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Examining the Role of Social Determinants of Health and COVID-19 Risk in 28 African Countries

Imelda K. Moise ^{1,*}, Lola R. Ortiz-Whittingham ¹, Kazeem Owolabi ², Hikabasa Halwindi ³  and Bernard A. Miti ⁴

¹ Department of Geography and Sustainable Development, University of Miami, 1300 Campo Sano Ave, Coral Gables, FL 33146, USA; lrw47@miami.edu

² iMMAP Nigeria Office, 1 Nuel Olu Court, #11 Ogbeh Street, Jabi, Abuja 900211, Nigeria; kazeemowolabi@gmail.com

³ Department of Community and Family Medicine, School of Public Health, University of Zambia, P.O. Box 50110, Lusaka 10101, Zambia; hikabasa@yahoo.com

⁴ Latkings Outreach Program, Chalala Road, Plot No. 25744, P.O. Box 37178, Lusaka 10101, Zambia; bernardamiti@gmail.com

* Correspondence: moise@miami.edu

Abstract: While the impact of the pandemic has varied between and within countries, there are few published data on the relationship between social determinants of health (SDoH) and COVID-19 in Africa. This ecological cross-sectional study examines the relationship between COVID-19 risk and SDoH among 28 African countries. Included were countries with a recent demographic and health survey (years 2010 to 2018). The response variables were COVID-19 case rates and death rates (reported as of 15 August 2020); and the covariates comprised eight broad topics common to multiple SDoH frameworks aggregated to the country level: geography (urban residence), wealth index, education, employment, crowding, and access to information. A negative binomial regression was used to assess the association between aspects of SDoH and COVID-19 outcomes. Our analysis indicated that 1 in 4 (25.1%) households in study countries are without safe and clean water and a space for handwashing. The odds of COVID-19 morbidity and deaths were higher in countries with a high proportion of households without access to safe and clean water. Having a high proportional of educated women (1.003: 95% CI, 1.001–1.005) and living in a less crowded home (0.959: 95% CI, 0.920–1.000) were negatively associated with COVID-19 deaths, while being insured and owning a mobile phone predicted illness. Overall, aspects of SDoH contribute either negatively or positively to COVID-19 outcomes. Thus, addressing economic and environmental SDoH is critical for mitigating the spread of COVID-19 and re-emerging diseases on the African continent.

Keywords: social determinants of health; Africa; vaccines; prevention; DHS; survey



Citation: Moise, I.K.; Ortiz-Whittingham, L.R.; Owolabi, K.; Halwindi, H.; Miti, B.A. Examining the Role of Social Determinants of Health and COVID-19 Risk in 28 African Countries. *COVID* **2024**, *4*, 87–101. <https://doi.org/10.3390/covid4010009>

Academic Editor: Andrea Fiorillo

Received: 28 December 2023

Revised: 6 January 2024

Accepted: 11 January 2024

Published: 14 January 2024



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1. Introduction

Currently, it is estimated that 6.99 million people have died from COVID-19 worldwide, with 175,477 deaths reported in Africa and representing approximately 2.5% of global deaths [1]. These numbers place COVID-19 among the ten leading causes of death, mostly among developed countries [2]. The factors contributing to these low death rates in Africa, despite a weak healthcare infrastructure, have drawn fierce debate and raised big questions among scholars and civic leaders [2–6]. Several hypotheses have been provided to support the low reported death rates and case fatality rates, such as low vaccine coverage and/or underreporting [7–16].

Despite the effective intervention strategies implemented for the prevention and treatment of COVID-19, with a significant decrease in new cases globally, this reduction has varied across communities, subgroups, regions, countries, and within countries (e.g., urban versus rural) [17–20]. In Africa, complex factors, both internal and external, exacerbate disease and the healthcare burden of disease outbreaks [21–25]. While COVID-19 prevention

via vaccines and treatment is available, it has become clear that to curtail infectious disease outbreaks, both biomedical and social issues must be addressed [26–29].

Social determinants of health include social and economic conditions that inhabitants are exposed to in their daily routines [24,26]. COVID-19 bears the direct and indirect impact of these SDoH factors, and influences its outcomes. For example, a weak healthcare system and poverty affect the dynamic of the infection and may reduce access to COVID-19 testing and personal protective equipment (PPE) [30]. Additionally, poor housing conditions including overcrowding poses serious health risks to people especially vulnerable subgroups (e.g., for people living in slums and often in close quarters) [27,31].

Consequently, low-income populations globally and minorities in the U.S. have been disproportionately affected by COVID-19, with poor outcomes [32–35]. Furthermore, although individual risk behaviors that contribute to COVID-19 have been established (e.g., close personal contact such as shaking hands) [24,36], there are few published data on how aspects of SDoH affect COVID-19 risk in the African context. Coping with disease outbreaks requires an expanded understanding of both ‘upstream’ causes such as social determinants [37,38] and ‘downstream’ causes such as responses—vaccines [39,40]. Thus, for those working in disease prevention, a deeper understanding of whether and how SDoH affect infectious diseases such as COVID-19 is increasingly important for designing targeted prevention interventions and for preparing for current and future disease outbreaks [41,42].

Given that improving the response to future pandemics requires an improved understanding of early disease dynamics and the role played by local, national, and international agencies [40], we conducted an ecological study to examine the associations between social determinants of health (SDoH) across 28 African countries and COVID-19 outcomes. The goals of the study are to characterize the potential relationships between SDoH and COVID-19 measures at the country level at a time when governments were scrambling to curtail the crisis.

2. Methods

2.1. Design and Setting

We conducted an ecological cross-sectional study comprising 28 African countries (Figure 1)—countries with a recent standard demographic and health survey completed conducted within the past ten years [43]. To be included, countries also had to have COVID-19 data publicly available. Initiated in 1984, the DHS was used because it captures comparable population-based data on indicators of household-level living conditions, as well as the broader socioeconomic, demographic, and environmental conditions in low- and middle-income countries (LMICs) [44] allowing a comprehensive assessment of a countries health situation, including comparison between and within countries (urban, rural). Moreover, the DHS questionnaires are consistent and this enhances the comparability of indicators across populations and time. The DHS survey participants are selected from clusters and households within a fully covered geographic sampling frame using multistage design, providing opportunities for examining both ecological and individual-level factors that relate to the distribution of health outcomes [45]. We excluded countries if they did not have a survey conducted in 2010 or later or if they did not include likely significant measures that contributed to differential COVID-19 outcomes as part of the information collected.

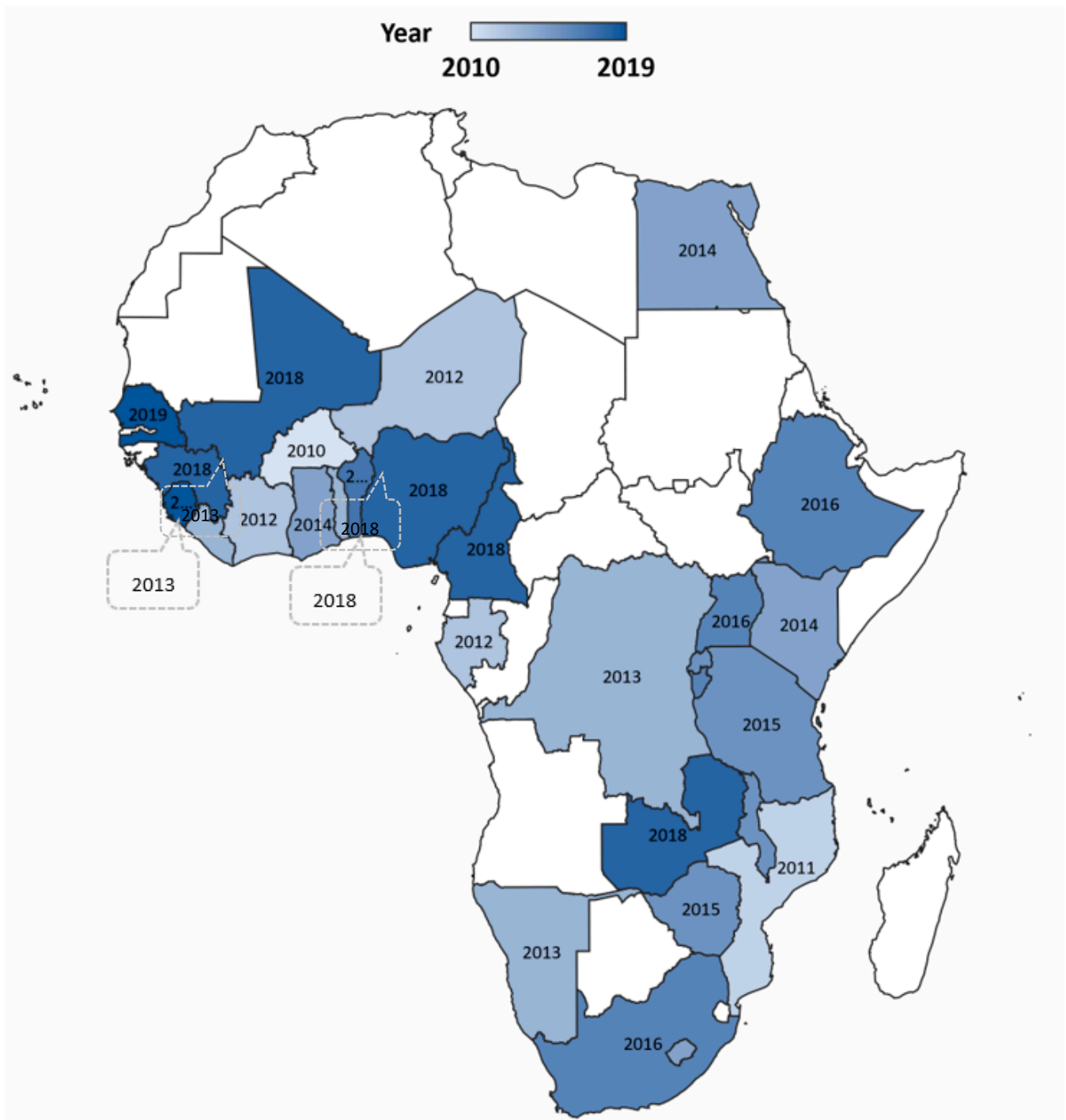


Figure 1. Location of the 28 study countries and the Demographic and Health Survey year conducted, 2010–2018.

2.2. Country-Level COVID-19 Data Source

We obtained reported COVID-19 hospitalizations and death data as of 15 August 2020 for 28 African countries from the Africa Centers for Disease Control and Prevention (CDC) Dashboard (accessible at: <https://africacdc.org/covid-19/>, accessed on 16 August 2023). The Africa CDC Dashboard compiles COVID-19 testing data from official regional collaborating centers and member country reports. Therefore, these data may not be indicative of the actual tests as of the date of the dashboard update. To determine the country-level case and death rates, we calculated the number of COVID-19 deaths and/or

cases per country in each period and divided it by the population exposed to risk of infection and death in that period multiplied by 10,000.

2.3. Country-Level Social Determinants of Health Data Source, Measures

To determine the association between SDoH and COVID-19 outcomes, we abstracted from the most recent DHS in each country ($n = 28$ countries) 9 variables commonly reported as shaping health outcomes. The measures comprised nine broad topics common to multiple SDoH frameworks, which were aggregated to the country level [24]. Because there are gender differences in educational attainment and because COVID-19 has affected girls and women differently compared to boys and men, a few independent indicators focus on women. Measures of interest represented geography (urban residence), wealth (Human Development Index or HDI rather than “GDP per capita”. HDI was used as it has been reported to be better indicator in measuring the progress of nations, particularly LMICs. Other indicators included a wealth index—poor or average living) [46,47], education (women with no education, primary, secondary, or higher, percentage, %), sanitation (women living in households with safe and clean water access, having a place to wash hands, with soap or detergent present, %), employment (currently working, %), insurance coverage (%), crowding (average number of household members based on more than three people per sleeping room), distance to safe clean water (average time to get to drinking water), access to information (women owning a mobile phone (%)), and women listening to the radio at least once a week (%). These SDOH measures were selected based on the literature and conceptual frameworks [26,48,49]. Studies have linked some of these measures to COVID-19 screening and testing outcomes [44,50].

The DHS dataset was used because it represents the primary source of data in many low–middle income countries on the demographic, socioeconomic, and environmental conditions and trends in a country [51], and datasets are available to the public upon request to the DHS Program [52]. The DHS Program uses a two-stage cluster sampling design to capture representativeness of the data at the national and sub-national level. The variables collected via the DHS are often the same across countries and period, enabling comparison over space and time.

2.4. Data Processing

Country-level measures: To abstract the SDoH measures of interest from the DHS, we first put together a full continent database, drawn from the DHS program [52]. We included only countries with the most recent DHS survey (conducted in the past 10 years) that had COVID-19 outcomes. We then converted the DHS household survey data to country level by using data processing and aggregation methods documented in detail elsewhere by LivWell; in Ref. [53]. Briefly, the household-level data were first aggregated to the sub-national level; with a corresponding *R* function used to transform the raw data into the final measures at the country level. The data were then validated using data obtained from other sources (e.g., the DHS compier, Livwell data repository, the subnational human development database) [53–55]. Sampling weights were used in calculations as provided by the DHS Program [51], and to account for sampling weight, the weight in the pooled data was divided by the number of surveys available for the respective countries, as used in previous studies [44].

This study uses publicly available secondary data; as such, ethical approvals are not necessary.

2.5. Statistical Analysis

We used ArcGIS Software version 10.5 [56] for generating maps. Negative binomial regression was used to assess the association between COVID-19 risks and SDoH measures. Negative binomial regression was chosen over Poisson regression because the COVID-19 death and case rates (dependent variable) were over-dispersed. The approach was adopted only after performing the likelihood ratio test for over-dispersion for both negative

binomial regression and Poisson regression. The denominator included all surveyed households in the DHS study countries with measures aggregated to the country-level ($n = 28$ countries). Predictors were added sequentially to the model, in which the fixed effects can be interpreted as conditional on countries, with all random effects fixed at zero (e.g., unit-specific models). The model goodness-of-fit and the assessment of outliers were evaluated by the Akaike information criterion (AIC), the Bayesian information criterion (BIC), and McFadden's pseudo-R-squared statistic. All the analyses were conducted using IBM SPSS statistics version 26.0 [57].

3. Results

3.1. Characteristics of Study Countries

Table 1 presents the characteristics of the DHS SDOH measures, count, and percentages for the study countries. The study sample ($n = 416,459$ surveyed households in 28 study countries). Of the 63.9% surveyed countries, inhabitants live in rural areas and 36.1% are urban dwellers. One in four (25.1%) respondents are without a designated place for household members to wash their hands, and a staggering 41% of residents reported not having soap or detergent for handwashing. The share of countries reporting households with more than three people per sleeping room is 21.4%, while approximately 36.0% of countries report that inhabitants do not have any education, and 42.6% of the surveyed countries have inhabitants living in poverty.

Table 1. Summary Statistics of Social Determinants of Health Typologies for 28 Study Countries with recent Demographic and Health Surveys, 2010–2018 ($n = 486,173$ surveyed households).

Country	Social Determinants of Health Measures										
	Residency (% Households)			Wealth Index (% Households)		Educational Status (% Head of Households)			Sanitation (% Households)		Overcrowding (% Households)
	<i>n</i>	Rural	Urban	Poor	Average	No Education	Primary	Secondary or Higher	Place to Wash Hands	Soap or Detergent Present	>3 People per Sleeping Room
Benin	14,423	55	45	36.9	18.9	51.8	22.2	24.5	55.5	20.4	22.5
Burkina Faso	14,156	69.4	30.6	37.3	19.3	76.1	13	10.9	80.9	17.4	18.6
Burundi	15,977	81.2	18.8	41.3	18.1	47.2	39.7	13.1	98.5	7.5	13.7
Cameroon	17,223	44.8	55.2	33.2	22.5	19.4	32.9	46	95.2	46.4	15.7
Côte d'Ivoire	4466	58.6	41.4	42.6	21.8	57.4	20.3	22.1	84.8	28.7	24.1
DR Congo	18,171	70.1	29.9	49.3	19.6	14.7	32.5	52.8	92.6	37.3	28.2
Egypt	28,175	50.4	49.6	34.4	16.7	25.3	15.6	59.1	97	90.8	8.4
Ethiopia	16,650	68.6	31.4	42.2	12.4	52.1	28	19.6	54.3	24.3	45.6
Gambia	11,835	50.2	49.8	45.7	15.1	67.1	7.4	25.3	98.9	66.9	21.3
Ghana	6215	49.8	50.2	41.7	21.8	28.3	14.1	57.6	90.2	40.2	20.2
Guinea	7912	65.9	34.1	42.2	18.8	68.4	9.8	21.3	70.2	34	21.2
Kenya	36,430	61.8	38.2	44.2	18.8	20.9	45.6	33.5	62.4	44.5	28.2
Lesotho	9333	70.2	29.8	42.6	19.9	17.3	53.1	27.8	7.5	47.2	15.5
Liberia	9402	63	37	58.4	19.7	38.3	21.3	40.4	26.3	38.3	25.6
Malawi	9510	81.1	18.9	39	19.1	15.8	56.1	27.5	84.2	14.7	19.4
Mali	26,361	69	31	38.3	19.6	69.4	12.8	17	74	24.9	21.2
Mozambique	13,919	63.4	36.6	33.7	20.2	29.6	50.9	17.5	98.6	39.1	18.9
Namibia	9840	51.6	48.4	37	20.4	17.6	28.3	53.7	94.6	60.1	13
Nigeria	40,427	58.5	41.5	37.4	22.1	30.7	21.2	48	79.3	36.4	20.8
Rwanda	12,699	77.2	22.8	42.5	18.4	25.5	60.9	13.6	76.6	54.1	11.4
Senegal	12,598	62.1	37.9	52	20.1	70.6	14.2	13.4	39	56.4	20.2
Sierra Leone	4592	63.8	36.2	39.7	18.3	66	9.4	24.5	89	35.8	23.7
South Africa	9548	40.8	59.2	42.8	21.3	13.4	21.1	64	87.2	48.9	8.7
Tanzania	12,561	71.1	28.9	34.1	20.4	20.8	60.4	18.7	77.2	59.5	17.6
Togo	19,588	61.9	38.1	37.1	22.4	35.4	27.8	36.8	80.4	63.5	21.9
Uganda	11,083	77.2	22.8	43.3	18.4	16.3	52	30.5	57.6	45.8	26.6
Zambia	12,831	63.3	36.7	44.6	20.4	9.7	42.7	45.7	52.4	40.5	25.1
Zimbabwe	10,534	58.8	41.2	32.9	16.8	6.6	31.4	61.1	97.4	45.6	15.4

We observed country differences in the rates of COVID-19 deaths and cases. Overall deaths from COVID-19 across the study African countries ranged from 0–1.99 per 10,000 population during the study period (Figure 2). As of 15 August 2020, South Africa had the highest COVID-19 case and death rates in Africa and still has the highest COVID-

19 related cases and deaths in Africa. For example, as of 23 December 2022, there were 4,046,603 confirmed cases of COVID-19 with 102,550 deaths reported to WHO.

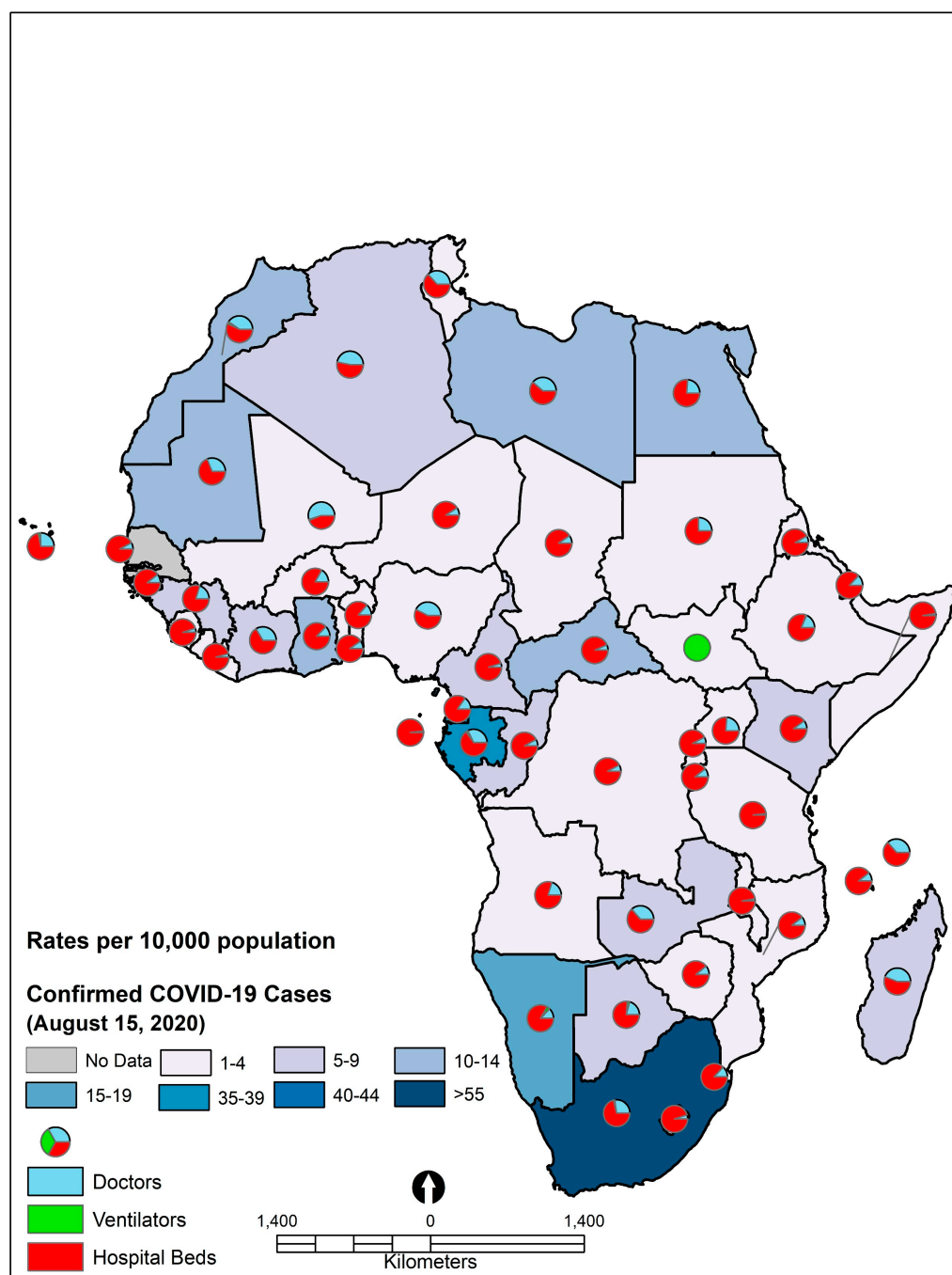


Figure 2. Confirmed COVID-19 case rates in 54 African countries, 2020.

3.2. Multivariate Analysis of Correlates for COVID-19 Case and Death Rates in the 28 Study Countries

The results of a binomial negative regression model on COVID-19 case rates across the 28 African study countries are shown in Table 2. Not having access to quality water or safe and clean water (1.153; 95% CI, 1.036–1.284), health insurance (1.262; 95% CI, 1.124–1.417), women not owning a mobile phone was positively associated with COVID-19 case rates.

Table 2. Negative binomial regression of 28 African countries social determinants of health factors on COVID-19 case rates.

	Coefficient	Std. Error	p-Value	Odds Ratio 95% Wald CI
Social Determinants of Health (SDoH) measures				
Geography				
Population living in urban areas (%)	−0.042	0.048	0.384	0.959 (0.874–1.053)
Wealth				
Human Development Index	−2.387	6.525	0.715	0.092 (0.000–32,925.611)
Education				
Women education (%)	0.089	0.054	0.102	1.093 (0.982–1.215)
Sanitation				
Households, quality water access, %)	0.143	0.055	0.009	1.153 (1.036–1.284)
Employment				
Women currently working (%)	−0.041	0.046	0.379	0.96 (0.877–1.051)
Healthcare access				
Not having health insurance (%),	0.232	0.059	0.001	1.262 (1.124–1.417)
Crowding				
Average number of householders (>than 3)	−1.735	1.069	0.105	0.176 (0.022–1.433)
Access to Information				
Women, mobile phone (%)	0.089	0.046	0.053	1.093 (0.999–1.195)
Women listening to the radio at least once a week (%)	0.061	0.057	0.284	1.063 (0.951–1.188)

Bold = $p < 0.05$. CI = Confidence Interval.

Regarding COVID-19 death rates, we also observed that the odds of COVID-19 death rates were higher in countries with a high proportion of households without access to quality water (1.004: 95% CI, 1.002–1.006) and uneducated women (1.003: 95% CI, 1.001–1.005 (Table 3). Having household crowding especially having fewer than three people sharing a room was negatively associated with COVID-19 death rates.

Table 3. Negative binomial regression of 28 African countries and social determinants of health factors on COVID-19 death rates.

	Coefficient	Std. Error	p-Value	Odds Ratio 95% Wald CI
Social Determinants of Health (SDoH) measures				
Geography				
Population living in urban areas (%)	−0.001	0.0010	0.166	0.999 (0.997–1.001)
Wealth				
Human Development Index	−0.182	0.1309	0.165	0.834 (0.645–1.078)
Education				
Women education (%)	0.003	0.0011	0.014	1.003 (1.001–1.005)
Sanitation				
Households with high quality water access, %)	0.004	0.0011	0.001	1.004 (1.002–1.006)
Employment				
Women currently working (%)	−0.001	0.0009	0.247	0.999 (0.997–1.001)
Healthcare Access				
Insurance coverage (%),	0.001	0.0012	0.370	1.001 (0.999–1.003)
Crowding				
Average number of householders (> than 3)	−0.042	0.0214	0.051	0.959 (0.920–1.000)
Access to Information				
Women owning a mobile phone (%)	0.001	0.0009	0.181	1.001 (0.999–1.003)
Women listening to the radio at least once a week (%)	0.002	0.0011	0.058	1.002 (1.000–1.004)
Healthcare System Measures				

Bold = $p < 0.05$. CI = confidence interval.

4. Discussion

This study augments the existing literature on the effects of the pandemic in Africa by examining the effects of country-level ($n = 28$ countries) SDoH measures on COVID-19 outcomes (cases and death rates) during a time when countries were scrambling to curtail the crisis. Consistent with the literature, this study found a link between country level SDoH measures and COVID-19 outcomes [23,25,58–61]. Overall, death rates and case rates varied by country, with South Africa exhibiting the highest COVID-19 case and death rates across sub-Saharan Africa. This finding supports evidence from previous observations in South Africa [62–66]. Notably, the low COVID-19 rates reported in other African countries may be somewhat limited by data gaps inherent in most health information systems in Africa's ministries of health [67]. The need for better data during pandemics extends to a need for better demographic surveillance systems for all vulnerable populations [61].

In our study, household overcrowding was negatively associated with both cases and death rates. The findings are consistent with those of previous studies that found household crowding or when the number of persons surpasses the number of rooms as a risk factor for COVID-19 [68–74] and those that linked crowding to infectious disease transmission [75,76]. A study conducted in Kenya by researchers from the University of Pécs on urban slums and COVID-19 provides recommendations for what non-governmental and government actors can do to prepare for future interventions on infectious disease outbreaks, including better coordination of efforts and expertise [77]. This finding is also consistent with those who noted a need for an integrated policy approach as a solution to Kenya's slum residents' risk to COVID-19 [73], and that any pandemic responses “that do not recognize these realities will further jeopardize the survival of large segments of the urban population globally [73]”.

Not surprising, the percentage of women with an education was a significant explanatory variable for the variation in COVID-19 across the 28 African countries. However, a closer examination reveals the presence of several preventative strategies that, when seen in their totality, have influenced significantly COVID-19 outcomes across the African continent [78]. Efforts and reasons as to why African exhibited low COVID-29 deaths and cases are detailed elsewhere [77,79–82]. This result also suggests the importance of educating women in developing countries, as this can improve health outcomes. In the context of Africa, women's educational level has been reported as shaping healthcare seeking behaviors, and among the most effective intervention strategies, those to do with women's education and health literacy have been the most effective at changing health behaviors and improving outcomes [44,83–86]. Moreover, a recent review noted that COVID-19 disproportionately affected girls and women differently compared to boys and men [87], and women are more vulnerable to COVID-19-related economic impacts because of existing gender inequalities [24,44,88].

We also observed that being uninsured was associated with COVID-19 risks, a finding supported by studies conducted in Germany [89], U.S. [90], and Korea [91]. The finding alludes to the relationship between socioeconomic status and COVID-19 risk. This finding is not surprising considering that those low-income people are more likely to be unemployed, have unstable work conditions and incomes, or to be employed in jobs that do not provide insurance, exacerbating their risks [92].

Women not owning a mobile phone considerably influenced the odds of COVID-19 case rates. The use of mobile phones has gained popularity as a low cost method of addressing health system needs in Sub-Saharan Africa [93], and a lack of mobile phone ownership is noted as a facilitator or hindrance to the implementation of health interventions [94,95]. For example, a study conducted in Malawi of mobile/cellular phone ownership and health behaviors in postpartum mothers noted low depressive symptoms among women who owned mobile phones. Moise et al., ref. [96]'s scoping review ($n = 22$ studies) of digital-technology-enabled health interventions implemented during the pandemic to improve maternal and birth outcomes noted high use of mobile phones for service delivery and case management [95]. Elsewhere, access to mobile devices has been

linked to health literacy [97], empowerment [67], improved self-efficacy and communication between healthcare workers, clients, and better adherence outcomes [98–100]. Thus, the results of this study suggest that access to a mobile phone is a social determinant of health and can influence women's health outcomes.

These findings suggest key implications for addressing future infectious disease outbreaks in Sub-Saharan Africa. For example, another finding is that access to high quality water is positively linked to COVID-19 cases. However, although access to water, sanitation, and hygiene (WASH) is vital to “protect human health during infectious disease outbreaks”, while “hand hygiene is a critical factor of the wider WASH framework and is highly recommended by WHO as a significant control measure to control infectious disease transmission [101–104]”, its effect on reducing the incidence of COVID-19 has not been widely investigated. A recent mini systematic review of thirteen studies noted not finding any studies on COVID-19 health outcomes and WASH [105]. Further studies, which take these variables into account, will need to be undertaken. One such study identified vital knowledge gaps and priorities for the research that can be used for current and future pandemics [106].

The most unanticipated finding of this study was the apparent negative relationship between the Human Development Index (HDI) and COVID-19 outcomes. This outcome is contrary to that in recent studies that noted an association between the HDI and COVID-19 incidence [107–110] but collaborates Roghani and Panahi's findings that noted GDP and not HDI as a significator measure for COVID-19 outcomes [111]. Notably, although we found a negative association between COVID-19 outcomes and HDI, higher country HDI has been linked to enhanced vaccine distribution and health infrastructure [112]. Given that economic measures are an aspect of SDoH concepts, they play a significant role in contributing to a country's capacity for implementing effective pandemic interventions, such as vaccine distribution and health infrastructure. Future studies on the current topic are, therefore, recommended.

5. Limitations

The current study adds to our knowledge regarding the influence of social determinants of health on the health outcomes in Africa. However, this study has limitations. First, a limitation of this study is the issue of omitted variable bias. For example, of all potential risk and protective factors (e.g., use of PPE) that can moderate an individual's exposure to the COVID-19, we only include select SDoH measures. Further, the DHS data on healthcare services are limited to evaluating availability and utilization, and no indicators on quality of care are collected. Further research should be undertaken to assess the quality of care beyond the use of cross-sectional surveys. In addition, the available DHS vary by country, capturing only a brief snapshot of SDOH overtime and shedding little light on how SDOH change over time. This limitation is largely unavoidable due to a dearth of longitudinal data on COVID-19 and protective factors in Africa. A further study with more focus on protective factors, such as the use of PPE, that can be generated via focus groups and surveys is, therefore, suggested.

6. Conclusions

Although many countries have managed to decrease the effect of the pandemic, variation in COVID-19 outcomes between countries is largely correlated with aspects of social determinant of health measures. The main predictors of case rates were access to quality water, not having health insurance, and ownership of mobile phones by women, while predictors of COVID-19 mortality rates include ownership of mobile phones by women, access to quality water, and the percentage of educated women in a county. These findings have implications for addressing healthcare systems in Africa and underscore the need to include and integrate capacity, economic, and environmental determinants in healthcare reform. This is critical for planning, preparedness, and response to the next major re/emerging disease outbreak. Additionally, ministries of health should recognize the importance of effectively allocating resources to areas with overcrowded housing, poor WASH, and education of girls, as this may help during future disease outbreaks. Our findings emphasize an imperative for further studies to explore the association between cell phone ownership and health outcomes, as well as potential risk and protective factors.

Author Contributions: Conceptualization, I.K.M. and L.R.O.-W.; methodology, I.K.M.; software, I.K.M.; validation, L.R.O.-W.; formal analysis, B.A.M. and L.R.O.-W.; data curation, L.R.O.-W.; writing—original draft preparation, I.K.M.; writing—review and editing, H.H.; visualization, K.O.; supervision, I.K.M.; project administration, I.K.M. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: Not applicable. This study used publicly available secondary data sources.

Informed Consent Statement: Not applicable.

Data Availability Statement: The data presented in this study are available on request from the corresponding author.

Conflicts of Interest: The authors declare no conflicts of interest.

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