First wave of the COVID-19 pandemic in Africa's island nations: A descriptive study of the variation in the disease burden

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ABSTRACT:

Motivated by the idea that island nations might respond differently to non-island countries in handling pandemic situations, we aimed to study the first wave of COVID-19, along with the potential reasons behind the variation in disease burden, across the six African island nations: Cabo Verde, Comoros, Madagascar, Mauritius, São Tomé e Príncipe, and Seychelles. We analysed the publicly available COVID-19 data on confirmed cases and deaths from the beginning of the pandemic through 29 November 2020, to give an overview of the course of the pandemic in these nations. To understand the variation in disease burden across nations, we first explored their economic statuses, healthcare expenditures and facilities, ranging from the numbers of hospital staff to the PCR tests performed, and the main health risk factors. We further examined the age and sex distributions and densities of the overall and urban populations, along with analyzing the main industries in these countries. We also reviewed the non-pharmaceutical response measures implemented nationally. By presenting a comprehensive picture of the healthcare, socioeconomic, and demographic situation and describing the control measures taken by the governments, we aimed to evaluate the possible determinants of the variation in COVID-19 disease burden across the islands.

Keywords: COVID-19, African island nations, SIDS, Cabo Verde, Comoros, Madagascar, Mauritius, Sao Tome e Principe, Seychelles, SARS-CoV-2, disease burden, non-pharmaceutical measures

Summary box

What is already known?

- The geographical context of island nations might enable them to control a disease outbreak better than other countries.
- However, many African island countries face substantial challenges in dealing with global health emergencies due to their limited healthcare facilities and strong dependence on tourism.

What are the new findings?

- All African islands, with the exception of Cabo Verde, experienced similar epidemiological curves with an initial increase of cases, which decreased in a relatively short amount of time after implementing measures.
- Variations in COVID-19 disease burden across the six island nations could be attributed to the substantial differences in their economy, healthcare system, health risk factors, testing facilities, major industries, age and sex distributions, urbanization, and population density.
- All countries followed similar non-pharmaceutical response strategies to contain the spread of COVID-19 and protect public health.

What do the new findings imply?

- Variations in the potential determinants of COVID-19 disease burden should be taken into account in designing or proposing effective policies to control a pandemic.
- Further research is needed to evaluate the role of the geographic context in the evolution of an outbreak, especially with regard to small island developing states such as five among the six African islands included.
- Early interventions and movement restrictions at the beginning of an outbreak were important in controlling its evolution at the local level. Hence, premature lifting of the imposed restriction measures might jeopardise the effective management of an outbreak at the national level.
- Action and investments are needed to strengthen the healthcare system of the studied countries, as well as to decrease the dependencies of their economies on international travel.

INTRODUCTION

In 2020, the global health situation changed due to the spread of a new virus, Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2), which was first detected at the end of 2019 in Wuhan, China [1]. The World Health Organization (WHO), on 11 March 2020, declared the novel coronavirus (COVID-19) outbreak a global pandemic [2]. This situation has led the scientific community to ponder various ways to control the pandemic. Motivated by the notion that island nations could perform differently from other countries in handling pandemic situations [3,4], similar to descriptions of the first wave of COVID-19 in New Zealand, Greece, Iceland [5-7] and Japan [8], we aimed to study the first wave of COVID-19 across the African island nations and the potential reasons behind the variation in disease burden.

During the pandemic, national governments implemented a combination of non-pharmaceutical measures that included travel and movement restrictions, lockdowns, curfews, limited social interactions, and physical distancing. These interventions were aimed to contain the outbreak, for which no effective vaccine or specific drug was available, in order to avoid overburdening the healthcare system, and otherwise mitigate the pandemic's negative impacts at the local and national levels [9,10,12]. Such interventions, though highly variable in methodologies and execution, most aimed at limiting viral transmission, protecting the most vulnerable individuals from exposure, and detecting, isolating and treating infected individuals. In most instances, the adopted strategies were based on the local context, available resources, critical challenges, and the epidemiological characteristics of COVID-19 at the time of the decision making [11]. While these policies are often in response to the existing pandemic situation such as a high number of newly confirmed cases, they also affect future transmission, morbidity, and mortality [13]. Hence, while discussing the factors that vary across the African islands and could account for the variation in the COVID-19 disease burden, we also reviewed the non-pharmaceutical response measures implemented nationally. Thus far, to our knowledge, there have been no published studies focusing exclusively on the COVID-19 outbreaks across these countries.

AFRICAN ISLANDS BACKGROUND

There are six island nations in the African continent: Cabo Verde, Comoros, Madagascar, Mauritius, São Tomé e Príncipe, and Seychelles, five of which belong to the Small Island Developing States (SIDS) [14]. Aside from Madagascar, which has a relatively large land area and population size, all are small countries characterized by small populations, remoteness, dependence on international trade, strong tourism and fishing industries, limited resources due to their small economies, and vulnerability to external global financial shocks [15-18]. Moreover, they also face limitations regarding access to healthcare services [19]. The resource constraints that SIDS face in combination with the limited access to healthcare restricts their capability to respond to global health emergencies [20]. Further, the global health security index, which measures the capacities of the countries to detect, prevent, and handle health emergencies, is below 35 across the studied countries, when the global average is 40.2, and average score of high income countries is 51.9 [21]. On the other hand, they share common geographic features such as fragmented populations and lack of land borders, which may help in restricting virus spread [19], by controlling their borders effectively and rapidly. However,

reduced connectivity can result in the delay of imported goods and jeopardise medical evacuations [22]. The performance of different island countries in response to COVID-19 likely depended on the complex interplay between these factors.

Box 1: Data analysis and information about various data sources used.

For the epidemiological description of the pandemic, to quantify the disease burden, we described the number of cases/deaths and cases/deaths per million in each African island country and constructed epidemiological curves from the beginning of the pandemic until 29 November 2020 (Tables 1 and S1; Figures S1-S3). We included cases confirmed with PCR tests and rapid diagnosis tests (viral antigen). At the time, confirmation required a positive PCR test result for SARS-CoV-2. However, cases marked as 'probable' due to sole availability of rapid diagnostic tests - representing only 70 cases from Comoros- were also included in the present analyses. We excluded cases with missing clinical outcome status.

The variables used in this analysis included: the reporting date, the laboratory results of the SARS-CoV-2 test (confirmed, probable), and the clinical outcome (alive, dead, recovered). These data were collected from each country's Ministry of Health report. The number of confirmed cases were presented in graphs with a timeline of restriction measures (Figure S3), whereas cases per million, deaths per million and case fatality rate (CFR) were presented in tables (Tables 1 and S1). In order to calculate the cases per million and deaths per million, population sizes were obtained from the indexmundi [23]. Information about the total number of PCR tests performed along with the positive number of PCR tests, were obtained from the country's situational reports or from the bulletins of the Ministry of Health (MoH). We have presented this information in a table (Table 3).

To prepare a complete overview of the socioeconomic, healthcare, and population structures of the studied countries, data were obtained from the latest available scientific reports published by various international institutions and nongovernmental organisations. Information about the measures adopted by each country in response to the COVID-19 pandemic were based on the COVID-19 Government Measures Dataset published by ACAPS, and were obtained from the published literature, the reports provided by the national health ministries, news articles, social media (including official government pages from FacebookTM and TwitterTM) [24].

Data were processed and analysed using the R software, version 4.0.2 (<https://www.r-project.org/>).

Stringency index: The measures adopted in response to the pandemic were described using the stringency index created by the Oxford Coronavirus Government Response Tracker (OxCGRT) project, a composite measure of the strictness of government policies based on nine response indicators, and can take values between 0 and 100 (100 = strictest). The response indicators used to produce the stringency index are: school closures, workplace closures, cancellation of public events, restrictions on public gatherings, closures of public transport, stay at home requirements, public information campaigns, restrictions on internal movements, international travel controls, as listed in the official website of the project [25].

COVID-19 PANDEMIC IN THE AFRICAN ISLANDS

In Table 1, we show the disease burden associated with COVID-19 using the total numbers of confirmed cases, deaths, case fatality rate (deaths/cases), cumulative attack rates (cases per million), and deaths per million (cumulative number of deaths/population size in millions). The total number of cases ranged from 172 in Seychelles to 17341 in Madagascar. Similarly, the number of deaths ranged from 0 in Seychelles to 104 in Cabo Verde and 251 in Madagascar, with four of the six islands managing to control the number of reported deaths below 20. However, after accounting for the population sizes, we found that Mauritius (395.83) and Seychelles (0.00) had the lowest cases per million and deaths per million, respectively. We also noticed that two islands present in the Atlantic ocean, Cabo Verde and São Tomé e Príncipe reported the highest and second-highest cumulative attack rates (cases per million) and deaths per million, respectively (Figures S1-S2; Table 1). In fact, Cabo Verde had the highest cases per million and second-highest deaths per million among all the sub-Saharan African countries (Table S1). Overall, CFR ranged from 0.00% in Seychelles to 2.00% in Mauritius. However, CFRs were lower or equal to the global average of 2-3% [13] during the first COVID-19 wave. The relatively small numbers of cases and deaths made it challenging to do any further analyses. Although the total number of confirmed cases appear low, the cumulative attack rates and deaths per million are high for most African islands compared to their non-island counterparts, owing to the low population sizes of the islands (Table S1).

An overview of the course of the pandemic in the African island nations (Figure S1) shows that the cumulative number of cases remained almost constant from August 2020 onwards, with the exception of Cabo Verde, where the daily incidence of confirmed cases was growing continuously until 29 November 2020. Similarly, the daily death counts and the number of deaths per million people in Cabo Verde kept increasing until the end of the study period, unlike other countries (Figure S2).

EXAMINING POTENTIAL FACTORS CONTRIBUTING TO VARIATION IN COVID-19 DISEASE BURDEN

Economy, healthcare, and health-risk factors: According to the World Bank classification, Mauritius and Seychelles are high-income countries, Comoros, São Tomé e Príncipe and Cabo Verde are lower-middle-income countries, and Madagascar is a low-income country [26]. In healthcare, the level of governmental expenditure, as well as the encumbrance that the out of pocket expenditure has on the livelihoods of the households differs substantially among the countries, while they roughly remained the same during 2016-18 for each country (Tables 2 and S2). At first glance, it seems that all countries invest similar percentages of their annual GDP in healthcare services with São Tomé e Príncipe spending the highest (6.3% of the total GDP in 2018), and Comoros the lowest (4.6% in 2018). However, due to large differences in their total GDP we can see that the expenditure per capita differs substantially, with Seychelles spending around 833 dollars per capita per year, while Madagascar is spending the lowest, 22 dollars per capita per year, in 2018. As a result, the out of pocket expenditure that the households need to cover can be as low as 15% and 23.5% of the total health expenditure for São Tomé e Príncipe and Seychelles, respectively, but it can increase up to 74.5% for Comoros [27]. Finally, the

higher numbers of doctors, nurses, and beds per 1,000 population, in Mauritius and Seychelles, are indicative of a better healthcare system (Table 2).

Table 2 also presents some indicators of the healthcare system in the African island countries and indicators about health risk factors [28]. According to WHO, pre-existing chronic health conditions, such as diabetes, obesity, and cancer, air pollution, and riskier behaviors like smoking, may increase the risk for severe COVID-19 disease [29]. Overall, Seychelles have a high prevalence of most of the pre-existing chronic health conditions (Table 2) despite their better healthcare facilities.

Testing: The availability of laboratory resources and equipment is a vital requirement for the early confirmation of positive cases and the epidemiological monitoring of the evolution of the outbreak at a national level. To this end, São Tomé e Príncipe and Cabo Verde, faced challenges at the beginning of the pandemic since they had to send samples for analysis to other countries, until their laboratories were ready to process suspected COVID-19 samples, which caused considerable delays in confirming positive cases [30,31]. This might have resulted in an early epidemic spread before the implementation of restriction measures and caused the very high cumulative attack rates (and deaths per million) in these islands (Table 1). In fact, it appears that the increase of cases in Cabo Verde occurred when the government initiated a free testing policy [31]. It is also possible that before that testing policy, the small number of available tests caused a sub-notification of cases, which led to a premature lifting of some restrictive measures while the number of cases was still increasing in the country. Table 3 shows information about the total number of tests performed in each country and the positivity rate. Mauritius, due to their mass testing policy that included precautionary testing of all frontliners [32], reported the highest number of total tests performed overall, with Seychelles reporting the lowest number of tests. However, when analyzing the number of tests by population, Cabo Verde did the largest number of tests per 10,000 inhabitants and Madagascar the lowest. The test positivity rate was the highest in Madagascar with 18.5% and the lowest in Mauritius with 0.4%, as of Nov 24, 2020. However, it should be noted that all countries did not equally access PCR tests. The criteria to test varied by country, as well as by period of the pandemic within each country. Countries used tests as a surveillance and/or diagnosis tool. Since the inclusion criterion in this study was a positive PCR test, possible misdiagnosis bias would decrease the number of cases considered.

Main industries: Tourism is a primary industry for most islands, whereas Comoros and São Tomé e Príncipe rely mainly on agriculture and fishing [33]. Fishing is a leading industry in Madagascar and Seychelles also [34]. The strong tourism and fishing industries causing a higher circulation of people in these countries may explain the quick increase in the number of cases at the beginning of the pandemic. The international movement of people, for tourism or work, was already documented as an important factor for the spread of the virus in the beginning of the epidemic [35-37].

Age distribution: There exist differences in the age structure among islands (Table 3), which can have an impact on the number of deaths. It is known that the risk of death is higher among older people [38]. Given that Mauritius and Seychelles have a much higher percentage of people over 55 years of age (23.4% and 19.7%, respectively) in comparison to the other four

island countries, we would expect higher mortality. Another interesting point about the age distribution is that Comoros, Madagascar, and São Tomé e Príncipe have approximately 40% of the population under 14 years of age. With this age distribution, it would be expected that these countries had lower mortality since children are less affected by severe COVID-19 [39,40].

Population structure and sex: Factors such as population density and urbanization have influenced the arrival of the first case and the within-country speed of the epidemic, respectively, in the context of the whole African continent [37]. While the dependence of the arrival of the first case may not be on population density in the context of islands, the early spread of COVID-19 could still be influenced by urbanization and might also explain the high attack rates in Cabo Verde, São Tomé e Príncipe, and Seychelles (see Tables 1 and 3). Further, while the mortality rates can be affected by sex [41], all islands have a population ratio of males to females approximately equal to 1. However, unless we know this fraction among the infected individuals, we cannot rule out the effect of sex.

NON-PHARMACEUTICAL MEASURES IN RESPONSE TO COVID-19 PANDEMIC

In response to the COVID-19 pandemic, each country enforced different restriction measures. The countries followed similar response strategies to contain the spread of the virus and protect public health. All island nations decided to close their international borders soon after the detection of the first confirmed case (Figure S3). The state of emergency, accompanied by the implementation of lockdowns, has been activated in all countries. More specifically, in Mauritius and Madagascar, it happened two days after the official confirmation, in Comoros after four days, in Cabo Verde after eight days, in São Tomé e Príncipe after 17 days, and in Seychelles after 23 days (Figure S3). Some of these islands implemented protective measures even before the reporting of the first case in their territory. In this case, the most used ones were health screenings at the entry points, entry restrictions, and isolation and quarantine policies. More specifically, Mauritius and Comoros organized quarantine centers for the isolation of COVID-19 patients [42]. No information about these facilities was available for the other countries. All countries enforced movement restrictions to contain the virus's spread soon after the confirmation of the first case in their territory [24]. Since decreasing crowding and people's movement have proven crucial to avoid the virus spreading, the scientific community developed the stringency index [25]. In Figure S4, we present the stringency index evolution for four of the six African islands nations (there was no information available about the stringency index for Comoros and São Tomé e Príncipe). All four islands implemented strict movement restrictions soon after the first COVID-19 case was confirmed. The level of strictness of the implemented measures did not differ considerably at the beginning of the outbreak. It is clear that Seychelles and Mauritius deactivated most of the restrictions in June 2020 and Madagascar in September 2020, while Cabo Verde maintained most restrictions until the end of November 2020. The evolution of the measures is compatible with the evolution of the outbreak in those countries. After the countries managed to decrease the daily incident, the implemented restrictions were decreased.

Impact of the policies and the epidemiological curves: All countries, with the exception of Cabo Verde, experienced similar epidemiological curves with an initial increase of daily

incidence, which decreased in a relatively short amount of time after implementing measures (Figure S3). In most countries the first wave was followed by a time period of several months of scarcely reported confirmed cases, except for Cabo Verde.

CONCLUSIONS

This research work presents a complete overview of the evolution of the COVID-19 outbreaks in the African island nations up to 29 November 2020. We have discussed in detail the variation in the demographic, socioeconomic, and healthcare system profiles of these countries that could be responsible for the observed difference in disease burden across them.

In a pandemic caused by a virus with respiratory transmission, where several containment measures were introduced simultaneously, the evaluation of their level of effectiveness in controlling the spread of the virus in the different stages of the outbreak was not feasible. However, it appears that the implemented restriction measures in the initial phase were crucial in containing the number of cases in the African island nations.

In the context of pandemic control in island countries, the closure of borders and possibly the control of imported cases might be easier. It would be important to discern the number of imported versus local transmissions. Unfortunately, this data was not available for these countries.

Future research work should investigate the impact of the geographic characteristics in the spread of a virus with aerial transmission. In addition, a detailed study on the course of the pandemic on all SIDS would help policy and decision makers of these countries. It would also be interesting to investigate how African islands performed in comparison with high income island countries from Europe and Asia-Pacific regions.

Moreover, considering the dependence of the island countries on imports and the tourism industry, extended lockdowns and border closure can clearly have grave results on the employment of the population and the local economies. Further research is needed to reveal the long term outcomes of COVID-19 in these countries.

Contributors:

TK conceived the idea of this study. JD, TK, DV, AJ designed the study and conducted the research. JD, TK, DV, AJ actively took part in weekly discussions and exchanged ideas that were crucial for the progress of this article. JD acquired, managed, cleaned, and analyzed the data with the support of AJ and JLA. JD, AJ, TK, DV interpreted the data. TK and DV conducted the literature review with the support of JD and AJ. JD, TK, DV, and AJ drafted the initial manuscript. AJ and JD finalised the manuscript after improving it substantially with the support of TK. CBH, JLA, CC, OK, and BI made substantial contributions in reviewing the design of the study and contributed by revising the manuscript critically for important intellectual content. We also acknowledge and thank Laëtitia Viau for initially compiling a portion of the data used. All authors contributed to final approval of the version to be submitted.

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Data availability statement: The authors confirm that the data supporting the findings of this study are available within the article [and/or] within its supplementary materials, and on https://github.com/JyotiDalal93/COVID-19_SSA/blob/main/data_6_country.csv

This research does not contain any studies with human participants or animals performed by any of the authors. Thus, ethics approval is not required.

Figures and Tables:

Table 1: The numbers of total cases and deaths, the case fatality rate (CFR), the cumulative attack rates (cases per million) and deaths per million for each island country are shown. We have shown CFRs in percentages.

Country	Cases	Deaths	CFR (in %)	Population in thousands	Cases per million	Deaths per million
Cabo Verde	10526	104	0.99	549.93	19140.62	189.11
Comoros	606	7	1.16	850.89	712.20	8.23
Madagascar	17341	251	1.45	26969.31	642.99	9.31
Mauritius	501	10	2.00	1265.71	395.83	7.90
São Tomé e Príncipe	989	17	1.72	215.06	4598.72	79.05
Seychelles	172	0	0	97.63	1761.75	0

Table 2: Various indicators measuring the level of healthcare in each country and the level of different health risk factors proven to increase the risk of severe disease and death from COVID-19. STP = São Tomé e Príncipe.

*(age standardized estimate) %

	Cabo Verde	Comoros	Mauritius	Madagascar	STP	Seychelles
#doctors/1k pop.	0.9	0.27	2.53	0.18	0.32	2.12
#Nurses & Midwives/1 k pop.	1.3	0.63	3.52	0.15	1.92	8.08

Available healthcare facilities	167 health posts, 19 health centers, 3 district hospitals, 2 regional hospitals	52 health posts (47 public), 12 health centers (10 public), 2 district hospitals, 2 provincial hospitals, 1 regional hospital	110 health posts, 2 health centers, 2 district hospitals, 5 provincial hospitals, 5 regional hospitals	1972 health posts (2435 public), 63 health centers (57 public), 76 district hospitals (30 public), 25 provincial hospitals (18 public), 6 regional hospitals	28 health posts, 4 health centers, no hospitals	19 health posts (13 public), 5 health centers (4 public), 1 regional hospital
Density of health posts/100k pop.	33.47	7.07	8.84	12.96	14.51	20.47
Density of the health center/ 100k pop.	3.81	1.63	0.16	0.28	2.07	5.39
#Hospitals	5	5	12	54	1	1
#Hospital beds/1k	2.1	2.2	3.4	0.2	2.9	3.6
Current health expenditure per capita (current US\$) in 2018	194.86	65.23	653.35	22.05	125.40	833.08
Current health expenditure (% of GDP) in 2018	5.36	4.59	5.83	4.79	6.27	5.11
Out-of-pocket	27.96	74.55	48.54	28.10	15	23.54

expenditure (% of current health expenditure) in 2018						
Health risk factors						
Prevalence of obesity among adults *	11.8	7.8	10.8	5.3	12.4	14
Estimate of daily tobacco use prevalence *	-	17.1	21.4	23	4.1	16.3
Alcohol per capita consumptio n 15+ (in liters of pure alcohol)	4.13	0.23	3.09	0.91	3.88	20.05
Estimate of insufficient physical activity among adults 18+ *	19.68	14.32	29.77	17.17	15.47	18.84
Air pollution attributable DALYs (per 100.000)	944.2	1378	976	1099	986.1	1178
100*Probab ility of	17.44	20.62	23.19	25.99	20.97	21.11

dying between the age of 30 to 70 due to diabetes, cardiovascular disease, cancer, or chronic respiratory disease						
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Table 3: Depicting the population distribution by age, population density, percentage of population staying in the urban areas, and males to females ratio, and the testing information (number of SARS-CoV-2 PCR tests performed and the positivity rate recorded in each country). We have shown test positivity in percentage. STP = São Tomé e Príncipe.

	Cabo Verde	Comoros	Madagascar	Mauritius	STP	Seychelles
Age distribution						
0 - 14 years (in %)	31.2	36.68	38.86	19.44	39.77	18.85
15-24 years (in %)	21.8	20.75	20.06	14.06	21.59	12.39
25-54 years (in %)	37.3	33.99	33.02	43.11	31.61	49.03
55-64 years (in %)	4.5	4.49	4.6	12.31	4.17	11.46
65+ years (in %)	5.2	4.08	3.47	11.08	2.87	8.27
Population density (per sq km)	135	447	45	623	220	210
Urban population (in %)	66.20	29.16	37.86	40.77	73.6	57.1
Males to females ratio	1.01	1.02	1	0.98	1	1.05
Testing information						
Total number of PCR tests	67280	6227	93734	133731	8578	3482

Positive PCR tests	9960	607	17341	497	981	167
Test positivity (in %)	14.8	9.7	18.5	0.4	11.4	4.8
Number of PCR tests per 10,000 habitants	1223.4	73.2	34.8	1056.6	398.9	356.7

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