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Coronavirus Pandemic

Air pollution and other risk factors might buffer COVID-19 severity in Mozambique

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Abstract

Mozambique is located on the East Coast of Africa and was one of the last countries affected by COVID-19. The first case was reported on 22 March 2020 and since then the cases have increased gradually as they have in other countries worldwide. Environmental and population characteristics have been analyzed worldwide to understand their possible association with COVID-19. This article seeks to highlight the evolution and the possible contribution of risk factors for COVID-19 severity according to the available data in Mozambique. The available data highlight that COVID-19 severity can be magnified mainly by hypertension, obesity, cancer, asthma, HIV/SIDA and malnutrition conditions, and buffered by age (youthful population). Due to COVID-19 epidemic evolution, particularly in Cabo Delgado, there is the need to increase laboratory diagnosis capacity and monitor compliance of preventive measures. Particular attention should be given to Cabo Delgado, including its isolation from other provinces, to overcome local transmission and the spread of SARS-CoV-2.

Key words: SARS-CoV-2; risk factors; COVID-19 severity; Mozambique.

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Introduction

Severe Acute Respiratory Syndrome CoronaVirus 2 (SARS-CoV-2) is the etiological agent of COVID-19, that emerged from China (East Asia) in Wuhan, Hubei Province, in December 2019, characterized mainly by fever, pneumonia, sneezing, and coughing [1-3].

SARS-CoV-2 was declared by the World Health Organization (WHO) as a pandemic coronavirus due to its ability to spread quickly and efficiently to most of the world's continents, swamping health-care systems, and devastating societies and economies. In fact, to date (14 May 2020) 4,248,389 cases and 294,046 deaths have been confirmed worldwide in Europe, the Americas, the Western Pacific, the Eastern Mediterranean, South-East Asia, and Africa [4].

In Africa, SARS-CoV-2 was confirmed on 14 February 2020 in Egypt. In the sub-Saharan region, the first confirmed case was reported in Nigeria, on 27 February 2020; and the first case in Southern Africa was confirmed on 5 March 2020 in South Africa. Unfortunately, COVID-19 has spread to 216 countries and territories, including 57 African countries [4,5]. To date (14 May 2020), 77,030 COVID-19 cases have been reported in Africa with 2,579 deaths, most of them in South Africa, Egypt, Morocco, Algeria, Ghana, Nigeria and Cameroon according to Worldometer [6], a reference website that provides real-time world statistics (https://www.worldometers.info/coronavirus/).

Mozambique reported the first positive case of COVID-19, on 22 March 2020, and was one of the last affected countries in Africa. Mozambique has used epidemic control policies learned from other countries, mainly physical distancing and isolation following the recommendations of the "state emergency" declared on 30 March 2020 (that has to be implemented from 1 to 30 April 2020), that was after extended to 30 May 2020, to avoid public places and close contact to infected persons. The main aim behind this policy is to "flatten the curve", allowing to decrease the number of gravely ill patients seeking hospital treatment in a short period of time and allow time for the country to increase hospital capacities.

On 24 April 2020, 65 cases were reported without any fatalities in Mozambique [7], showing the epidemic evolution. Therefore, is important to analyze the possible contribution of risk factors such as age, medical conditions (including cardiovascular and lung

diseases, obesity, diabetes, hypertension, and cancer), and air pollution in Mozambique. These risk factors have been associated with increasing mortality rates by COVID-19 worldwide [8,9].

Herein, we aim to analyze the evolution and the possible contribution of air pollution and other risk factors of COVID-19 severity in Mozambique.

COVID-19 confirmed cases in Mozambique

Patient Zero

Like other countries, the first positive case of COVID-19 in Mozambique was travel-related. Reported on 22 March 2020, the case was a > 75-year-old Mozambican man, who returned from United Kingdom (UK) in the middle of March. He was first placed in isolation and afterward admitted to a private hospital in Maputo city. Fortunately, he was later discharged on 4 April 2020. The patient zero generated 23 contacts that were isolated in quarantine and placed under observation by health authorities [7].

Evolution of COVID-19 cases in Mozambique

Since the identification of COVID-19 patient zero, the number of people confirmed to be infected has been increasing and now involves three provinces, namely, Maputo city and Maputo province (in the South) and Cabo Delgado (in the North) of Mozambique. Indeed, within a few days of the reported patient zero case, two

Table 1. Evolution of COVID-19 reported cases in Mozambique.

Date	Reported cases/day	Locally transmitted cases	Imported cases (Country)	Localization of patients (Number of cases)	Recovered cases	Deaths
22 March	1	0	1 (United Kingdom)	Maputo city	0	0
23 March	0	0	0	0	0	0
24 March	2	1	1 (South Africa)	Maputo city	0	0
25 March	2	0	2 (Portugal and South Africa/Dubai)	Maputo city	0	0
26 March	2	0	2 (France and England)	Maputo city	0	0
27 March	0	0	0	0	0	0
28 March	1	1	0	Maputo city	0	0
29 March	0	0	0	0	0	0
30 March	0	0	0	0	0	0
31 March	0	0	0	0	0	0
1 April	0	0	0	0	0	0
2 April	2	1*	1 (Portugal)	Maputo city	0	0
3 April	0	0	0	0	0	0
4 April	0	0	0	0	1	0
5 April	0	0	0	0	0	0
6 April	0	0	0	0	0	0
7 April	0	0	0	0	0	0
8 April	8	7	1 (Portugal)	Cabo Delgado (6) and Maputo city (2)	0	0
9 April	0	0	0	0	0	0
10 April	3	3	0	Cabo Delgado	1	0
11 April	0	0	0	0	0	0
12 April	1	1	0	Maputo city	0	0
13 April	0	0	0	0	0	0
14 April	6	6	0	Cabo Delgado	0	0
15 April	1	1	0	Maputo city	0	0
16 April	3	3	0	Maputo province (2) and Maputo city (1)	0	0
17 April	1	1	0	Cabo Delgado	0	0
18 April	2	2	0	Maputo province	2	0
19 April	4	4	0	Cabo Delgado	4	0
20 April	0	0	0	0	0	0
21 April	0	0	0	0	0	0
22 April	2	2	0	Cabo Delgado	0	0
23 April	5	5	0	Cabo Delgado (4) and Maputo province (1)	1	0
24 April	19	19	0	Cabo Delgado	0	0
Total	**65**	**57**	**8**	**-**	**9**	**0**

*Case number 10 of COVID-19 (10-Moz-Covid-19).

new cases were reported on 24 March 2020: one of local transmission, a 70-year-old Mozambican woman who had contacted patient zero; and the other a new imported case, a > 30-year-old South African woman who had returned from the region of South Africa neighboring Mozambique [7].

On 25 March 2020, two new cases of COVID-19 were reported. Both were > 30-year-old Mozambican women, living in Maputo city, one of whom had returned from Portugal and had also travelled to Switzerland and Austria, while the other had returned from Dubai after also visiting South Africa, accounting for five cases [7] (Table 1).

On 26 March 2020, two new case of COVID-19 were reported, both of whom were > 40-year-old men living in Maputo city. One of the men was French and had returned from France; the other was a Mozambican, who had visited England in the middle of March, bringing the number of cases in Mozambique to seven [7].

On 28 March 2020, one case of local transmission was reported in Maputo city, accounting for eight cases in the country.

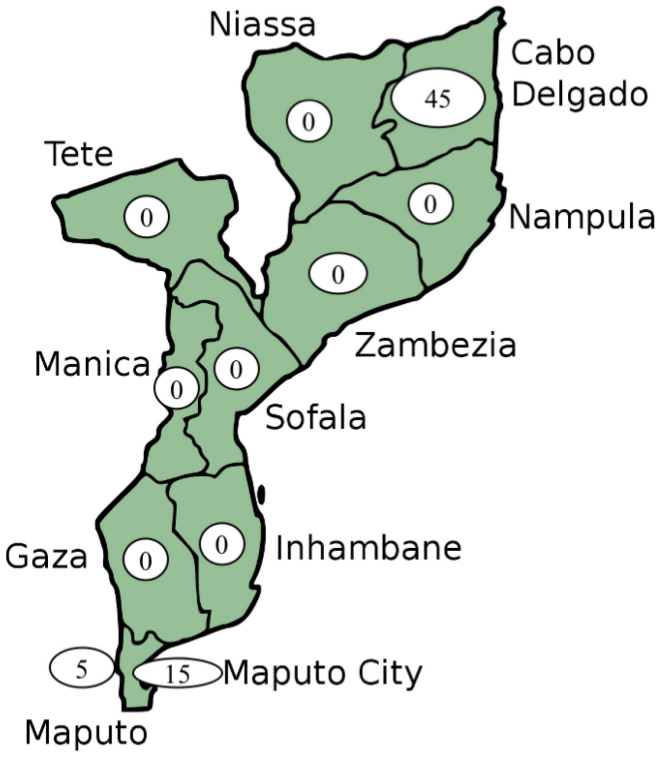
After four days without positive cases (29 March to 1 April 2020), on 2 April 2020, the number of cases of COVID-19 increased in Mozambique by ten. Of these ten new cases, one was an > 18-year-old Mozambican man who had recently returned from Portugal. Another one of these ten new cases was local transmission in a > 60-year-old Mozambican man (first considered as South African) who works at a gas exploration camp in Afungi belonging to the Total Company) Cabo Delgado, in northern most province of Mozambique Case number 10 (Index case) [7]. Notably, the "state emergency" started to be implemented on 1 April 2020, when Mozambique had eight cases that had emerged in spite of the first restriction measures (including travel restrictions, school closures, limitations of people at events, and visa cancellations) that had been declared on 18 March 2020.

Case 10-Moz-Cov-19 (reported on 2 April 2020) was interesting as the patient was diagnosed positive in Maputo city but he had returned from Afungi, Cabo Delgado, on 29 March. Additionally, the case was considered as local transmission with no recent report of travel history although it represented the second Mozambican province with reported cases of COVID-19.

Interestingly, the 10-Moz-Covid-19 was especially complex and generated 66 contacts, including 52 in Mozambique (mainly in Nampula and Cabo Delgado provinces) and 14 contacts cases abroad in South Africa, Australia, New Zealand, the United Kingdom, and the United States of America (USA). In Mozambique, most of the contacts were from Cabo Delgado, mainly in Afungi (35 cases), and 17 were from outside the camp, who were quarantined and followed by health authorities [7,10]. In addition, the identification of case 10-Moz-Covid-19 suggests that SARS-CoV-2 might have circulated in Mozambique in asymptomatical individuals, pointing to the necessity to increase testing capacity of COVID-19 in the country.

From 3 to 7 April 2020, no new cases of COVID-19 were reported in Mozambique, with the number of identified cases in the country remaining stable at ten on those days. Notably, on 8 April 2020, eight new cases were reported, of which seven were identified as local transmission related to Cabo Delgado investigation and one identified as imported and registered in Maputo city, increasing the number of COVID-19 cases in Mozambique to 18. Of these 18 cases, 10 were considered to be of local transmission case and eight imported [7]. Additionally, on 8 April 2020, Cabo Delgado became the new epicentre of COVID-19 in Mozambique. From 8 to 24 April 2020, 54 new cases of COVID-19 were reported linked with 10-Moz-Covid-19. In addition, from 8 to 24 April 2020,

Figure 1. Distribution of COVID-19 cases by Province in Mozambique (From 22 March to 24 April 2020).



Source: https://commons.wikimedia.org/wiki/Main_Page.

one local transmission case (> 20-year-old Italian man) was reported on 23 April 2020, without association with 10-Moz-Covid-19 case, accounting for 55 new cases [7].

From the first case of COVID-19 reported on 22 March to 24 April 2020, a total of 65 cases were reported in Mozambique, of which eight were imported and 57 of local transmission, most of them from Cabo Delgado in Afungi gas exploration camp (45 cases), followed by Maputo city (15 cases) and Maputo province (5 cases) (Figure 1).

Fortunately, to date (24 April 2020), no deaths have been reported and 9 patients have recovered, while 56 cases remain active.

Apart from the 65 cases of COVID-19 Mozambicans living in the country, another eight Mozambicans living abroad were affected, with one case in each of Spain (recovered), Angola, Portugal, and Germany; two in Switzerland; and three in the USA [7]. Unfortunately, the patient in Germany was died.

Risk factors and COVID-19 in Mozambique

Environmental and population characteristics have been influencing the spread of communicable diseases. Recently, population demographics (age, cardiovascular, hypertension, obesity, respiratory, diabetes, cancer, and HIV/SIDA conditions) and environmental (air pollution, temperature, and humidity) characteristics have been analyzed worldwide to understand their possible association with COVID-19.

Africa is the youngest continent in the world, with a median age of 18 [9,11]. According to the last census (2017), the median age is 16.6 in Mozambique [12], which may contribute to lower number of the severity of COVID-19. In Italy, which has a median age of 47.3 years, mortality rate has reached 4.5%, with high burden in Lombardy and Emilia Romagna [8]. Adults mainly elderly who have serious underlying medical conditions may be at higher risk for more severe illness [13]. Older adults are a lower segment of the population in Mozambique, where > 60-year-olds make up 4.6% of the population, followed by ages 15-45 years at 38.5%, and ages 0-15 years at 46.7% [12]. This demographic likely buffers the number of COVID-19 cases with severe (Table 2).

Regarding underlying medical conditions, including non-communicable diseases (NCD), Africa is on a much weaker footing than other continents. It is well known that people with cardiovascular disease (heart), hypertension, respiratory conditions, obesity, cancer, and diabetes are at greater risk for infection and death by SARS-CoV-2/COVID-19. Additionally, the NCDs are increasing rapidly in sub-Saharan Africa and thereby increasing the risk of COVID-19 severity [14]. According to a previous study, NCDs (mainly

Table 2. Available data of COVID-19 risk factors in Mozambique.

Risk factors	Available data	General characteristics
Percent of population, age > 60 (%) [12]	4.6%	The majority of population are youth
Smoking prevalence, total (ages > 15) (%) [19]	16.6%	Smoking prevalence is decreasing and was 23.4% in 2000
PM2.5 air pollution, mean annual exposure (micrograms per cubic meter) [27]	21 μg/m^3	Air pollution exceed the recommended maximum of 10 μg/m3 or 20 μg/m3 for PM10 by WHO
Cardiovascular Disease (hypertension) (%) [17]	14.8% and 33.1% in women and men, respectively	Alcohol consumption in women was associated with increased prevalence of hypertension
Chronic obstructive pulmonary disease (asthma) (%) [17]	13.3%	Asthma Deaths reached 1,485 or 0.59% of total deaths in Mozambique
Obesity (%) [16]	30.5% and 18.2% in women and men, respectively	Prevalence of overweight and obesity has been high in urban areas and in women
Cancer (%) [25]	Kaposi sarcoma (24.7%), cervix uteri (16.7%), prostate (6.4%), breast (5.3%), and liver (4.7%)	Cervix uteri, prostate and Kaposi sarcoma are associated with high mortality
Diabetes (%) [20,21]	2.9% (2011) and 4.6% (2016)	Diabetes prevalence is low in Mozambique, but most patients have not been aware of their condition; and more case are in urban than rural area
Malnutrition (%) [32,34]	43%	The major burden is in children under 5 years old but also affect adults
HIV/SIDA (%) [22]	12.6%	The number of deaths has been decreasing since 2010

hypertension and diabetes) accounted for 28% of deaths in Mozambique [15]; consequently, cardiovascular deaths may continue to increase during the current COVID-19 epidemic.

Severe obesity puts people at higher risk for complications from COVID-19. The prevalence of obesity is increasing in Mozambique, especially in urban areas at 11.5% compared with 2.6% in rural areas with high burden in women (6.8%) than men (2.3%) [15]. Recent studies showed that overweight and obesity increased from 18.3 to 30.5% in women and from 11.7 to 18.2% in men [16], showing that obesity is a concern in urban area and in women.

According to a previous study on cardiovascular diseases, 14.8% and 33.1% of hypertension in men and women, respectively, were found in Mozambique [17], particularly in people with higher Body Mass Indexes (BMI) and abdominal obesity. Additionally, alcohol consumption in women was associated with increased prevalence of hypertension, suggesting that the interaction of these two factors may contribute significantly to COVID-19 severity in Mozambique. Moreover, cardiovascular diseases commonly found in adults also affect children and adolescents in Mozambique [15].

Although there is a lack of data, chronic obstructive pulmonary disease (mainly asthma) prevalence in Mozambique is estimated at 13.3% in children aged 6-7 years and adolescents aged 13-14 years [15]. Asthma may put people at higher risk for severe illness from COVID-19.

Tobacco use has been a contributing cause of cardiovascular and respiratory conditions, where smoker prevalence is high in Oceania, the Middle East, North Africa, and the Eastern and Southern regions of Europe [18,19], putting the consumers from these countries at higher risk of developing severe COVID-19 disease and poor outcome. In Mozambique, smoking prevalence is decreasing and was 16.6% in 2016 (29.1% male and 5.1% female) against 23.4% in 2000 [19], which may be advantageous during the current COVID-19 epidemic.

According to published data, diabetes prevalence is low in Mozambique. In 2011, the diabetes prevalence was 2.9% in people aged from 25-64 years, where most of patients were not aware of their condition [20]. The prevalence had increased to 4.6% in 2016 [21]. Moreover, other diseases, including HIV/SIDA and tuberculosis, may increase the risk of COVID-19 severity in African countries, including Mozambique. HIV/SIDA prevalence among adults (15-49 years) was 12.6% in Mozambique in 2018 [22].

Cancer is an emerging public health concern in sub-Saharan Africa due to population growth and the westernization of lifestyles in urban areas [23]. In Mozambique, cancer has caused high morbidity and mortality. Infectious diseases such as HIV contribute to cancer mortality in rural areas [24]. In 2018, Mozambique reported 25,631 and 17,813 cases and deaths by cancer, respectively. Among the 25,631 cases of cancer, Kaposi sarcoma, cervix uteri, prostate, breast, and liver were common with the following prevalence: 24.7%, 16.7%, 6.4%, 5.3%, 4.7%, respectively. Other types of cancers were 42.1% [25], suggesting that cancer linked with the HIV epidemic and COVID-19 might be a concern in Mozambique.

People living in areas with high levels of pollutants are more prone to develop breathing problems, chronic diseases, and susceptibility to respiratory infectious agents. Air pollution contributes to increased hospitalization and premature mortality through particles, known as particulate matter (PM2.5) and (PM10) [26]. In fact, according to recent studies carried out in Italy, one of the European countries most affected by COVID-19, it was concluded that the high level of pollution in the northern part of the country (Lombardy and Emilia Romagna) should be considered an additional co-factor for the high case fatality rates recorded in that area [8].

In Mozambique, the air quality is moderately unsafe, particularly in Maputo with annual mean concentration of 21 μg/m3 of PM2.5, exceeding the recommended maximum 10 μg/m3 recommended by WHO. The aluminum, petroleum, textiles, and cement industries, as well as food processing, vehicle emissions, and waste burning, are the main sources for air pollution in Mozambique [27]. For instance, household use of fuels has been influencing air pollution in Mozambique: likely 95% of households burn solid fuels for cooking, which increases PM2.5 concentrations (carbon monoxide, nitrogen oxides, and others) and subsequent health and climate impacts [28]. In addition, the use of portable kerosene lamps for domestic lighting contributes to air pollution in Mozambique, mainly in rural areas. Air pollution has been associated with tuberculosis, acute respiratory infections in children, low birth weight, and neonatal mortality [29]. Therefore, air pollution including other factors may contribute to COVID-19 severity in Mozambique. Other African countries such as Angola, considered one of eight in the whole of Africa with the highest atmospheric pollution-related mortality rates in the world, according to the WHO, may have higher COVID-19 associated fatalities [30].

Conclusions

In conclusion, it is well known that COVID-19 severity rises sharply for the elderly and those with underlying health conditions, including cardiopulmonary disease, cancer, obesity, and diabetes; and air pollution is considered an additional co-factor of the high level of lethality. However, there is little COVID-19 data available worldwide to analyze this association, and still less in Mozambique. Mozambique was one of the last countries reporting cases of COVID-19, and unfortunately, the COVID-19 cases have been increasing gradually since patient zero reported on 22 March 2020, with the highest number of cases (19), to date, reported on 24 April 2020 [7]. Among the analyzed risk factors of COVID-19 severity, the available data suggests that NCDs (mainly hypertension, obesity, cancer and asthma) might play an important role in COVID-19 severity. Parallel to NCDs, air pollution exposure may be important factor for COVID-19 severity, mainly in some cities due industries and other urban activities. Moreover, is clear that HIV/SIDA and tuberculosis co-infection will also probably contribute to COVID-19 severity as Mozambique has a significant number of people living with these diseases. However, youthful population can buffer the severity. Case fatality rates for individuals with certain chronic medical conditions are up to five times higher than the overall case fatality rate for COVID-19 patients, although there is scarce data on immunocompromised COVID-19 patients [31]. Malnutrition may make some patients, particularly children, more susceptible to COVID-19. Chronic malnutrition is a concern in Mozambique, with a prevalence of 43% in children under the age of 5 years, contributing to infant deaths and poor child health. In some provinces, such as Nampula, Cabo Delgado (current epicentre of COVID-19), Niassa, and Zambézia northern provinces, the prevalence is double [32]. Chronic malnutrition has a detrimental effect on health, exacerbating diseases such as pneumonia, which occurs up to 36 times higher for malnourished children [33]. The adult population also faces malnutrition in Mozambique. For instance, 51% of women of reproductive age have anemia [34].

However, it is still unclear how the COVID-19 risk factors will interact and what will be the burden. More data is needed to better understand the relationship between malnutrition and COVID-19 in Mozambique.

In Mozambique, 65 cases including 57 locally transmitted cases and eight cases imported mainly from the United Kingdom, Portugal, and South Africa have been reported. The COVID-19 epidemic is evolving, mainly in Cabo Delgado, Maputo province, and Maputo city. Therefore, the need exists to increase laboratory diagnosis capacity, and to monitor compliance of preventive measures. Particular attention should be given to Cabo Delgado, including its isolation from other provinces to overcome local transmission and the spread of SARS-CoV-2.

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