Analysing the reported incidence of COVID-19 and factors associated in the World Health Organization African region as of 31 December 2020

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SUMMARY

This study analyzed the reported incidence of COVID-19 and associated epidemiological and socio-economic factors in the WHO African region. Data from COVID-19 confirmed cases and SARS-CoV-2 tests reported to the WHO by Member States between 25 February and 31 December 2020 and publicly available health and socio-economic data were analyzed using univariate and multivariate binomial regression models. The overall cumulative incidence was 1846 cases per million population. Cape Verde (21350 per million), South Africa (18060 per million), Namibia (9840 per million), Eswatini (8151 per million) and Botswana (6044 per million) recorded the highest cumulative incidence, while Benin (260 per million), Democratic Republic of Congo (203 per million), Niger (141 cases per million), Chad (133 per million) and Burundi (62 per million) recorded the lowest. Increasing percentage of urban population (beta=-0.011, p=0.04) was associated with low cumulative incidence, while increasing number of cumulative SARS-CoV-2 tests performed per 10000 population (beta=0.0006, p=0.006) and proportion of population aged 15-64 years (adjusted beta=0.174, p<0.0001) were associated with high COVID-19 cumulative incidence. With limited testing capacities and overwhelmed health systems, these findings highlight the need for countries to increase and decentralize testing capacities and adjust testing strategies to target most at-risk populations.

Key Words: COVID-19, Incidence, African region.

Key results:

- The overall cumulative incidence was 1846 cases per million population.
- Cape Verde (21 350 per million), South Africa (18060 per million), Namibia (9 840 per million), Eswatini (8 151 per million) and Botswana (6044 per million) were the five countries with the highest cumulative incidence as of 31 December 2020.
- Increasing percentage of urban population was associated with low cumulative incidence.
- Increasing number of cumulative SARS-CoV-2 tests performed per 10000 population and proportion of population aged 15-64 years were associated with high COVID-19 cumulative incidence.
INTRODUCTION

Since early January 2020, the coronavirus disease 2019 (COVID-19) has spread globally and was declared a pandemic by the World Health Organization (WHO) on 11 March 2020 [1]. The COVID-19 is an acute respiratory illness caused by the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), first reported in December 2019 in Wuhan, China [2]. The virus spreads by close person-to-person contact, mainly via respiratory droplets or aerosols produced when an infected person coughs, sneezes, sings, exercises, or talks [2].

Twelve months into the pandemic, the African region, one of the six World Health Organization (WHO) regions [3], remains the second least affected, accounting for 2.4% of confirmed cases and deaths globally [4]. As of 3 January 2021, over 83.3 million COVID-19 cases and 1.8 million deaths were reported globally, of which 1.9 million cases and over 43000 deaths were recorded in the WHO African region [4] which is comprised of 47 of the 54 countries on the African continent, constituting its Member States [5]. The relatively low number of COVID-19 cases and deaths could partly be explained by insufficient testing, a comparatively young population, favourable climate and possible cross immunity [6-8].

Despite the low caseload, the COVID-19 pandemic remains a major threat to public health security in the WHO African region. Countries in this region are characterized by heterogenous income levels; 45% classified low income, 54% middle income and 4% high-income countries, as well as underfunded and fragile health systems [9-10]. At the same time, most countries experience recurrent infectious diseases outbreaks. In 2018, 96 new disease outbreaks were reported across 36 of the 47 Member States with cholera, measles and yellow fever being the most commonly reported [11].

The response to these recurrent diseases has informed the overall coordination of the response to the COVID-19 pandemic in the WHO African region. Using its internal grading system, the WHO graded the pandemic at the highest level, requiring regional offices, with assistance from the WHO headquarters, to coordinate support to Members States in responding to the event, as per the WHO emergency response framework [12]. This is also the first time that the WHO Regional Office for Africa (WHO AFRO) had to provide technical assistance and coordinate international support to all Member States simultaneously.

In order to prioritize countries requiring support, WHO AFRO monitors a set of key epidemiological parameters, including new cases and deaths, case fatality ratio, healthcare worker infections and cumulative incidence. Monitoring the disease incidence at national and regional levels helps WHO AFRO track the evolution of COVID-19, assess the effect of different public health and social measures on the trajectory of the pandemic, identify hotspots, compare current trends in different countries and areas within countries, and allocate the resources required to support the ongoing response. The COVID-19 incidence is also one of the key indicators used to assign a transmission pattern and alert level to each Member State, as per the WHO guidance for implementing and adjusting public health and social measures in the context of the COVID-19 pandemic [13]. The difference in cumulative incidence between countries can be explained by a wide range of factors including but not
limited to testing strategies, health system capacity to respond to COVID-19, and population density.

The objectives of this study were to compute the reported incidence of COVID-19 in each country of the WHO African region over time and identify the epidemiological and socioeconomic factors associated with COVID-19 incidence.

METHODS

We conducted a retrospective study using the most recent data on confirmed cases of COVID-19 reported by countries in the WHO African Region between 25 February and 31 December 2020.

Key epidemiological and selected socio-economic factors from the literature were used to analyse factors that may be associated with the incidence of COVID-19 in countries from the WHO African region.

Inclusion and exclusion criteria

Only cases meeting the COVID-19 case definition as per the most updated WHO technical guidance [14] and laboratory-confirmed COVID-19 cases using a reverse transcriptase polymerase chain reaction (RT-PCR) test or an antigen rapid diagnostic test approved by the WHO, and officially reported by Member States were considered for this study.

We included countries of the WHO African region that reported confirmed COVID-19 cases to the WHO from 25 February to 31 December 2020. Countries that did not formally submit reports on COVID-19 cases including reports of zero cases during the last three months were excluded. Among the 47 countries of the WHO African region, only Tanzania met the exclusion criteria.

Data sources and measurement

We built a dataset that included the following variables: country, population, cumulative number of cases, cumulative number of tests performed, percentage of the population aged 15-64 years, population density, percentage of the population living in urban areas, universal health service coverage, health expenditure (as a percent of gross domestic product), prevalence of diabetes, prevalence of obesity, crude death rate, incidence of Human Immunodeficiency Virus (HIV) infections, incidence of tuberculosis, mortality rate attributed to exposure to unsafe WASH (water, sanitation and hygiene) services, and density of nursing and midwifery personnel.

Data were extracted from:

- The line list of COVID-19 cases maintained by the WHO AFRO based on notification by its Member States between 25 February and 31 December 2020 as per their obligations under the International Health Regulations (2005) [15] and the Integrated Disease Surveillance and Response Strategy (IDSR) [16]. Only laboratory-confirmed COVID-19 cases officially reported by Member States were recorded in this dataset. Data were summarised as cumulative number of COVID-19 confirmed
cases reported as of 31 December 2020 by each country. The cumulative incidence expressed as cases per million population was computed by dividing the cumulative number of confirmed cases by the total population.

- The World Bank Open Data (2019 revision) for population density (people per square kilometre land area), percentage of population aged 15-64 years, percentage of urban population (percentage of population living in urban areas), universal health coverage index (average coverage of essential services based on tracer interventions that include reproductive, maternal, new-born and child health, infectious diseases, non-communicable diseases and service capacity and access, among the general and the most disadvantaged population), and health expenditure (percent of gross domestic product) by country [17].
- The WHO diabetes country profiles 2016 for the prevalence of diabetes and prevalence of obesity [18].
- World Mortality 2019 data for the crude death rate [19].
- The database on tests performed as of 31 December 2020, maintained by WHO AFRO based on country reports. The daily number of PCR-tests performed by each country were recorded in this dataset. We computed the cumulative number of tests performed per 10000 population by dividing the cumulative number of tests performed by the total population of each country.
- The World Health Statistics 2020 [20] for the incidence of HIV infections (number of new HIV infections per 1000 population), the tuberculosis incidence (number of new tuberculosis cases per 100000 population), the mortality rate attributed to exposure to unsafe WASH services (expressed per 100000 population) and the density of nursing and midwifery personnel (number of nursing and midwifery personnel per 1000 population).

Data analysis

Using the dataset derived from all collected data, we performed the following analyses:

a) Evolution of the COVID-19 incidence over time

We computed the COVID-19 incidence in each country of the WHO African region during six periods corresponding to time for surpassing the following benchmark in term of cumulative confirmed cases: 1000, 100000, 500000, 1 million and 1.5 million of cumulative COVID-19 cases. The following periods were considered accordingly: 25 February-13 April 2020 (period 1), 14 April-31 May 2020 (period 2), 1 June-14 July 2020 (period 3), 15 July-23 August 2020 (period 4), 24 August-01 December 2020 (period 5) and 02 December -31 December 2020 (period 6).

b) Multivariable analysis of factors associated with COVID-19 incidence

Our outcome of interest was the cumulative COVID-19 incidence. All other variables included in the dataset were selected as covariates. Covariates included the cumulative number of tests performed per 10000 population, percentage of population aged 15-64 years,
population density, percentage of urban population, income classification, universal health service coverage index, health expenditure, prevalence of diabetes, prevalence of obesity, and crude death rate, HIV incidence, tuberculosis incidence, mortality rate attributed to exposure to unsafe WASH services and density of nursing and midwifery personnel.

Due to its flexibility in allowing for overdispersion, risk factors for cumulative COVID-19 incidence were fitted using negative binomial regression. We assumed that the negative binomial model was more appropriate than the Poisson model. The likelihood ratio test was used to test this assumption. Both univariable and multivariable regression models were fitted. As result of the univariable analysis, all covariates with a p-value less than 0.25 [21] were included in the initial multivariable model. A backward stepwise method was used with gradual deletion of variables with p greater than or equal to 0.25. The strength of the association between each covariate and the dependant variable was measured by the beta coefficients with a 95% Confidence Interval (CI). The likelihood ratio test was used to test the goodness of fit of the final model.

Data were analysed using R version 4.0.3 [22] for statistical analysis and ESRI 2017 ArcGIS Pro 2.1.0 [23] for mapping.

RESULTS

Cumulative incidence by country

Between 25 February 2020 and 31 December 2020, a total of 1906726 laboratory confirmed cases of COVID-19 including 43067 deaths were reported from the 46 countries of WHO African region included in this study, resulting in a case fatality ratio of 2.3%. The countries that reported the highest number of cases were South Africa (1057561), Ethiopia (124264), Algeria (99610), Kenya (96458) and Nigeria (87510). These countries accounted for 76.9% of reported cases during the study period. The distribution of confirmed cases reported weekly in the five most affected countries from the WHO African region is shown in Figure 1.

The cumulative incidence as of 31 December 2020 in the WHO African region was 1846 cases per million population. The highest cumulative incidence was reported from Cape Verde (21350 per million), South Africa (18060 per million), Namibia (9840 per million), Eswatini (8151 per million) and Botswana (6044 per million). The lowest incidence was seen in Benin (260 cases per million), Democratic Republic of Congo (203 cases per million), Niger (141 cases per million), Chad (133 cases per million) and Burundi (62 cases per million). Figure 2 shows the distribution of countries by cumulative incidence as of 31 December 2020.

Evolution of the cumulative incidence over time

During period 1 (25 February -13 April 2020), which lasted 46 days, the median incidence was 6 cases per million [range: 0; 256]. The median incidence then increased to 48 cases per
million [range: 1; 2227] during period 2 (14 April to 31 May 2020), 133 cases per million [range: 5; 4507] during period 3 [1 June-14 July 2020], 156 cases per million [range: 2; 5101] during period 4 (15 July-23 August 2020), and 224 cases per million [range: 18, 13245] during period 5 (24 August-01 December 2020), before decreasing to 89 cases per million [range: 3; 4459] during period 6 (2-31 December). The three countries with the highest incidence by period were (i) Mauritius (256 per million) Algeria (46 per million) and South Africa (39 per million) during period 1, (ii) Sao Tome and Principe (2227 per million), Equatorial Guinea (1278 per million) and Gabon (1253 per million) during period 2, (iii) South Africa (4507 per million), Cape Verde (2404 per million) and Equatorial Guinea (1944 per million) during period 3, (iv) South Africa (5101 per million), Cape Verde (3040 per million) and Eswatini (2383 per million) during period 4, (v) Cape Verde (13245 per million), Botswana (3708 per million) and Namibia (3334 per million) during period 5, (vi) and South Africa (4459 per million), Namibia (3987 per million) and Eswatini (2528 per million) during period 6.

Figure 3 shows the geographical distribution of incidence rate by period from 25 February to 31 December 2020.

**Risk factors associated with high COVID-19 cumulative incidence as of 31 December 2020**

Table 2 shows the association between the cumulative COVID-19 incidence and potential risk factors using the non-adjusted and adjusted negative binomial regression analyses.

In the final model, increasing percentage of urban population (beta=0.011, p=0.04) was associated with low cumulative incidence while increasing number of cumulative SARS-CoV-2 tests performed per 10000 population (beta=0.0006, p=0.006) and the proportion of the population aged 15-64 years (adjusted beta=0.174, p<0.0001) were associated with high COVID-19 cumulative incidence.

**DISCUSSION**

In the WHO African region, as of 31 December 2020, South Africa, Ethiopia, Algeria, Kenya and Nigeria were the countries that reported the highest cumulative number of COVID-19 confirmed cases while only South Africa was among the five countries with the highest cumulative incidence (Cape Verde, South Africa, Namibia, Eswatini and Botswana). The disease incidence (cumulative or for a specific period) is one of the metrics used for assessing infectious diseases risk at national or subnational levels [13,24,25]. The difference in incidence between countries in the WHO African region reflects not only the heterogenicity and diversity of countries in the region, but may also reflect the varying response interventions implemented by these countries in accordance with the guidance provided by WHO at regional and global levels [26]. The COVID-19 pandemic has been assigned the highest level of operational response required by the WHO as per its emergency response framework [12]. In such a situation the WHO support to Member States is led by regional
The COVID-19 incidence in countries can be influenced by number of risk factors. In this study, countries with high proportion of the population aged 15-65 years were associated with high COVID-19 cumulative incidence. Although the COVID-19 incidence is known to be higher in non-elderly populations especially in developing countries, the younger population is considered by several authors as one the reasons for low infection rates in Africa [27, 28]. Indeed, Sub-Saharan African countries have a younger demographic structure, with only 3% over the age of 65 years, compared with 23% in Italy [29]. Our results suggest that despite the low number of COVID-19 cases reported in the African region compared to other regions in the world [4], within countries, those with a higher proportion of young population recorded higher COVID-19 incidence. According to Diop et al. [27], the large youth population in Sub-Saharan Africa may lead to more infections but most of these infections will be asymptomatic or mild and a proportion of them will remain undetected. Asymptomatic persons seem to account for approximately 40% to 45% of SARS-CoV-2 infections and can transmit the virus to others for an extended period, perhaps longer than 14 days [30,31].

A modelling study performed by Diop et al. [27] showed that the presence of rural population may be a factor that limits the spread and severity of COVID-19 in Africa. Similarly, an analysis of the time-space geographies of COVID-19 infection focusing on Nigeria suggests that high population densities enhance the spread of COVID-19 [32]. In this study, no association between COVID-19 incidence and population density was found, and the proportion of urban population was negatively associated with the reported COVID-19 cumulative incidence. Our results suggest that countries whose populations are not concentrated in urban areas are more susceptible to the spread of the virus. In most countries in the African region, urban areas are the epicentres of the epidemic, accounting for the vast majority of the confirmed COVID-19 cases [33]. According to Ogunkola IO et al. [34], most attention and implementation of responses to COVID-19 have taken place in urban areas in Africa. Major challenges related to the COVID-19 response in rural areas in Africa include limited access to these areas due to poor road networks, which may hamper the possibility of providing resources and manpower, shortage of healthcare workforce, poor health facilities and limited access to COVID-19 diagnostic services [34]. A concentrated outbreak, especially in major cities, makes containment and response measures easier to implement, especially in a context of limited capacity and scarce resources. Unlike our study, Gupta S et al. [35] found that the number of cases per million was correlated with the percentage of urban population in 17 countries in Europe and America. Gupta D et al. [36] found a positive association between urbanization and COVID-19 incidence in India.

In this study, the cumulative incidence of COVID-19 was positively associated with the cumulative number of SARS-CoV-2 tests performed per 10000 population. In a context of community transmission, it is known that the more SARS-CoV-2 tests are performed the more cases are detected. Testing capacity is a major limiting factor in assessing the true extent
of SARS-COV-2 transmission, as countries tend to restrict testing to individuals that meet specifically narrowed criteria [37,38]. While countries in the WHO African region appear to be experiencing much lower rates of COVID-19 compared to countries in other WHO regions, their significantly lower testing capacity may grossly under-estimate incidence rates [37]. Such correlations underscore not only the importance and centrality of testing in detection, monitoring and control of the pandemic, but also the need for Member States in the WHO African region to widely scale up testing capacity.

Our study did not find an association between the cumulative COVID-19 incidence and the prevalence or incidence of comorbidities such as diabetes, obesity, HIV infections and tuberculosis. Comorbidities are known to be risk factors for severe illness and mortality from COVID-19 [39,40].

No association was found between high COVID-19 cumulative incidence and health and economic indicators such as health expenditure and universal health service coverage index. However, such lack of association may be related to the nature of the study, which considers only national reported figures, since subnational data are generally not available. The effect of health systems and the level of income on COVID-19 incidence may have been masked by the simultaneous nature of the COVID-19 outbreak across the region, which has universally suffered from overwhelmed health systems and response capacities.

LIMITATIONS

In this study, we estimated the reported cumulative COVID-19 incidence assuming that repeated positive laboratory confirmations from the same individual are not included in the case count. The incidence for each country was calculated based on reported cases, which included only confirmed cases as Member States are not reporting probable cases. Given the low testing capacity in most countries of the WHO region, there is likely under-detection of cases leading to under-estimation of the reported incidence. Further investigations are needed to better estimate attack rates as seroprevalence data become available for most Member States.

Regarding the selected risk factors, we used the most recent available data, most of which were not from the same year as the data used to calculate the cumulative COVID-19 incidence. Some data used were sourced from publicly available repositories and therefore subject to the limitations of their sampling, study design, and data collection processes. Further, some of the risk factor metrics used, such as HIV incidence, TB incidence, mortality rate attributed to exposure to unsafe WASH services, may have been influenced by PHSM implemented by each Member State. Only national data were used for risk factors as subnational data are not available in most country. This may have masked the association between the cumulative incidence and some metrics used as risk factors in this study. The interpretation of the results presented here should take these limitations into account.
CONCLUSION

The African region continues to be affected by the COVID-19 pandemic with disparities in disease incidence. Our study showed the relationship between the cumulative COVID-19 incidence and the number of tests performed per 10000 population, the proportion of population aged 15-64 years and the proportion of urban population. In a context of limited testing capacities and overwhelmed health systems, the findings of this study highlight the need for countries not only to increase and decentralize their testing capacities, but also to adjust testing strategies to target those most at risk in the population. The rapid control of the pandemic, even with the potential for vaccine distribution, will rely on country capacity to detect and rapidly isolate all cases. Countries need to continuously monitor the COVID-19 incidence at sub-national level to adjust public health and social measures in areas with increased incidence and ongoing widespread community transmission. More generally, our findings highlight the need for developing a culture of data management and use for strategic decision-making as part of preparedness and response to public health emergencies.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on request from the corresponding author.

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Figure 1: Distribution of COVID-19 confirmed cases by week of reporting in the WHO African region, Top 5 countries and 41 other countries (data as of 31 December 2020).

Period 1: 25 February-13 April 2020, Period 2: 14 April-31 May 2020, Period 3: 1 June-14 July 2020, Period 4: 15 July-23 August 2020, Period 5: 24 August-01 December 2020, Period 6: 02 December -31 December 2020.
Figure 2: Cumulative number of COVID-19 cases per million population in 46 countries of the WHO African region, as of 31 December 2020
Table 1: COVID-19 incidence (cases per million population) in the African region by period from 25 February to 31 December 2020

| Country     | 25 Feb-13 April (Period 1) | 14 April-31 May (Period 2) | 1 June-14 July (Period 3) | 15 July-23 August (Period 4) | 24 August-01 December (Period 5) | 02 December-31 December (Period 6) |
|-------------|-----------------------------|------------------------------|---------------------------|-------------------------------|----------------------------------|------------------------------------|
|             | Nb* cases | Incidence | Nb cases | Incidence | Nb cases | Incidence | Nb cases | Incidence | Nb cases | Incidence | Nb cases | Incidence | Nb cases | Incidence | Nb cases | Incidence |
| Algeria     | 1983      | 46        | 7411     | 172       | 10822    | 251       | 21244    | 493       | 42692    | 992       | 15458    | 359       |
| Angola      | 19        | 1         | 67       | 2         | 455      | 16        | 1630     | 56        | 13080    | 447       | 2302     | 79        |
| Benin       | 35        | 3         | 208      | 17        | 1220     | 98        | 652      | 52        | 940      | 75        | 196      | 16        |
| Botswana    | 13        | 5         | 25       | 10        | 361      | 147       | 909      | 371       | 9409     | 3841      | 4088     | 1669      |
| Burkina Faso| 515       | 25        | 368      | 18        | 155      | 8         | 300      | 15        | 1672     | 81        | 3818     | 185       |
| Burundi     | 5         | 0         | 58       | 4         | 206      | 16        | 161      | 12        | 259      | 20        | 133      | 10        |
| Cameroon    | 855       | 33        | 5049     | 195       | 10153    | 392       | 2916     | 113       | 5647     | 218       | 2228     | 86        |
| Cape Verde  | 10        | 18        | 425      | 773       | 1345     | 2446      | 1729     | 3144      | 7307     | 13287     | 1024     | 1862      |
| CAR         | 11        | 2         | 1058     | 223       | 3293     | 694       | 328      | 69        | 231      | 49        | 42       | 9         |
| Chad        | 23        | 1         | 767      | 48        | 94       | 6         | 102      | 6         | 714      | 45        | 413      | 26        |
| Comoros     | 106       | 14        | 537      | 100       | 1747     | 325       | 1492     | 277       | 1924     | 358       | 426      | 79        |
| Congo       | 74        | 14        | 2179     | 85        | 10204    | 397       | 4550     | 177       | 3791     | 147       | 872      | 34        |
| Cote d'Ivoire| 654      | 25        | 2954     | 34        | 4968     | 57        | 1679     | 19        | 3145     | 36        | 4671     | 54        |

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| Country         | 25 Feb-13 April (Period 1) | 14 April-31 May (Period 2) | 1 June-14 July (Period 3) | 15 July-23 August (Period 4) | 24 August-01 December (Period 5) | 02 December-31 December (Period 6) |
|-----------------|-----------------------------|-----------------------------|---------------------------|-------------------------------|----------------------------------|----------------------------------|
|                 | Nb* cases | Incidence | Nb cases | Incidence | Nb cases | Incidence | Nb cases | Incidence | Nb cases | Incidence | Nb cases | Incidence |
| Eq Guinea       | 41        | 30        | 1733     | 1278      | 2694     | 1987      | 458      | 338       | 233      | 172       | 118      | 87        |
| Eritrea         | 34        | 11        | 5        | 2         | 193      | 60        | 74       | 23        | 271      | 84        | 743      | 231       |
| Eswatini        | 14        | 12        | 271      | 236       | 1149     | 1001      | 2791     | 2431      | 2217     | 1931      | 2916     | 2540      |
| Ethiopia        | 74        | 1         | 1098     | 10        | 7009     | 63        | 32490    | 290       | 69883    | 624       | 13710    | 122       |
| Gabon           | 76        | 35        | 2727     | 1255      | 3139     | 1445      | 2446     | 1126      | 803      | 370       | 380      | 175       |
| Gambia          | 9         | 4         | 16       | 7         | 39       | 17        | 2622     | 1117      | 1079     | 460       | 35       | 15        |
| Ghana           | 636       | 21        | 7245     | 238       | 18691    | 614       | 17197    | 565       | 8429     | 277       | 2732     | 90        |
| Guinea          | 319       | 25        | 3452     | 270       | 2429     | 190       | 2767     | 217       | 4176     | 327       | 595      | 47        |
| Guinea-Bissau   | 40        | 21        | 1282     | 667       | 605      | 315       | 222      | 116       | 292      | 152       | 6        | 3         |
| Kenya           | 208       | 4         | 1754     | 33        | 8829     | 168       | 21573    | 410       | 51805    | 985       | 12289    | 234       |
| Lesotho         | 2         | 1         | 254      | 120       | 793      | 373       | 1088     | 512       | 440      | 207       | 163      | 33        |
| Liberia         | 57        | 12        | 239      | 48        | 760      | 154       | 234      | 47        | 347      | 70        | 163      | 33        |
| Madagascar      | 108       | 4         | 687      | 25        | 4548     | 169       | 8984     | 333       | 3014     | 112       | 373      | 14        |
| Malawi          | 16        | 1         | 268      | 14        | 2213     | 119       | 2917     | 157       | 614      | 33        | 555      | 30        |
| Mali            | 123       | 6         | 1140     | 58        | 1045     | 53        | 397      | 20        | 2057     | 105       | 2328     | 118       |
| Mauritania      | 7         | 2         | 523      | 116       | 4988     | 1102      | 1387     | 306       | 2454     | 542       | 4283     | 946       |
| Country           | 25 Feb-13 April (Period 1) | 14 April-31 May (Period 2) | 1 June-14 July (Period 3) | 15 July-23 August (Period 4) | 24 August-01 December (Period 5) | 02 December-31 December (Period 6) |
|-------------------|----------------------------|-----------------------------|---------------------------|-------------------------------|-----------------------------------|-----------------------------------|
| Mauritius         | 324                        | 11                          | 8                         | 3                             | 159                               | 22                                |
| Mozambique        | 21                         | 233                         | 1014                      | 2127                          | 12375                             | 2872                              |
| Namibia           | 16                         | 8                           | 936                       | 5070                          | 8447                              | 10068                             |
| Niger             | 570                        | 388                         | 141                       | 73                            | 414                               | 1622                              |
| Nigeria           | 343                        | 9819                        | 23454                     | 18611                         | 15611                             | 19672                             |
| Rwanda            | 127                        | 243                         | 1046                      | 1673                          | 2859                              | 2435                              |
| Sao Tome & Principe | 4                       | 479                         | 253                       | 156                           | 104                               | 18                                |
| Senegal           | 301                        | 3344                        | 4598                      | 4706                          | 3158                              | 3033                              |
| Seychelles        | 9                         | 95                          | 29                        | 37                            | 95                                | 95                                |
| Sierra Leone      | 10                         | 851                         | 790                       | 341                           | 421                               | 147                               |
| South Africa      | 2272                       | 30411                       | 265609                    | 311481                        | 182526                            | 265262                            |
| South Sudan       | 4                          | 1143                        | 1006                      | 354                           | 611                               | 440                               |
| Togo              | 77                         | 365                         | 289                       | 546                           | 1720                              | 636                               |
| Uganda            | 54                         | 399                         | 590                       | 1319                          | 19047                             | 14102                             |
| Zambia            | 45                         | 1034                        | 1284                      | 8719                          | 6583                              | 3060                              |
| Zimbabwe          | 18                         | 159                         | 887                       | 4866                          | 4199                              | 3738                              |
| Country            | 25 Feb-13 April (Period 1) | 14 April-31 May (Period 2) | 1 June-14 July (Period 3) | 15 July-23 August (Period 4) | 24 August-01 December (Period 5) | 02 December-31 December (Period 6) |
|--------------------|-----------------------------|-----------------------------|---------------------------|-----------------------------|----------------------------------|-----------------------------------|
|                    | Nb* cases | Incidence | Nb cases | Incidence | Nb cases | Incidence | Nb cases | Incidence | Nb cases | Incidence | Nb cases | Incidence |
| African region     | 10397     | 10        | 92541    | 90        | 405823   | 393       | 495214   | 479       | 498040   | 482       | 404711   | 392       |

*Nb= number of. ** Central African Republic *** Democratic Republic of Congo

† Data in this table may be slightly different to those publicly available in the World Health Organization website due to reporting delays.
Figure 3: Geographical distribution of the COVID-19 incidence by period (from 25 February to 31 December 2020) in the WHO African region.

Table 2: Multivariable analysis of factors associated with the high cumulative COVID-19 incidence in the WHO African region as of 31 December 2020.

| Explanatory variables                        | Mean value ± sd | Crude Beta coefficient [95% CI] | Adjusted Beta coefficient (final model) [95% CI] |
|----------------------------------------------|-----------------|---------------------------------|-----------------------------------------------|
| % Population aged 15-64 years                | 56.6 ± 4.8      | 0.212 [0.154, 0.275]***        | 0.174 [0.111; 0.239]***                      |
| percentage of urban population               | 56.6 ± 17.4     | -0.014 [0.032; 0.004]          | -0.011 [-0.002; -0.0008]*                    |
| Population density                           | 111.8 ± 139.5   | -0.002 [-0.005; -0.0005]*      | -0.001 [-0.0003; 0.0002]                     |
| Universal health service coverage index      | 56.6 ± 4.8      | 0.081 [0.061; 0.102]***        |                                               |
| Health expenditure (percent of growth domestic product) | 5.7 ± 2.2      | 0.097 [-0.089;0.288]          | -0.070 [-0.157; 0.021]                      |
| Number of SARS-CoV2 tests performed per 10,000 population | 406.9 ± 626.5   | 0.016 [0.001; 0.002]***       | 0.0006[0.00009; 0.0012]**                   |
| Prevalence of Diabetes (%)                   | 5.6 ± 2.2       | 0.416 [0.224; 0.621]***       |                                               |
| Prevalence of Obesity (%)                    | 9.3 ± 6.0       | 0.171 [0.017;0.229]***        |                                               |
| Crude death rate (per 10,000 population)     | 56.6 ± 4.8      | -0.148 [-0.324; 0.268]        |                                               |
| HIV infections incidence (per 1000 population) | 1.7± 2.2       | 0.207[0.059; 0.383]**         | 0.089 [-1.124; 0.197]                       |
| Explanatory variables                                                                 | Mean value ± sd | Crude Beta coefficient [95% CI] | Adjusted Beta coefficient (final model) [95% CI] |
|----------------------------------------------------------------------------------------|-----------------|--------------------------------|-----------------------------------------------|
| Tuberculosis incidence (per 100,000 population)                                         | 218.4± 160.2    | 0.002[-0.0007; -0.005]**       |                                               |
| Mortality rate attributed to exposure to unsafe WASH services (per 100,000 population) | 38.9± 23.0      | -0.042[-0.051; -0.032]**       |                                               |
| Density of nursing and midwifery personnel (per 10,000 population)                      | 25 (54.3)       | 0.074 [0.041; 0.109]**         |                                               |

*p < 0.05; **p < 0.01; ***p < 0.001; sd: Standard Deviation. CI: confidence interval. Likelihood ratio test: $\chi^2 = 21.1, p = 0.58.$