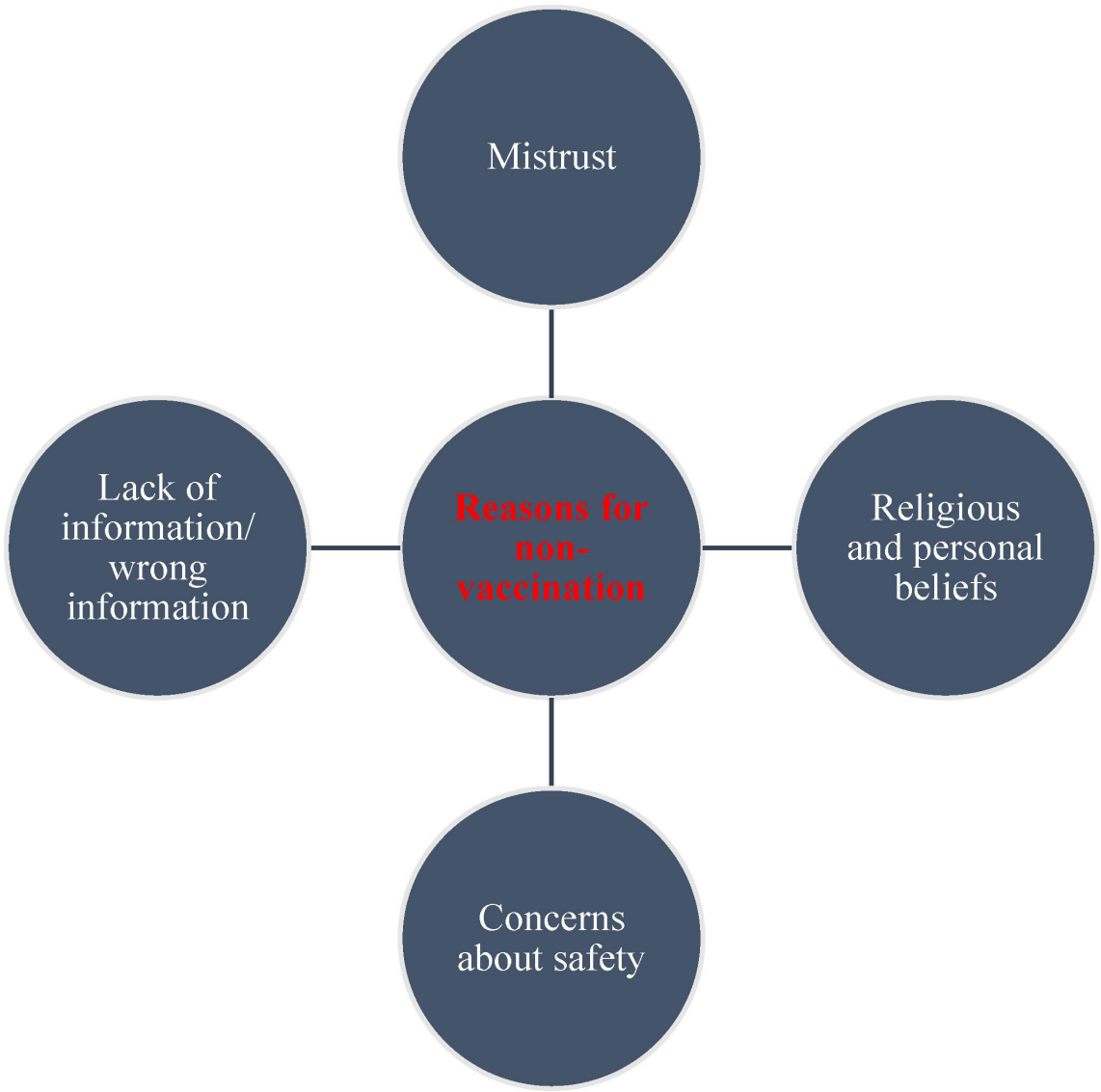

Figure 5. *Emergent themes for reasons for rejecting the COVID-19 vaccines.*

3.5. Motivations to Get COVID-19 Vaccines

About one-quarter of the participants accepted that they would take the vaccine if it were made available to them. Other participants indicated an unwillingness to take the vaccine, while some of the participants were uncertain about their willingness to take the vaccine. One of the participants clearly stated that the reason she was unvaccinated was that the "Government has not just vaccinated the mass population".

The majority said they would accept the vaccine if more information were to be provided about the production, availability, safety and side effects of the COVID-19 vaccine, while a significant number also said they would accept the COVID-19 vaccine only if it were given for free of charge or if it were a condition for travelling.

Other participants said that they would accept the vaccine if they were given some form of incentive. Pregnant women were more concerned with feedback about their health and the health of their unborn babies. The following responses typify this: "if I get more education on the vaccines, their side effects and how effective they are" (51.9% cases, 37.7% controls); "if I get positive feedback from those vaccinated" (51.9% cases, 29.9% controls). On the other hand, non pregnant women were more concerned about travel conditions (16.7% cases, 27.3% controls), employment and financial inducements. The participants' responses regarding the reasons that could increase vaccine acceptance are presented in Figure 6.

4. Discussion

This study compared the uptake of COVID-19 vaccines among pregnant and non pregnant women in SSA, who were matched by age. For the non-vaccinated pregnant women, including those who were hesitant or did not intend to take the COVID-19 vaccines when they became available in their countries of residence, we also determined the reasons for their decisions and identified the factors associated with hesitancy and refusal to take the vaccine. Multivariable analysis revealed that level of education, marital status, belief in the common misconception that the vaccine was meant to implant a microchip into the body and higher risk perception were significantly associated with non-vaccination against COVID-19 in this study.

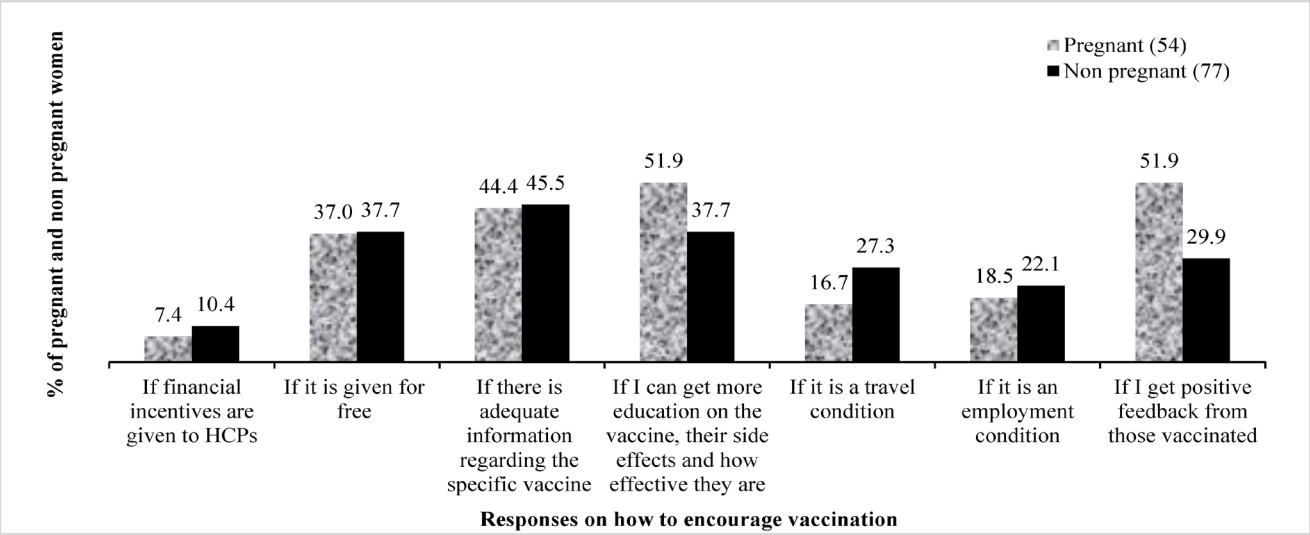

Figure 6. Conditions that would encourage acceptance of the COVID-19 vaccines. HCPs—healthcare practitioners.

Despite having received previous vaccinations for other conditions, pregnant women were significantly less likely to take the COVID-19 vaccines compared to non pregnant women in this study, which is likely to increase their risk of severe complications if infected. For those women who indicated they had not had access to the vaccine yet, one main reason could be the reduced availability of the vaccines in Africa [27]. Interestingly, it can be seen from this study that more pregnant women took the COVID-19 vaccine compared to the flu vaccine (about 30% vs. less than 20%). A similar report was given in a retrospective study [28], where just under 20% of pregnant women out of about 500,000 got vaccinated against influenza. The fact that influenza is not easily differentiated from other rampant infectious diseases (presenting with fever), such as malaria, which occur in the tropics [29], may have accounted for less attention being paid to this vaccination.

From this study, it was observed that pregnant women had a higher proportion of those who had tested (and were) positive for COVID-19. However, they had the lowest proportion of those who were vaccinated, despite being at higher risk. The higher proportion of pregnant women who had taken the COVID-19 test could be due to concerns about not wanting to be infected, or they may have been asked to take the test by their healthcare providers. The finding that twice the number of pregnant women tested positive may have resulted from more pregnant women having access to these tests. Furthermore, the low acceptance of vaccines among pregnant women was also found in a study conducted in northern Nigeria [20], where only one-third of the respondents indicated that they would accept the vaccine during pregnancy. The low vaccine acceptance found in the present study may be associated with the safety concerns expressed by the women since most believed in common myths about the COVID-19 vaccines, which significantly influenced the low uptake. This is not different from what was found in other studies, especially among Africans, where concerns about the safety of the vaccines were the reasons for vaccine hesitancy [30]. Notwithstanding, some side effects have been reported, mostly mild and expected, such as pain at the site of injection, headache and, in some rare cases, allergic reactions [31].

The findings of this study showed that pregnant women had a lower perception of the risk of getting infected and dying from COVID-19. This may suggest that they were unaware of the implications of being infected with the coronavirus disease while pregnant. Lack of information was also part of the reasons given for non-vaccination in this study. A higher perception of the risk of a disease ordinarily leads to greater compliance with health measures. Issues of health and safety concerns were more paramount for pregnant women, as revealed by their responses to the reasons that could increase their vaccine acceptance.

The safety of the vaccines, which most pregnant women agreed was an issue, portrays similar findings to a previous study [18] where respondents knew that infection with the virus could be potentially fatal but refused to take the vaccines due to doubts about their safety for themselves and their unborn children. This finding, therefore, highlights the importance of proper vaccine education to increase acceptance.

The responses to factors that encourage COVID-19 vaccine acceptance further identified pregnant women as very concerned about the safety of the vaccines. Of all the conditions asked, the responses

with the highest percentage were related to the effectiveness and safety of the vaccines. Additionally, more pregnant women lacked trust in the health system of their countries. In a systematic review, authors found that factors such as trust in the safety and efficacy of vaccines, trust in the individuals who administer or give advice about the vaccines and trust in the healthcare systems of countries are all important in the vaccine decision-making process [32]. The lack of trust observed in this study is not far from their lack of confidence in the ability of the health system to appropriately manage their condition when a problem or complication arises due to the deplorable state of most health facilities in Africa and their concern that health professionals lack the required competence to handle the novel disease. The emergence of COVID-19 exposed the poor conditions of health systems in terms of infrastructure, equipment, drugs and human resources required for standard patient care. Additionally, the history of mistrust from past interactions with official institutions may have influenced the public trust of the participants in this study. Such diverse histories and experiences may lead to highly variable and locally specific public trust in vaccines and other immunisation programmes in society [33].

A recent study [34] that evaluated the functioning of the health system in SSA, including challenges and responses, identified the poor structure of health systems and a dearth of essential health services as major setbacks during the COVID-19 pandemic. These weaknesses, coupled with the unmet demands arising from the COVID-19 pandemic, may have contributed to the mistrust of pregnant women towards the health care system. Being eager to receive positive feedback from others highlights the need to constantly educate women so they can make informed choices [35]. A detailed record of vaccine dissemination and outcomes may also be needed to aid this education.

Limitations and Strengths

Vaccination campaign programmes could be designed based on the results of this study, particularly considering the participants' intention to vaccinate. However, there are some limitations to this study, including the convenient sampling of online users and women in rural areas with limited internet access, which limits the generalizability of our findings beyond the study sample. This is important, considering that online users were more likely to believe the common myths about the COVID-19 vaccine that could potentially reduce vaccine uptake among women [34]. In addition, key indicators such as the postpartum period and parity were not investigated because the study was not specifically designed for pregnant and postnatal women. The study also did not investigate whether the COVID-19 vaccines were available in the countries during the survey and, therefore, the participants' decisions might change whenever the vaccines became available later. However, at the time of this study, some African countries had either just rolled out the vaccination programme [36,37] or targeted only front-line health workers [38]. Despite these limitations, the strength of this study is in the mixed-method approach, which provided more insight into the perception of pregnant women on vaccine hesitancy and reasons for non-vaccination among this high-risk group in the SSA region. Second, the language diversity of both the English and French versions of the survey also captured opinions from members of Francophone and Anglophone countries spanning 17 countries in SSA. Third, the

robustness of the analysis minimised the influence of potential confounders. Lastly, this study used a validated questionnaire shown to have satisfactory internal validity among SSA respondents [39]. However, further studies targeting pregnant women are needed in the region to provide an in-depth analysis of the reasons behind their decisions regarding COVID-19 vaccine uptake and the influence of social media.

5. Conclusions

This study has shown that over two-thirds of pregnant and non pregnant women in SSA agree that COVID-19 vaccines can prevent COVID-19 infection and its complications. However, only one in four pregnant women was vaccinated, despite their higher rate of previous vaccinations. The lower vaccination rate could be attributed to their lower perceived risk of being infected, their greater likelihood of believing in the false information about the COVID-19 vaccine and their increased concern about the vaccine's safety, in addition to the mistrust of their countries' health systems and their lack of confidence in the production process of the vaccines. More enlightenment campaigns should be carried out to create awareness about the safety of the vaccines, primarily targeted at high-risk groups, to emphasise the safety and efficacy of the COVID-19 vaccine, as well as dispel any misconceptions regarding common false beliefs. Public health officials can also seize this opportunity to establish meaningful relationships with the communities they serve to gain their trust, which may in turn increase the uptake of the COVID-19 vaccination. These approaches should target women who are married, have tertiary education and have a high perception of the risk of contracting the virus. Most importantly, this information is crucial for governments and policymakers to make targeted policy changes for future pandemics.

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Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: The data presented in this study are available on request from the corresponding author. The data are not publicly available due to institutional policy. Data can be made available on request from the corresponding author.

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17. Assessment of Knowledge, Practice and Guidelines towards the Novel COVID-19 among Eye Care Practitioners in Nigeria: A Survey-Based Study

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Abstract

The paper was included because it involved some members of AfTreG who initiated this study and was sponsored by Nigerian Optometric Association (NOA)

The aim of this study was to explore knowledge, practice of risk and guidelines of the novel corona virus disease (COVID-19) infection among the eye care practitioners and the potential associated factors. A cross-sectional self-administered online survey was distributed via emails and social media networks between 2nd and 18th May 2020 corresponding to the week of the lockdown in Nigeria to eye care practitioners (ECPs). Data for 823 respondents were analyzed. Knowledge and risk practice were categorized as binary outcome and univariate and multivariate linear regression were used to examine the associated factors. The mean score for COVID-19-related knowledge of public health guidelines was high and varied across the ECPs. Ophthalmic Nurses, Ophthalmologists and Optometrists showed higher COVID-19-related knowledge than other ECPs ($p < 0.001$), particularly those working in the private sector.

More than 50% of ECPs stated they provided essential services during the COVID-19 lockdown via physical consultation, particularly the Ophthalmologists. Most respondents reported that the guidelines provided by their Association were useful but expressed their lack of confidence in attending to patients during and after the COVID-19 lockdown. Compared to other ECPs in Nigeria, more Ophthalmic Nurses received training in the use of Personal Protective Equipment (PPE). This survey is the first to assess knowledge, attitudes and practice in response to the COVID-19 pandemic in Nigeria. ECPs in Nigeria displayed good knowledge about COVID-19 and provided eye care services during the COVID-19 lockdown in Nigeria, despite the majority not receiving any training on the use of PPEs with concerns over attending to patients. There is need for the government to strengthen health systems by improving and extending training on standard infection prevention and control measures to ECPs for effective control of the pandemic and in the future as essential health workers.

Keywords: coronavirus; personal protective equipment; essential service; pandemic; eye care practitioners

1. Introduction

Unlike some businesses and occupations considered as essential services, eye care professions (ECP) discontinued operations during the lockdown denying many patients—particularly those in need of emergency care or receiving routine injections for management of blinding eye diseases such as diabetes macular edema—access to eye care. ECPs may be susceptible to infection due to close patient proximity during examination such as slit lamp examination, applanation tonometry and the potential contamination of instruments [12]; however, medical visits related to systemic and ocular disease or injury where there is significant risk of permanent vision loss because of any postponement of care, as determined by the treating ECP, are considered essential visits [13]. Other conditions considered by ECPs as essential services have been summarized in Table 1. Additionally, the same groups burdened by COVID-19 complications could also suffer more vision problems including individuals with hypertension, respiratory conditions, and heart disease and the elderly [14]. Patients who have lost or broken their glasses or contact lenses with consideration given to prescription needs and level of disability without correction are considered as essential services [13]. There are also concerns existing around the pandemic with various reports from news outlets and social media reporting how best to limit the chance of infection, with significant amounts of misinformation and speculation [5] which many patients may request clarification from their ECPs to keep them safe through this period.

The emergence of the novel coronavirus disease in 2019 (COVID-19) in December 2019 in the city of Wuhan, the Chinese province of Hubei city, halted the ever-busy human society and threatened every nation [1]. A completely different type of acute pneumonia [2] which had close resemblance to the previous Middle East respiratory syndrome (MERS) and Severe acute respiratory syndrome (SARS) viruses but appeared to be much more lethal than the two was reported [3]. The infection soon became a cause of concern with the World Health Organization, declaring the rapid spread of cases of COVID-19 a pandemic on 11th March, 2020 and recommended that a globally coordinated effort was needed to fight the pandemic [4]. While there is

currently no vaccine for COVID-19 [5], the symptoms can include fever, flu-like symptoms such as a cough, sore throat and fatigue and/or shortness of breath, diarrhea, nausea and vomiting [6]. The risk of death in COVID-19-infected individuals increases with older age, presence of hypertension, diabetes and coronary heart diseases [7]. There are also reports of conjunctivitis and transmission of the virus by aerosol contact with conjunctiva [8] with some uncertainty as to whether the virus is evident in human tears [1].

On the 28th of January 2020, sub-Saharan Africa's first confirmed case of COVID-19 was announced In Nigeria. This led to the activation of the country's National Coronavirus Emergency Operation Centre by the government. During to the Ebola outbreak of 2014, of the 15,000 confirmed cases, there were over 9000 suspected cases in West Africa, but this was controlled in just 92 days [9]. Currently, the control of COVID-19 is becoming challenging for the Nigerian government despite the mobilization of resources and manpower by the Nigeria Centre for Disease Control NCDC [9,10]. There are about 16,658 confirmed cases of COVID-19 and 424 lost lives of humans from the infection (16 June 2020). The majority of the cases are in the former capital city of Lagos (7319 cases, 82 deaths), Federal Capital city of Abuja (1264 cases, 26 deaths) and Kano (1158 cases, 50 deaths) [10].

As the country continues to experience steady increase in the number of confirmed cases [10], the different levels of government have taken proactive steps to curtail the spread of coronavirus throughout the country. Movements were restricted within and between states, and the society observed a partial lockdown in response to the pandemic. Current evidence suggests that the implementation of outbreak response strategies for COVID-19 can limit the disease. However, these situational responses affect businesses including their interactions with relevant regulators/professional bodies causing the Government to respond through the Nigerian National Assembly's Emergency Stimulus Bill, the Central Bank of Nigeria's policy measure which dedicated its credit facility to develop the healthcare sector [11].

Table 1. Examples of essential care requiring emergency office visit.

Referral of patient from emergency department	House Price Index analysis of 2016 Healthcare Cost and Utilization Project data showed that 1% of all visits to the United States of America emergency department units were for eye-related encounters and that 98.9% of those eye-related encounters were treat and release that could be taken care of by doctors of optometry in their offices.
Trauma reported by patient	Blunt force, sharp object or foreign body or chemical to an eye; followed by pain, photophobia, sustained flashes of light, metamorphopsia or visual field loss.
Eye pain report by patient	Unexplained eye pain that cannot be resolved by virtual methods. This would include, but not limited to, acute angle closure glaucoma and corneal compromise (e.g., includes pain associated with contact lens wear and not resolvable after discontinuing contact lens wear).
Vision loss report by patient	Acute or gradual with or without pain, sudden onset blurred vision, color desaturation. Acute retinal arterial ischemia, including vascular transient monocular vision loss and branch retinal artery occlusion and central retinal arterial occlusions, are ocular and systemic emergencies requiring immediate diagnosis and treatment.
Double vision reported by patient	New onset.
Dropping of eyelid as reported by patient	Acute or sudden.
Flashes or floaters reported by patient with or without pain	New onset.
Source: American Optometry Association. Available at: https://www.aoa.org/coronavirus/health-policy-institute-covid-19/doctors-of-optometry-essential-care-guidelines-for-covid-19-pandemic.	

Unlike some businesses and occupations considered as essential services, eye care professions (ECP) discontinued operations during the lockdown denying many patients—particularly those in need of emergency care or receiving routine injections for management of blinding eye diseases such as diabetes macular edema—access to eye care. ECPs may be susceptible to infection due to close patient proximity during examination such as slit lamp examination, applanation tonometry and the potential contamination of instruments [12]; however, medical visits related to systemic and ocular disease or injury where there is significant risk of permanent vision loss because of any postponement of care, as determined by the treating ECP, are considered essential visits [13]. Other conditions considered by ECPs as essential services have been summarized in Table 1. Additionally, the same groups burdened by COVID-19 complications could also suffer more vision problems including individuals with hypertension, respiratory conditions, and heart disease and the elderly [14]. Patients who have lost or broken their glasses or contact lenses with consideration given to prescription needs and level of disability without correction are considered as essential services [13]. There are also concerns existing around the pandemic with various reports from news outlets and social media reporting how best to limit the chance of infection, with significant amounts of misinformation and speculation [5] which many patients may request clarification from their ECPs to keep them safe through this period.

The aim of this study was to assess knowledge and practice of COVID-19 exposure risk among ECPs as well as understand their confidence in current Federal Ministry of Health (FMoH) guidelines for identifying possible COVID-19 cases, knowledge of Personal Protective Equipment (PPE) recommendations and training in its usage when managing such cases. The impact of COVID-19 lockdown among practitioners was also assessed. This survey is among the first to assess knowledge level, practice of risk and awareness of the guidelines for consulting patients at risk or confirmed cases of COVID-19 in Nigeria incorporating responses from all tiers of ECPs in Nigeria. The findings will also provide first evidence on ECPs' knowledge of COVID-19 in Nigeria. This will help to reduce their risk, and that of their family, of contracting the virus, reduce morbidity and mortality associated with being infected. Evidence from the study can also be used to implement emergency policies to counter the spread and impact of a similar outbreak in future. The study will provide clarity on the essential nature of ECPs services to help policy making in future outbreaks.

2. Materials and Methods

2.1. Study Population

This study on the knowledge, practice, impact and guideline on COVID-19 was conducted among eye care practitioners in Nigeria. According to The World Bank Group (2019), Nigeria has an estimated population of 195,874,740 people. Majority of eye care service practitioners are located in the cities [15]. Nigeria is home to 7000 registered optometrists [16], about 300 ophthalmologists [17], 2000 ophthalmic nurses [18] and 941 dispensing opticians [16].

All eye care practitioners practicing in Nigeria have overlapping roles without distinct borders. Ophthalmologists undergo a minimum of four (4) years postgraduate training after a medical degree and provide surgical as well as medical eye care [19]. Optometry is a licensed professional program completed in a minimum of six

(6) years leading to the award of Doctor in Optometry (OD) which empowers Optometrists to provide general eye care including treating eye diseases, refractive errors, low vision and contact lenses [16]. An Ophthalmic nurse has a one-year post-basic nursing training in eye care and work with other ECPs to engage in blindness prevention activities and care for patients for ocular surgeries. Dispensing opticians obtain a three-year National Diploma and work in optical laboratories to interpret and dispense optical prescriptions [20].

A self-administered questionnaire developed and used previously for ECPs [21] was modified and pre-tested to ensure that it was suitable for use in Nigeria. The initial survey was piloted among 10 Optometrists who were not part of the study team and did not participate in the final survey to ensure clarity and understanding as well as to determine the duration for completing the questionnaire prior to disseminating them.

2.2 Ethics

The study adhered to the principles of the 1967 Helsinki declaration (WMA, 2013) and the protocol was approved by the Human Research Ethics Committee of the Cross River State Ministry of Health, Nigeria (Ref #: CRSMOH/RP/REC/2020/116).

Participation was anonymous and voluntary. Informed consent was obtained from all participants prior to commencement of the study and after the study protocol has been explained. Participants consented to voluntarily participate in this study by answering either a 'yes' or 'no' to the question inquiring whether they voluntarily agree to participate in the survey. A 'no' response meant that the participants could not progress to answering the survey questions and were excluded from the study.

2.3 Sample Size Determination and Sampling Procedure

The required sample size for this study was determined using a single population proportion formula given as:

$$n = \frac{Z^2 pq}{d^2} = \frac{1.96^2 x 0.50 x 0.50}{0.04^2} = 600 \quad (1)$$

In the absence of similar studies in Nigeria, the study assumed a proportion of 50% of the population and used a desired precision of 4% and 95% confidence level for a two-sided test. To make up for non-response rate of 25%, the sample size was determined to be 800 persons, which was adequate to detect statistical differences in the analysis of online cross-sectional study on COVID-19 among ECPs in Nigeria. Respondents were proportionately determined across the 4 categories of ECPs. A self-administered anonymous online survey was administered using convenience sampling technique, on a first-come bases until the required number was obtained within the one-month duration of the survey. A total of 823 questionnaires were fully completed and retrieved in the estimated proportions for the different categories of ECPs except for Ophthalmic Nurses where we got less than the required sample (Ophthalmologists [n = 66], Optometrists [n = 598], Ophthalmic nurses [n = 48] and Dispensing Opticians [n = 111]).

2.4 Procedure

The survey was created in survey monkey and disseminated to registered ECPs in Nigeria including Optometrists, Ophthalmologists, Opticians, Ophthalmic nurses, and phthalmic technicians between 2nd and 18th May 2020. Distribution was through the administrative heads of the

various professional bodies including the Ophthalmological Society of Nigeria (OSN), Nigerian Optometric Association (NOA), Nigeria Ophthalmic Nurses Association (NONA) and Association of Nigerian Dispensing Opticians (ANDO) and individually. A link to the online survey was disseminated via the emails and social media platforms (Facebook and WhatsApp) of the different professional organizations. Survey link remained active from 2 May to 18 May 2020, within which time participants completed the survey. The practitioners did not receive incentives for participating in the study and were not under any obligation to complete the survey.

Participants included ECPs who were currently registered to provide clinical services at different levels of eye care within Nigeria at the time of the study. Responses from non-ECPs, non- Nigerians, ECPs practicing outside Nigeria, and non-practicing practitioners were excluded from the analysis.

2.5. Instrument for Data Collection

The survey tool was shown in Table S1 and consisted of 36 items divided into five sections (demographic characteristics, knowledge, practice of risk of contracting the infection, impact and guidance) utilizing closed-ended questions and a four point 'Likert-type scale' to score participants' responses. The responses ranged from 'yes' (score '1′) to 'no' (score '-1′). A 'not sure' response was scored as 'zero'. For responses utilizing Likert scale, the scores ranged from '3′ for 'extremely confident' to '1′ for confident and '-1′ was scored for 'not-confident'

The impact of COVID-19 pandemic on practitioners, their family members and practices, including questions on their confidence in the current FMoH guidelines for identifying possible COVID-19 cases, their knowledge of Personal Protective Equipment (PPE) recommendations, and training in its usage during consultation were assessed.

2.6. Independent and Dependent Variables

The explanatory (independent) variable included basic characteristics and explanatory factors including gender, age in categories, region of practice, level of education, marital, employment and religion status, type of ECP, practice setting and practice years.

The dependent variables in the regression analysis was knowledge relating to COVID-19. The total score ranged from 1 to 9. The scores were derived from questions inquiring on 'whether the participants knew the occupation classified as 'Essential work' by the Ministry of Health during the COVID-19 lockdown', if ECPs could correctly identify from a list of nine items, the recommended PPEs by the NCDC in preventing COVID-19 transmission, during consultation of confirmed/suspected cases for health care workers?

2.7. Statistical Analysis

Descriptive statistics and Multivariable analysis were performed to demonstrate the outline of the findings of this study and sample characteristics. The responses were presented descriptively in tables. First, the entire cohort—men and women— was analyzed —to determine the knowledge towards COVID-19. Then, chi-square tests were used to examine the variability in responses by gender, for the different ECPs, concerning the knowledge, practice and understanding of the guidelines of the FMoH. The variability in responses

between ECPs from the different specialties concerning their understanding of guidelines was also assessed. Univariate linear regression analysis was calculated in order to assess the unadjusted coefficient. All confounding variables with a p value < 0.20 were retained and used to build a multivariable linear regression model. A manual stepwise backwards model was used to estimate the adjusted estimate for independent variables and to determine factors associated with KAP scores towards COVID-19. A p-value ≤ 0.05 was considered statistically significant and we checked homogeneity of variance and multicollinearity using Variance Inflation Factors (VIF). All statistical analyses were carried out using the Statistical Program for Social Sciences, version 25.0 (SPSS Inc, Chicago, Illinois, USA).

3. Results

3.1. Demographic Profile of the Respondents

A total of 823 respondents (males, n = 374, 45.4%, females n = 449, 54.6%) aged 21–72 years (mean age ± SD, 38 ± 10 years) completed the online questionnaire. About 84.3% were aged less than 50 years and male respondents were significantly older than the females (39 ± 10 years, 95% CI 38–39.7 versus 37 ± 10 years, 95% CI 36.3–38.2; p = 0.033). Table 2 presents the demographic characteristics of the respondents including their employment status and years of practice.

Table 2. Demographic profile of respondents.

Variables	Frequency (%)
n (%)	823 (100)
Age category (years)	
20–34	368 (44.7)
35–49	326 (39.6)
50+	129 (15.7)
Sex	823 (100.0)
Males	374 (45.4)
Females	449 (54.6)
Region of practice	820 (100.0)
Eastern Region	256 (31.2)
Western Region	246 (30.0)
Northern Region	211 (25.8)
Southern Region	107 (13.0)
Marital Status	**823 (100.0)**
Married	565 (68.7)
Not married	258 (31.3)
Highest level of education	**823 (100.0)**
Postgraduate Degree (Fellowship/Masters/PhD)	171 (20.5)
Bachelor's degree	557 (67.7)
National Diploma	95 (11.5)
Eye care profession	**823 (100.0)**
Ophthalmologists	66 (8.0)
Optometrists	598 (72.7)
Ophthalmic nurses	48 (5.8)
Opticians	111 (13.5)
Religion	**823 (100.0)**
Christianity	764 (92.8)
Others	59 (7.2)
Practice setting	**823 (100.0)**
Public hospital/service	394 (47.9)
Private clinic/optical shop	429 (52.1)
Employment status	**823 (100.0)**
Self employed	178 (21.6)
Private employee	229 (27.8)
Government employee	382 (46.4)
Unemployed	34 (4.1)
Years of practice	822 (100.0)
1–12	560 (68.1)
13–24	156 (19.0)
25+	106 (12.9)

3.2. Knowledge Relating to COVID-19

The total knowledge score relating to COVID-19 ranged from 1 to 9 with a mean score of 6.98 ± 2.00. Figure 1 shows the mean knowledge score for each eye care profession in the survey. There was a significant difference in the mean knowledge score between the professions (one way analysis of variance, $p < 0.0001$) with post hoc analysis revealing that the differences was only when Ophthalmic nurses (7.71 ± 1.81), Optometrists, Ophthalmologists (7.10 ± 1.85 and 7.39 ± 2.08, respectively) were compared with the Opticians (5.77 ± 2.34, $p < 0.0001$) who had the least knowledge of COVID-19 transmission. No other multiple comparison showed significant difference.

In the multivariable analysis, we found that, after adjusting for all cofounders in the final model, eye care profession (job title) was the only factor associated with knowledge of risk towards COVID-19 (adjusted coefficient, −0.182, 95% Confidence Interval −0.601, −0.22; $p < 0.0001$) (Table 3).

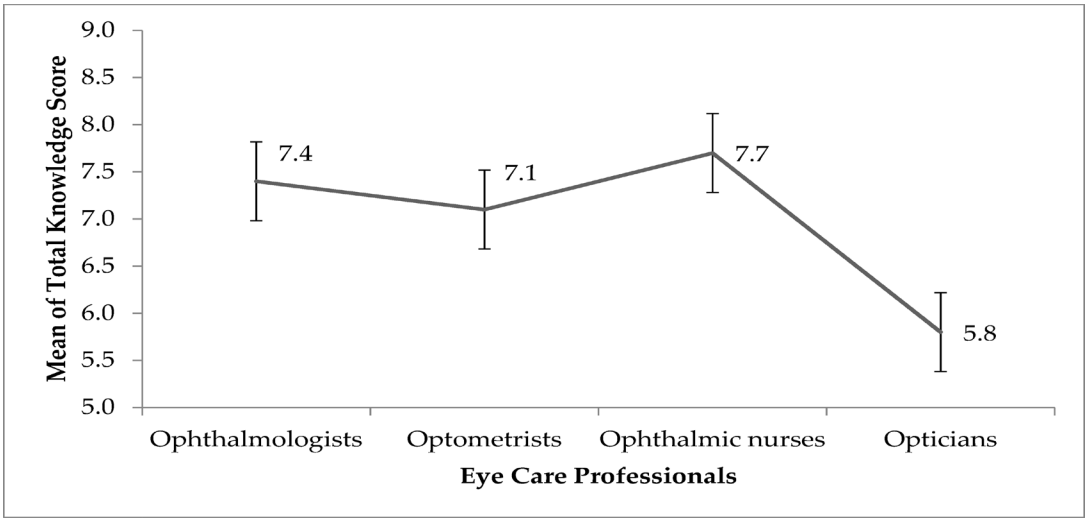

Figure 1. *The mean knowledge score for each eye care profession in the survey. Error bars represent standard error of the mean.*

Table 3. Multiple regression of factors associated with knowledge related to COVID-19 among eye care professionals in Nigeria during the lockdown.

Variable	Unadjusted Coefficient	Adjusted Coefficient	*p*-Value	95% CI of Adjusted Coefficient	
Age group (years) (50+ = Reference)					
20–34	−0.016	0.984	0.975	0.357	2.71
35–49	−0.164	0.849	0.7	0.368	1.958
Marital status (Not married = Reference)					
Married	0.234	1.263	0.411	0.724	2.204
Religion (others = Reference)					
Christian	−0.628	0.534	0.166	0.219	1.297
Highest Educational Qualification (National Diploma = Reference)					
University degree (Bachelors/ Doctor of Optometry/ Professional degree)	0.716	2.046	0.238	0.623	6.721
Fellowship, Postgraduate degree and PhD	0.419	1.52	0.52	0.424	5.448
Job title (Optician = Reference)					
Ophthalmologist	−2.705*	0.067	0.001	0.014	0.323
Optometrist	−2.038*	0.13	0.004	0.032	0.527
Ophthalmic nurse	−2.623*	0.073	0	0.018	0.29
Place of work (Private hospital/clinic = Reference)					
Public hospital	−1.425 *	0.241	0.039	0.062	0.931
Employment status (Unemployed = Reference)					
Self employed	−0.556	0.574	0.488	0.119	2.758
Government employee	0.953	2.594	0.287	0.448	15.014
Private employee	−0.219	0.803	0.779	0.174	3.701
Years of practice (25+ = Reference)					
1–12	−0.134	0.875	0.787	0.331	2.308
13–24	−0.094	0.91	0.833	0.379	2.184

3.3. Perception of Risk of Contracting COVID-19 During the Lockdown Period

Table 4 shows the opinion of ECPs with respect to COVID-19 during the lockdown. Over 70% of the subjects reported lack of confidence in the guideline of the Federal Ministry of Health did not consider eye care workers as "Essential workers" during the lockdown. Notwithstanding, 43.2% were either not so confident or not at all confident attending to any patient during the lockdown while 54.6% also reported they were not so confident or not all confident attending to COVID-19 patient or those at risk of COVID-19. When questioned about their level of confident attending to patients after the lockdown, 26.3% of eye care professionals reported lack of confident attending to patients even after the lockdown is over and for majority of the practitioners (90%), COVID-19 will change the way the deliver eye care service in their practice.

The results also revealed that a high proportion of eye care professionals provided eye care services to patients during the lockdown (Figure 2) with more Ophthalmologists and an equal proportion of Optometrists and Ophthalmic Nurses providing services. Of the various means of consultation during the lockdown (Figure 2) , it can be seen that many Ophthalmologists (73%), Optometrist and Ophthalmic nurses (65% and 62%, respectively) did so via physical consultations in the clinic. More Optometrist than Ophthalmologist (10.4% vs. 6.1%) utilized videoconferencing to provide this much- needed service during the lockdown while consultation over the phone, social media were also utilized by ECPs during the lockdown (Figure 2).

Table 4. Practice of respondents during the lockdown.

Practice	Frequency (%)
How confident/informed do you feel in the Federal Ministry of Health guidelines that currently do not consider Eye care practitioners as 'Essential workers'?	767 (100.0)
Extremely confident	43 (5.6)
Very Confident	79 (10.3)
Somewhat confident	105 (13.7)
Not so confident	227 (29.6)
Not at all confident	313 (40.8)
During the corona virus disease 2019 (COVID-19) lockdown, how confident do you feel attending to any patient?	769 (100.0)
Extremely confident	42 (5.5)
Very Confident	151 (19.6)
Somewhat confident	244 (31.7)
Not so confident	269 (35.0)
Not at all confident	-8.2
How confident do you feel attending to a patient with or at risk of COVID-19?	768 (100.0)
Extremely confident	26 (3.4)
Very Confident	103 (13.4)
Somewhat confident	208 (27.1)
Not so confident	263 (34.2)
Not at all confident	168 (20.4)
After the lockdown, how confident would you feel attending to any patient?	770 (100.0)
Extremely confident	87 (11.3)
Very Confident	202 (26.2)
Somewhat confident	279 (36.2)
Not so confident	166 (21.6)
Not at all confident	36 (4.7)
How much would COVID -19 change the way you practice?	771 (100.0)
Very much	543 (70.4)
Moderately	179 (23.2)
Very little	35 (4.5)
Not at all	14 (1.8)

3.4. Practice of Professional Guidelines During COVID-19

Compared to other practitioners, a significant higher percentage of optometrists reported that their professional association provided information on guidelines during COVID-19 (Figure 3). For over 80% of the respondents from each eye care profession, the guidelines were useful and regarding the use of personal protective equipment (PPE), less than 40% of each eye care professionals received training on the use of PPE in the control of COVID-19. Slightly more ophthalmic nurses (28.9%) received training on PPE compared to the ophthalmologists (14.0%) but this was at borderline significance ($p = 0.056$) (Figure 3).

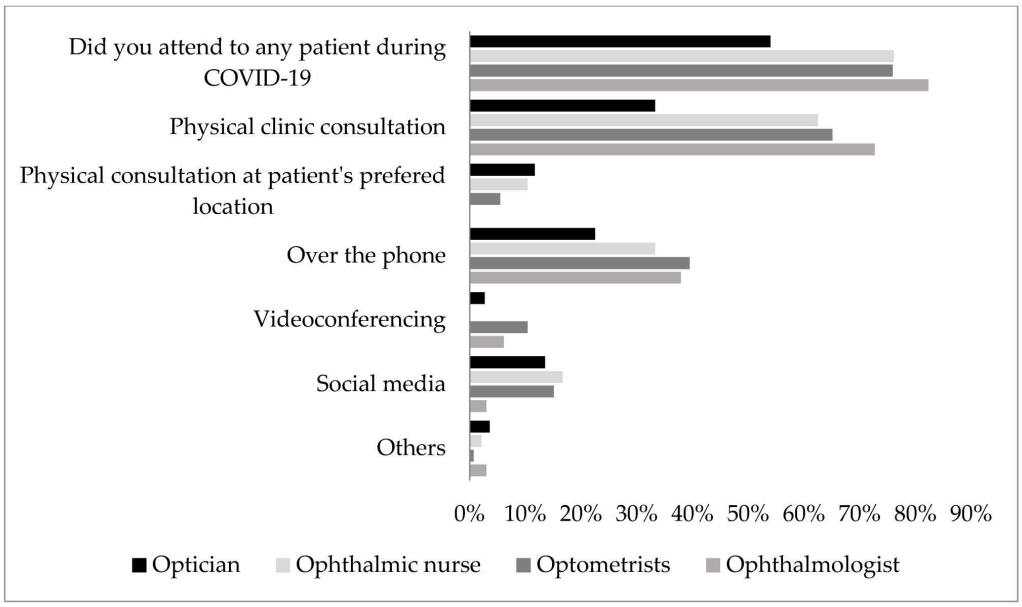

Figure 2. *Provision of eye care services and the methods employed for the purpose by respondents during the novel coronavirus disease 2019 (COVID-19) lockdown*

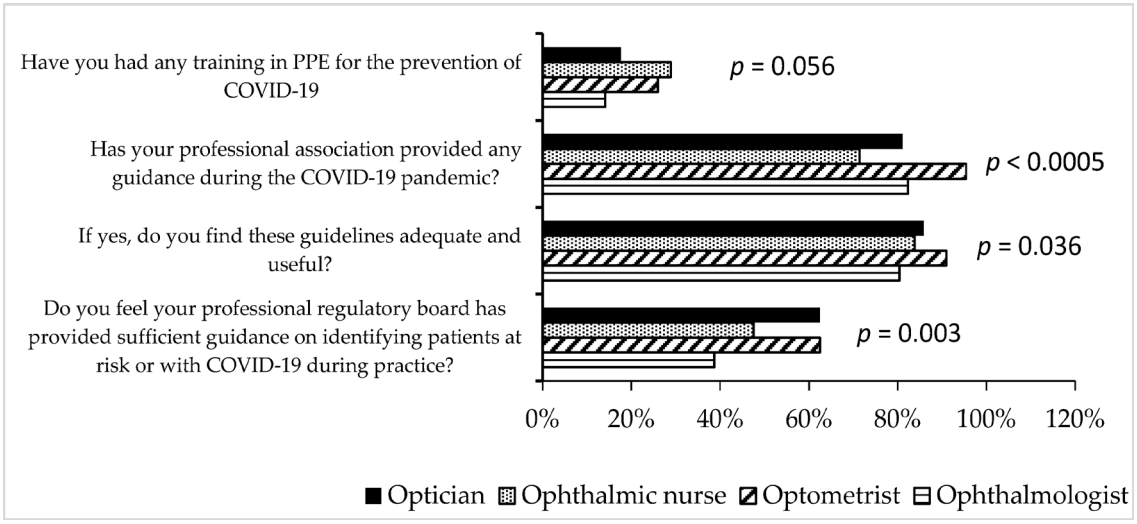

Figure 3. *Practice of professional guidelines of respondents during the novel coronavirus disease 2019 (COVID-19) lockdown. PPE = Personal Protective Equipment.*

4. Discussion

This is the first study to assess the knowledge, attitude and guidelines of all tiers of ECPs regarding the Public Health initiatives for the novel coronavirus (COVID-19) in Nigeria. The study found that knowledge about COVID-19 preventive guidelines was high among ECPs and Ophthalmic nurses, Ophthalmologists and Optometrists were significantly more knowledgeable compared to Opticians. The majority of the ECPs did not receive training on the proper use of PPEs despite a significant proportion stating that they attended to patients during the lockdown period. Although the majority of the ECPs felt that their professional Association provided some useful information on guidelines during the pandemic, this was considered grossly inadequate for many of the Ophthalmologists and Ophthalmic nurses. More than half of the ECPs expressed lack of confidence in caring for patients at risk of COVID-19 and, for more than a quarter of them, this will continue even after the lockdown is over.

Similarly high COVID-19-related knowledge was reported in the general Nigerian population [22], and that of the Chinese population [23] as well as those of the health care practitioners [14] but an earlier survey found a lack of understanding of the Public Health guidelines related to COVID-19 among ECPs in the UK. The study included 100 ECPs (ophthalmologists, optometrists, ophthalmic nurses and healthcare assistants) [21]. Compared to the UK study, the present study found high knowledge scores among respondents and this difference may be related to timing of both studies as the time lag may have allowed for the respondents in the present study to learn more about COVID-19 and, as such, demonstrated higher knowledge scores. At the time of the UK study, the coronavirus outbreak had just been designated a pandemic by the WHO [4], although the first confirmed case was reported in the UK on 29 January 2020.

The significant association found between COVID-19-related knowledge and the category of ECP may be attributed to the Ophthalmic Nurses having more training on PPEs than other ECPs, which may have translated to the higher knowledge scores. Although the Nigerian Federal Ministry of Health do not consider ECPs as essential workers, a large proportion of the respondents disagreed with this and more than half confirmed that they provided emergency eye care services via physical examination of patients during the lockdown. This finding suggests the need to consider the inclusion of ECPs as part of the essential healthcare team since ocular emergencies can occur at any time and viral conjunctivitis may be a symptom of COVID-19 [16,24].

Several guidelines to limit the risk of infection and help ECPs safely provide eye care services have been published by the Ophthalmic Associations, Societies and Researchers during the pandemic [10,12,16,25,26,27,28,29,30]. This is vital as several procedures involve the practitioner to be in close proximity to patients and as such proper use of PPE is essential. A survey of Optometrists and Opticians conducted in Austria, Germany and Switzerland reported that over 50% of the ECPs planned to wear masks during refraction, contact lens fitting and practiced hand washing and disinfection before performing procedures [31]. However, training in the use of PPE is important to avoid the ECP being infected. The finding that majority of ECPs did not receive any training on proper use of PPEs, was concerning and potentially dangerous, as it puts the practitioner at high risk of contracting COVID-19 [32,33].

An interesting finding of this study was the increased use of telemedicine for delivering eye care services during the COVID-19 pandemic, although only a few utilized this service. There is need for education on the methods of delivering this service and the associated benefits for ECPs in Nigeria. In addition, the fact that majority of the participants in this study were Optometrist may be a reflection of the higher number of registered Optometrists compared to Ophthalmologists and the fact that most of them are practicing in urban centers [34].

This study has some limitations. Firstly, the majority of the respondents were practicing in urban areas and their responses may not represent that of ECPs practicing in rural areas. Secondly, the low number of responses from ophthalmic nurses was lower than estimated from their registry, and this may affect the responses obtained from the group. Future studies should consider other ways of reaching this subgroup as their knowledge and practice as front-line workers is important. In

addition, further studies are needed to investigate the knowledge and preparedness of ECPs in rural settings to provide service during the COVID-19 pandemic in Nigeria. Despite these limitations, this study is strengthened by the larger sample size compared to a previous study [21]. Another strength of this study was the representation of the opinions of all tiers of ECPs who are involved in the delivery of eye care services during the lockdown in Nigeria. In addition, the study was the first to provide evidence on knowledge, practice and guidelines of African ECPs during a pandemic. It identified major gaps in the ability of the ECPs to continue providing care during and after the pandemic which, if not addressed, might put the ECPs and their patients at risk of contracting the virus infection during consultation. Addressing these gaps is important to build confidence among ECPs and their patients during a pandemic and, more so, as most African countries prepare for a possible second wave of the virus.

5. Conclusions

This study demonstrated that ECPs in Nigeria were knowledgeable about COVID-19 and readily explored several avenues to serve the Nigerian population during the COVID-19 lockdown. However, the ECPs reported lack of confidence on the non- inclusion of eye care workers as essential in the government guidelines for the control of this pandemic, which places them at increased risk. Therefore, to ensure that ECPs continue to provide the needed services during the pandemic or similar events, there is need for training on the proper use of PPE and recognition as essential worker; this will, in turn, boost their confidence when attending to patients even after the lockdown. The Nigerian government need to strengthen health systems by improving and extending training on standard infection prevention and control measures for effective control of the pandemic.

Supplementary Materials

The following are available online at https://www.mdpi.com/1660-4601/17/14/5141/ s1, Table S1: Survey tool used in this study.

Author Contributions

Conceptualization, B.E., L.O., and D.E.; methodology, L.O., G.O.-O., O.O.C., K.A., D.C.E., and B.E.; software, L.O., and C.O.; formal analysis, L.O., B.E., and G.O.-O.; investigation, U.L.O., G.O.-O., O.O.C., K.A., D.C.E., and B.E.; resources, O.L., B.E., U.L.O., and D.C.E.; data curation, C.O., K.A., and B.E.; writing—original draft preparation, B.E., C.J.O., and U.L.O.; writing—review and editing, O.L., D.C.E., G.O.-O., and K.A.; project administration, O.O.L., B.E., and D.C.E.; funding acquisition, O.L. All authors have read and agreed to the published version of the manuscript.

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Conflicts of Interest

The authors declare no conflict of interest.

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Glossary

Adherence is the act of consistently and faithfully following a rule, law, agreement, or belief.

Confidence intervals of the proportion or mean are ranges with upper and lower limits estimated from the dataset.

Coronavirus is an infectious disease caused by the SARS-CoV-2 virus that leads to various respiratory, gastrointestinal, and neurological illnesses in humans and other animals.

Diaspora refers to a group of people who share a cultural and regional origin but live away from their traditional homeland. Risk perception is people's subjective assessment of hazards based on their beliefs, attitudes, judgments, and feelings toward risk, influenced by social and cultural values.

An Eye Care Practitioner is a healthcare professional who helps people maintain good eye health and prevent vision loss.

Healthcare Workers are professionals who provide medical care to sick and ailing patients in various settings, such as hospitals, clinics, and social care settings, including nursing homes.

Hesitancy is the failure to act immediately or quickly due to uncertainty or nervousness.

Hierarchical Regression is a type of regression model in which predictors or independent variables are entered in steps based on theoretical considerations.

A Likert Scale is a type of psychometric rating scale that typically consists of a series of statements that the respondent rates on a scale of agreement or disagreement, usually ranging from "strongly agree" to "strongly disagree."

Linear Regression is used to describe the relationship between two continuous variables: one independent variable and one dependent variable.

Lockdown is a public safety or health emergency measure restricting movement or access to an area.

Misinformation is wrong, false, or misleading information given to someone with the intention of deceiving them. Sub-Saharan Africa encompasses the regions of Africa that lie south of the Sahara, including Central, East, Southern, and West Africa.

Odds ratios (OR) are statistics that measure the relationship between independent variables and dependent variable(s).

Public health is the science of protecting against disease, prolonging life, and improving and promoting the health of people and their communities.

Resistance is being unwilling to acknowledge or agree with something. 5G Network is the fifth generation of cellular network technology.

Transmission is the act or process of passing something or changing its direction from one person, place, or thing to another.

The Tuskegee Study, also known as the Tuskegee Syphilis Study, was conducted between 1932 and 1972 by the U.S. Public Health Service (PHS) and the Tuskegee Institute in Macon County, Alabama. The study which aimed to observe the natural progression of untreated syphilis in African American men raised a host of ethical issues. For instance, the participants were not informed of the nature of the experiment, were not given the option to refuse participation and the researchers failed to respect the dignity and worth of the participants by denying them proper medical treatment.

Resources

The articles were crafted with the aid of various resources. Websites were instrumental in tracking the daily fluctuations in infection rates, fatalities, and emerging outbreak zones. Moreover, these platforms provided insight into the evolving landscape of public health policies amid the pandemic. Additionally, databases were consulted extensively during literature searches to enrich our research papers. It's important to note that this list is not exhaustive.

Relevant websites:

- WHO Health Cluster: https://healthcluster.who.int/resources/covid-19-resources-and-guidance
- WHO African Region: Coronavirus (COVID-19). https://www.afro.who.int/covid-19-africa-response-areas
- Africa Centers for Disease Control and Prevention: COVID-19 Resources. https://africacdc.org/covid-19/covid-19-resources/
- Our World in Data: Coronavirus Pandemic (COVID-19). Edouard Mathieu, Hannah Ritchie, Lucas Rodés-Guirao, Cameron Appel, Charlie Giattino, Joe Hasell, Bobbie Macdonald, Saloni Dattani, Diana Beltekian, Esteban Ortiz-Ospina and Max Roser (2020) – "Coronavirus Pandemic (COVID-19)". Published online at OurWorldInData.org. Retrieved from: 'https://ourworldindata.org/coronavirus'

Relevant Databases:

- Cochrane Library: https://www.cochranelibrary.com/
- JaypeeDigital Med: https://www.jaypeedigital.com/home
- Medline: https://www.nlm.nih.gov/medline/medline_home.html
- Web of Science: https://www.webofscience.com/wos/woscc/basic-search
- Psycinfo: https://www.apa.org/pubs/databases/psycinfo/
- Pubmed Central: https://pubmed.ncbi.nlm.nih.gov/
- UTD: Finding Peer-Reviewed Articles and Journals – Scholarly and Peer Reviewed Journals – LibGuides at University of Texas at Dallas (utdallas.edu): https://libguides.utdallas.edu/scholarly-and-peer-reviewed-journals/finding-peer-reviewed-articles-and-journals
- EBSCO: https://www.ebsco.com/products/research-databases/ebsco-open-dissertations
- ProQuest: https://www.proquest.com/?accountid=36155
- Scopus: https://www.scopus.com/search/form.uri?display=basic&basic
- ScienceDirect: https://www.sciencedirect.com/

About the Editors

Dr Uchechukwu Levi Osuagwu (PhD, MSc, OD, FAAO) is a Senior Lecturer and Academic Lead at Bathurst Rural Clinical School, Western University Sydney, Australia. With a profound background in Optometry and Vision Science, Dr. Levi emerges as a recognized expert in public and eye health research, spearheading initiatives with far-reaching implications. As a coordinator of diverse local and international research projects, Dr. Levi pioneers advancements in population screening, diabetes identification and prevention, and health promotion.

His multidisciplinary, translational approach echoes in collaborations with leading institutions globally, resulting in the establishment of two impactful research groups—Center for Eyecare and Public Health Intervention Initiative (CEPHII) and the African Translational Research Group. Together, these groups boast an impressive record: 18 peer-reviewed papers, presentations at three international conferences, four community forums, and a prestigious Tet fund grant from the Nigerian government. Dr. Levi's influence extends across borders, fostering collaborations with the African Vision Research Institute and orchestrating international partnerships with entities like the Tongan GDM taskforce and Diabetes Foundation Aotearoa (New Zealand).

Beyond academic realms, Dr. Levi actively contributes to global health dialogue, presenting at esteemed conferences such as the Association for Research in Vision Conference in Canada. His editorial prowess extends to over 15 international journals, and he serves as a reviewer for the Irish Health Research Board, an affiliate of the University of Kwazulu-Natal, and a committee member for curriculum development at Masinde Muliro University of Science and Technology, Kenya. Dr. Levi's impact reverberates in groundbreaking initiatives, from a collaborative epidemiological study in Auckland, NZ, to upskilling Indigenous communities on retinal screening protocols. His innovative model of using a van for diabetes self-care promotion in Wollondilly has set a precedent, now emulated by numerous Local Health Districts (LHDs). With over 95 publications in esteemed journals and a citation count of 900 (H-index=22), Dr. Levi Osuagwu stands as a trailblazer whose work transcends disciplines, fostering positive change in public health and beyond.

Associate Professor Kingsley Agho (PhD, MPH, MSc, MEng, BEd)) is from the School of Health Sciences, Western University Sydney, Australia, and is a world-leading researcher in Global Public Health. His work has contributed to programs of research, education and policy-related messages across Australia, South Asia and Sub-Saharan African countries. Kingsley has also been involved in designing and analysing large-scale community-based cluster RCTs worth over 12 million dollars with a track record of over 300 peer-reviewed journal articles (H-Index=63, according to Google Scholar, January 2024). Kingsley has mentored young researchers and has facilitated growth and development of alumni through mentorship, including graduating 25 PhD students in the past decade, many of whom have been employed in recognised universities overseas and in Australia. Kingsley is also an Honorary Professor at the University of KwaZulu-Natal and a Visiting Professor at the University of Johannesburg, both in South Africa.

Bernadine Nsa Ekpenyong (PhD, MPH, FNCO, OD, FAAO)) is an esteemed academic, editor and researcher, and boasts over two decades of expertise in optometry and public health (Epidemiology). She is currently an Associate Professor of Public Health Epidemiology and Unit Head at the Epidemiology unit, Department of Public Health, University of Calabar, Nigeria. Her academic journey began with a Doctor of Optometry (OD) degree from Abia State University, Uturu, Nigeria, followed by MPH and PhD degrees in Public Health (Epidemiology) from the University of Calabar. As a Fellow of the Nigeria Post Graduate College of Optometrists (FNCO) and the American Academy of Optometry (FAAO), Doctor Ekpenyong has received accolades for her impactful research, securing awards and grants locally and internationally. In addition to her academic roles, she holds leadership positions, including Chair of the Faculty of Public Health Optometry at the Nigeria Post Graduate College of Optometrists. Serving as Editor-in-Chief of the Journal of the Nigerian Optometric Association from 2016 to 2023 and as an Editor of the Journal of Epidemiological Society of Nigeria, Dr Ekpenyong contributes significantly to scholarly publications. Engaging in global research collaborations, Dr Ekpenyong has played pivotal roles in initiatives such as the Center for Eyecare and Public Health Intervention Initiative (CEPHII) and the African Transitional Research Group (ATRG). Her contributions, including notable work on the COVID-19 pandemic published in high-impact journals, exemplify her dedication to advancing Optometry and Public Health. Dr Bernadine Nsa Ekpenyong is a model of excellence, shaping these fields through her multifaceted contributions.

Professor Khathutshelo Percy Mashige (PhD, MOptom, BOptom) completed a Bachelor of Science (BSc) degree at the University of Witwatersrand. He graduated with a Bachelor of Optometry (BOptom) degree at the former University of Durban Westville. Professor Mashige completed his Master of Optometry (MOptom) and Doctor of Philosophy (PhD) degrees at the University of KwaZulu-Natal, South Africa. He is the current Dean and Head of the School of Health Sciences at the University of KwaZulu-Natal. Professor Mashige is the Chief Executive Officer (CEO) of the African Vision Research Institute (AVRI), Chairperson of the Education, Training and Registration Committee (ETRC) of the Professional Board for Optometry and Dispensing Opticians (PBODO) and the Chairperson of the African Eye Institute (AEI). He is a member of the African Translational Research Group (ATReG) and the Centre for Eye Care and Public Health Intervention Initiative (CEPHII), which are global forums for African researchers to stimulate greater collaboration in Africa in health-related research. Prof Mashige has published extensively in clinical optometry, epidemiology and public health. He is a South African National Research Foundation-rated scientist and an Associate Editor of BMC Ophthalmology. He is a recipient of many research grants and awards for outstanding contributions to his field.

Professor Tanko Ishaya (Ph.D., MSc., BSc) is a highly accomplished academic specialising in computer science and mathematics, boasting over 25 years of experience in the field. After graduating from the University of Jos, Nigeria, with a BSc in Mathematics, he pursued advanced studies abroad, earning an MSc and PhD in Computer Science from the University of Manchester, UK. Throughout his career, Professor Tanko has held various leadership positions, including Director of Information and Communication Technology (ICT) and Head of the Computer Science Department at the University of Jos. He has also served as a visiting Professor at the University of Hull, UK, where he made significant contributions to internet computing.

With a keen research interest, Professor Tanko has published extensively and secured numerous research grants, contributing to the advancement of data engineering, computer security and forensics. His academic endeavours have led to the supervision of both PhD and MSc students in the UK and Nigeria, as well as mentorship of undergraduate students in their final-year projects. As a Fellow of both the British Computer Society and the Nigerian Computer Society, Professor Tanko's expertise and leadership have made him a respected figure in academia and the IT industry.

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This page lists major changes to this guide, each marked with a 0.01 increase in the version number. Because new information is continuously added to this guide, content updates do not appear on this page. Instead, a "Page added | Last update" textbox is posted near the bottom of each chapter. Additional files (e.g., PDF, ePUB) are provided upon request to libraryresearch@westernsydney.edu.au.

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