

Surveillance of COVID-19 in Cameroon: Implications for policymakers and the healthcare system

Bruno Bonnechère,¹ Osman Sankoh,²⁻⁵ Sékou Samadoulougou,^{6,7} Jean Cyr Yombi,⁸

Fati Kirakoya-Samadoulougou⁹

¹REVAL Rehabilitation Research Center, Faculty of Rehabilitation Sciences, Hasselt University, Diepenbeek, Belgium; ²Statistics Sierra Leone, Freetown, Sierra Leone; ³Njala University, Njala, Sierra Leone; ⁴School of Public Health, University of the Witwatersrand, Johannesburg, South Africa; ⁵Heidelberg Institute of Global Health, University of Heidelberg Medical School, Heidelberg, Germany; ⁶Evaluation Platform on Obesity Prevention, Quebec Heart and Lung Institute Research Center, Quebec City, Canada; ⁷Centre for Research on Planning and Development (CRAD), Laval University, Quebec, Canada; ⁸Department of Infectious diseases, cliniques Universitaires Saint Luc, Institut de Recherches Expérimentales et Cliniques (IREC), UCLouvain, Bruxelles, Belgium; ⁹Centre de Recherche en Épidémiologie, Biostatistique et Recherche Clinique, Ecole de Santé Publique, Université Libre de Bruxelles (ULB), Bruxelles, Belgium

Abstract

At first less impacted than the rest of the world, African countries, including Cameroon, are also facing the spread of COVID-19. This study aimed to analyze the spread of the COVID-19 in Cameroon, one of the most affected countries in sub-Saharan Africa. We used the data from the Africa Centre for Disease Control and Prevention, reporting the number of confirmed cases and deaths, and analyzed the regularity of tests and confirmed cases and compared those numbers with neighboring countries. We tested different phenomenological models to model the early phase of the outbreak. Since the first reported cases on the 7th of March, 18,662 people have been diagnosed with COVID-19 as of the 24th of August, 186,243 tests have been performed, and 408 deaths have been recorded.

New cases have been recorded only in 50% of the days since the first reported cases. There are considerable disparities in the reporting of daily cases, making it difficult to interpret these numbers and to model the evolution of the pandemic with the phenomenological models. Currently, following the finding from this study, it is challenging to predict the evolution of the pandemic and to make comparisons between countries as screening measures are so sparse. Monitoring should be performed regularly to provide a more accurate estimate of the situation and allocate healthcare resources more efficiently.

Introduction

In December 2019, the first cases of the new severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) were reported in Wuhan, China.¹ Coronavirus disease 2019 (COVID-19) has been successfully contained in China but is now spreading all over the world and was classified as a pandemic by the World Health Organization (WHO) on the 11th of March, 2020.² As of the 24th of August, 2020, 23,441,581 cases of COVID-19 had been confirmed in more than 207 countries and territories, and at least 809,422 deaths had been recorded around the world.³

At first less impacted than the rest of the world, the African continent has been facing the spread of COVID-19,⁴⁻⁶ but still to a much lower extent compared to European countries.⁷ Amongst the African countries, with 18,662 reported cases (the 24th of August), Cameroon is ranked ninth with the most cases after South Africa ($n=609,773$), Egypt ($n=97,237$), Nigeria ($n=52,227$), Morocco ($n=50,812$), Ghana ($n=43,505$), Algeria ($n=41,460$), Ethiopia ($n=40,671$), and Kenya ($n=32,364$). Cameroon is the third most severely affected country in the West Africa region.⁶

The first officially recognized case of COVID-19 in Cameroon was reported on the 7th of March, 2020, and was a 58-year-old French citizen who arrived in Yaoundé on the 24th of February, 2020.⁸

In an effort to control the pandemic, the Cameroonian government has implemented series of strategies in line with WHO recommendations.⁹ These include social distancing, lockdown, screening measures at land transportations points and airports, active case finding, and isolation of suspected cases. The Cameroonian Prime Minister announced that as of the 18th of March all land, sea, and air borders were closed due to COVID-19.¹⁰

Disease surveillance and response is

Correspondence: REVAL Rehabilitation Research Center, Faculty of Rehabilitation Sciences, Hasselt University, Diepenbeek, Belgium.

E-mail: bruno.bonnechere@uhasselt.be

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one of the milestones for effectively managing and curtailing the pandemic. This is of particular importance in countries with limited resources allocated to the healthcare system. Phenomenological models have been developed in the past to monitor the evolution of the epidemic (*e.g.*, Ebola, SARS) and evaluate different intervention scenarios, especially in countries with limited resources. These models are robust and have made initial predictions of epidemic trajectories, growth rate, and speed of evolution, which have helped to implement strict preventive measures.¹¹ Phenomenological models, or other modeling techniques, rely on the quality of the data (*i.e.*, data must represent the current situation. A sufficient quantity of data needs to be collected to have an accurate model. For example, the coverage must be over a sufficiently long period of time and performed regularly, otherwise the information obtained (*e.g.*, growth rate, epidemic size)

can be biased.¹²

In this paper, we aim to present the surveillance of COVID-19 in Cameroon to elucidate the high number of cases reported compared to other African countries and assess whether the quality of the monitoring system has an impact on the prediction performed using phenomenological models.

Materials and methods

We used the data from the COVID-19 data repository of the Africa Center for Disease Control and Prevention,⁶ aggregated at the country level, to summarize the number of confirmed cases, the date the first cases were confirmed, the duration of the follow-up, and the number of days in which no new cases were reported until the 24th of August, 2020. To compare the situation with other countries, we also aggregated the results of other Western African countries to assess the percentage of monitoring coverage, defined as the number of days with confirmed cases divided by the total days since the reporting of the first cases. We used the number of inhabitants, from the World Factbook,¹³ to standardize the number of tests and positive cases between countries.

To analyze the impact of the monitoring coverage, we plotted the number of confirmed cases against the number of tests for the different countries.

To assess the impact of the monitoring system on the models, we tested different phenomenological models using the results of the early phase of the outbreak (from the 7th of March until the 7th of May). Based on the different models, we then predicted the evolution of the pandemic for the next month (until the 7th of June), after calibration for the different models, and compared our results with the actual confirmed cases. To generate the confidence intervals at 95% level (95% C.I.) of uncertainty associated with the model estimates, we used parametric bootstrap simulation (M = 500) datasets, assuming a Poisson error structure.¹⁴

Different logistic growth models (non-linear growth models) were used to analyze the data. Using these models, we assume that there are exponential growth dynamics in the absence of control interventions. To this end, both the generalized logistic growth model (GLM) and Richards growth model were applied to the daily national confirmed COVID-19 cases to estimate growth parameters.¹⁵

We tested four phenomenological models in order to select the model that best fit our data. These growth models are defined by differential equations as follows:

$$\frac{dC(t)}{dt} = C'(t) = rC(t) \tag{1}$$

$$\frac{dC(t)}{dt} = C'(t) = rC(t)^p \tag{2}$$

$$\frac{dC(t)}{dt} = C'(t) = rC(t)^p \left(1 - \frac{C(t)}{K}\right) \tag{3}$$

$$\frac{dC(t)}{dt} = C'(t) = rC(t)^p \left(1 - \frac{C(t)^\alpha}{K}\right) \tag{4}$$

Equations 1 to 4 represent the exponential growth, the generalized growth (GGM), the generalized logistic growth, and Richards growth models, respectively. In these formulas, C'(t) is the incidence curve over time t, the solution C(t) describes the cumulative number of cases at time t, r is a positive parameter denoting the growth rate, p is a “deceleration of growth” parameter, and α represents an exponent that measures the deviation from the symmetric s-shaped dynamics of the simple logistic curve. K is the final epidemic size or carrying capacity.

Since phenomenological models are used to evaluate the early stage of the pandemic, we focused on the two first months to assess the quality of the different models.

The analyses were carried out in RStudio (version 1.1.442), using R version 3.4.4 and in MATLAB 2019. No ethical approval was sought. All data used were publicly accessible.

Results

Cameroon has a population of 26,545,863.¹³ As of the 24th of August, 186,243 tests had been performed in Cameroon, 10% of the tests were positive (n=18,662), and 408 deaths had been recorded due to COVID-19 (case fatality rate: 2.2%). Since the report of the first case on the 7th of March, 50% of the days had no new cases being reported (Figure 1). Twelve of these days were in March, at a relatively early stage of the pandemic, but we still observed 9 days in April, which is inconsistent with the profile of the evolution of the pandemic observed in other regions of the world.³ When comparing the percentage of monitoring coverage we observed that, unfortunately, only a few Western African countries have a high coverage and that despite presenting a high number of cases, Cameroon has one of the lowest monitoring coverages (Figure 2A). Complete results for the different countries are presented in Table 1. Finally, we observed a significant positive correlation between the number of tests and the number of confirmed cases at the country level (β = 0.053 (per 1 million inhabitants), SE=0.0028, p<0.001, Figure 2B).

The different phenomenological models are presented in Figure 3. The best fitting is

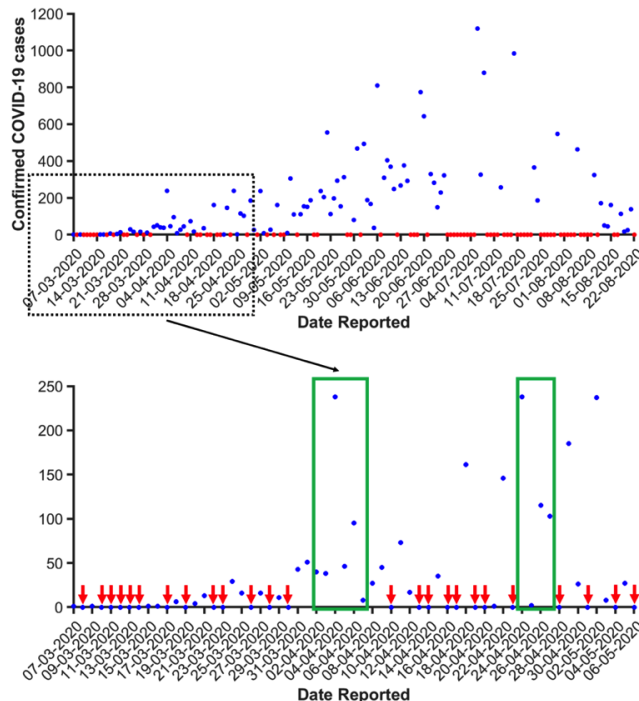


Figure 1. Daily confirmed COVID-19 cases in Cameroon since the reporting of the first case on the 7th of March, 2020. In the upper figure, the complete duration of the monitoring is presented, while the figure below shows a zoomed view of the beginning of the pandemic (first two months). The red color indicates days without new cases being reported. The green rectangles indicate the two periods with intensive testing during the early phase of the outbreak. Data source: Africa CDC.

observed for the GGM; all the other models underestimate the real cases. However, even with the GGM, we observed that the one-month prediction is far away from the real confirmed cases.

Discussion

We observed a very inconsistent surveillance program of COVID-19 in Cameroon, no new reported cases in 50% of the days since the first case and large peaks of detection between those. One of the issues is that the supply of tests was slowed down in the early phase of the pandemic, and test kits were out of stock for days.¹⁶ Concerning the monitoring of the early outbreak of the pandemic (from the 7th of March to the 7th of May), the Minister of Health announced the launch of a coronavirus test campaign in the city of Douala on the 30th of March. Dedicated teams went from door-to-door in the economic capital from the 2nd of April to the 6th. This campaign resulted in a massive increase in the number of cases of 457 over the five days. More than 20% of the cases in the early phase of the epidemic were thus reported during this campaign. Another campaign was organized later on in April.

This is compelling for two reasons: the temporal and spatial distribution. We have seen that modeling techniques rely on the quality of the data. In the case of monitoring pandemics, a sufficient quantity of data needs to be collected to ensure model accu-

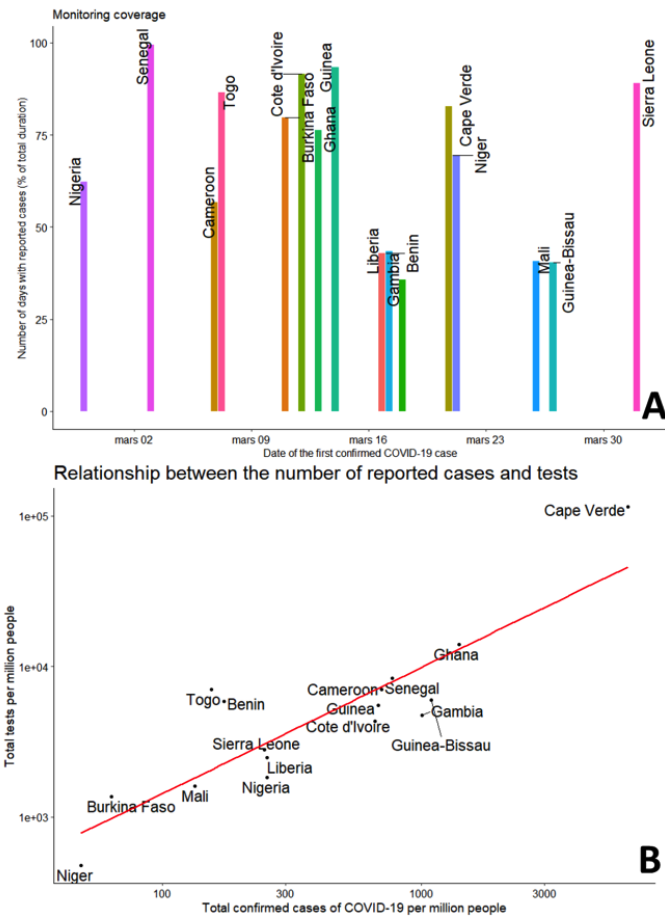


Figure 2. A) Date of first reported cases by country and the number of days with reported new cases as a percentage of the total duration of the monitoring. B) Relationship between the number of confirmed cases and the number of tests in different Western African countries. Data source: Africa CDC.

Table 1. Information related to the COVID-19 cases, tests at the country levels, and sociodemographic characteristics.

Country	COVID-19 information							Sociodemographic characteristics			
	First case	Days without reporting	Monitoring (%)	Cases	Death	Case Fatality Rate	Tests	Positive tests (%)	Population	Age in year (median)	Country size (km ²)
Benin	17-03-20	92	42.86	2,095	39	1.86	70,781	2.96	12,123,200	19	112,760
Burkina Faso	11-03-20	34	79.64	1,328	55	4.14	28,539	4.65	20,903,273	18	273,600
Cameroon	07-03-20	74	56.73	18,662	408	2.19	186,243	10.02	26,545,863	19	472,710
Cape Verde	21-03-20	27	82.80	3,509	37	1.05	64,239	5.46	555,987	28	4,030
Cote d'Ivoire	12-03-20	14	91.57	17,471	113	0.65	114,420	15.27	26,378,274	17	318,000
Gambia	18-03-20	103	35.63	2,437	84	3.45	11,440	21.30	2,416,668	18	10,120
Ghana	13-03-20	39	76.36	43,505	261	0.60	433,503	10.04	31,072,940	22	227,540
Guinea	14-03-20	11	93.29	8,967	53	0.59	72,510	12.37	13,132,795	18	245,720
Guinea-Bissau	27-03-20	90	40.40	2,149	33	1.54	11,753	18.28	1,968,001	19	28,120
Liberia	17-03-20	90	43.40	1,286	82	6.38	12,586	10.22	5,057,681	19	96,320
Mali	26-03-20	90	40.79	2,705	125	4.62	32,499	8.32	20,250,833	16	1,220,190
Niger	21-03-20	48	69.43	1,172	69	5.89	11,512	10.18	24,206,644	15	1,266,700
Nigeria	28-02-20	68	62.22	52,227	1002	1.92	378,023	13.82	206,139,589	18	910,770
Senegal	03-03-20	1	99.43	12,949	269	2.08	140,252	9.23	16,743,927	19	192,530
Sierra Leone	01-04-20	16	89.04	1,980	69	3.48	22,384	8.85	7,976,983	19	72,180
Togo	07-03-20	23	86.55	1,277	27	2.11	58,050	2.20	8,278,724	19	54,390

Information about COVID-19 was obtained from the COVID-19 data repository of the Africa Center for Disease Control and Prevention (24th of August, 2020),⁶ and data on the median age of the populations and the size of the countries from the World Factbook¹³.

racy. Therefore, tests must be performed and reported on a daily basis, and the testing capacities must be ideally increased or should at least remain constant overtime to be able to monitor the shape and the speed of the outbreaks.¹² As seen in Figure 3, the lack of consistency in testing and reporting of confirmed cases means that phenomenological models cannot be used to predict the course of the pandemic, while these models have been successfully used to predict the early evolution of the outbreak in China.¹⁴ This is consistent with previous studies showing that the testing rate and change in the testing rate can mask or modify the growth rate of the epidemiology.¹⁷

The spatial distribution is also essential to detect not only the center of the outbreak but also the spread;¹⁸ by focusing efforts on Douala, the first affected city in Cameroon, the early monitoring program did not ensure that the epidemic was contained in that city and that it had not spread throughout the territory. This information is not only crucial for public health measurement, which is of particular importance in low-income countries with very limited resources, but also, later on, for implementation of effective strategies to exit lockdown.¹⁹

If we compare the situation during the early phase of the pandemic to other Western African countries, seven of them

reported more than 300 confirmed cases (as of the 7th of May).⁶ Amongst them, Ghana ($n=3,091$) has a very similar trend compared to Cameroon; the first case was reported on the 13th of March, but since then, 11 days have been reported without cases, and on the 13th of April, a peak of 158 cases was reported. On the other hand, Burkina Faso ($n=729$), Senegal ($n=1,423$), and Cote d'Ivoire ($n=1,516$) have had continuous reporting systems since the first case was discovered. Finally, Guinea ($n=1,856$), Niger ($n=770$), and Nigeria ($n=3,145$) had a delay of about two weeks between the discovery of the first case in mid-March and the start of the continuous reporting, which now allows modeling. Concerning the monitoring coverage, it is important to note that regardless of the screening strategy, the optimal number of tests required to monitor the pandemic successfully still needs to be defined and is still a hot topic of discussion worldwide. The cost of the tests but also field supply and conservation of samples are potentially limiting factors.¹⁶

The large number of cases reported in Cameroon, at least during the early phase of the outbreak, compared to other West African countries, is the result of national policy and investment in monitoring. However, in order to be more effective and

to allow better forecasting, and thus allow better use of the limited health resources, monitoring should take place on a regular daily basis instead of larger scale spot-check campaigns like in Ghana and Cameroon. Despite the relatively high number of cases in Cameroon, compared to neighboring countries, the number of cases in African countries is still much lower than in other regions of the world.³ Several explanations have already been proposed and discussed in the literature to explain the lower prevalence observed in African countries, though a consensus has not yet been reached.

The first one, discussed in this paper, is the low number of tests. A surveillance program that does not include sufficient testing leads to a significant under-evaluation of the pandemic.^{20,21} On average, the number of tests in Western Africa is 11,804 per million inhabitants, while the average for the United States of America and most of the European countries is around 250,000 per million.

The age of the population is certainly a protective factor for severe cases and deaths; with a mean life expectancy of 64·9 (5·5) years, but overall median age of 20·5 (4·4) years, Africa is the continent with the youngest population worldwide.¹³ Large-scale epidemiological studies in China,

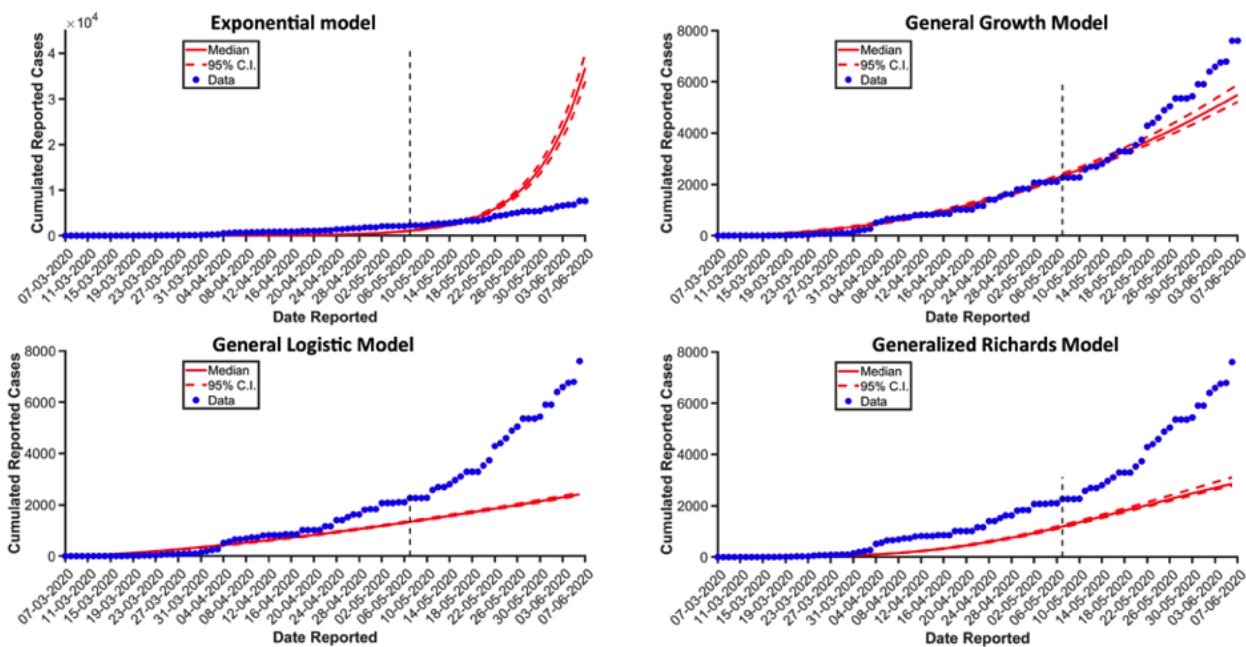


Figure 3. The four different phenomenological models tested to model the early phase of the outbreak in Cameroon. The vertical dashed lines separate the calibration (two months) and the forecasting periods (one month). The median (solid red line) and 95% C.I. (dashed red lines) of the model fit ensembles are plotted. The blue points represent the real observations. Sources: Africa CDC

Europe, and the USA have shown that the median age of the patients is approximately 45 years old,²²⁻²⁴ but the severity of the disease and the risk of death are increasing exponentially with age, with patients aged above 65 years old being at higher risk. In this context of a relatively young population, a part of the population is likely being infected but only present minor symptoms and do not seek healthcare. Serology testing is needed to determine the level of infection in those populations.²⁵

After severely hitting Asia, Europe, and the Americas, perhaps as a result of implementing containment measures too late, African countries quickly took measurements in an attempt to confine the virus when the first cases were reported before community transmission in order not to overwhelm the healthcare system. Most countries have restricted movement to some degree, and 21 have imposed partial or complete lockdowns, while 43 countries have full border closures.⁴ Social distancing and lockdown measurements at the early stage of the outbreaks could explain the low observed number of cases. African countries strictly follow guidance from the WHO and Africa CDC.⁶ As presented in the paper, the quality of the monitoring may be another explanation, since we observed a positive correlation between the number of tests and confirmed cases (Figure 2B).²⁰ As things stand, it is therefore difficult to predict the evolution of the pandemic and to make comparisons between countries as screening measures are so sparse. However, this type of information is essential to best organize the response and implement the most appropriate measures in light of the current pandemic situation.

We propose a few thoughts in order to improve the surveillance of infectious diseases in Africa.

The first one is to strengthen epidemiological surveillance by integrating information from remote areas and not only focusing on the main cities, as is currently the case. In the absence of universal testing, a random-sample-based population surveillance framework could be used as a solution to ascertain the true prevalence.²⁶ It is also important to not only look at the confirmed cases but also at the symptomatic cases; syndromic surveillance at the village level (community-based agent) must be implemented, and the integration of such suspected cases into the epidemiological surveillance system must be guaranteed. Loss of smell and taste, in combination with other symptoms, is a strong predictor of COVID-19 infection and can be easily assessed.²⁷ Not only should COVID-19 be monitored, but efforts should also focus on analyzing

the time series and spatial distribution of all causes of the acute respiratory syndrome and the death rate. The monitoring must be based on the comparison with historical time series.

The second one is to strengthen the preventive action based on community involvement. Surveillance should be proposed within the communities, the villages, and neighborhoods. A dedicated place (e.g., a room or small house) should be available for the COVID-19 positive persons in the community, in order to maintain the social link while respecting containment measures.

The last point is to increase hygienic measures and ensure that social distancing is enforced. The barrier measures will be sufficient if correctly and widely applied. The community health worker will be a central actor in this situation. As part of the COVID-19 response strategy, in all countries, severe cases must be hospitalized in health centers. Social surveillance of contacted persons should also be enhanced, with the distribution of masks and soap. Each house should have at the entrance a water container and soap.

Conclusions

Africa is still the continent with the lowest number of cases per inhabitant compared to other regions of the world. We have seen that several potential protective factors (e.g., age of the population, early containment measurements) could explain this. However, as presented in this paper, the surveillance is far from being perfect, with a low number of tests performed and a very irregular temporal evaluation.

By combining some simple measures to improve the monitoring, based on a regular reporting of the cases as well as a more local follow-up, and by making the population more aware of the danger of the virus and the need to adopt hygienic and social distancing practices, the effect of the pandemic in African countries will continue to be more limited.

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