The Economic Cost of Treatment for Patients with Severe Covid-19 in Maputo Province, Mozambique

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Summary

BACKGROUND

Mozambique has an under-resourced and fragile healthcare system that is already facing a high burden of comorbidities. Determining the cost of COVID-19 treatment is therefore an early priority to inform the resource-constrained pandemic response. This study aimed to estimate the economic cost of treating patients with severe COVID-19 in Mozambique.

METHODOLOGY

Cost data were collected retrospectively from the provider perspective. A "one-way" deterministic sensitivity analysis was performed to test the robustness of the assumptions.

RESULTS

The total economic cost of treatment for inpatients with severe COVID-19 at Centro da Matola 1 (CM1) was 21,157,159 MZN, corresponding to US$334,501. The economic cost per capita per day was 22,039 MZN, corresponding to US$348. The costs of treatment for patients with tuberculosis and patients with pneumonia did not vary considerably, ranging between 176,122 MZN (US$2,785) and 176,113 MZN (US$2,784) for the affected comorbidities; without co-morbidities, 176,105 MZN (US$2,784) to 176,087 MZN (US $2,784), respectively. COVID-19 patients co- infected with bronchopneumonia and HIV were the ones with the least costly morbidities, ranging from 88,085 MZN (US$1,393) to 88,053 MZN (US$1,392).

CONCLUSION

The results show a substantial cost to treat COVID-19 inpatients in a resource-constrained context. The course of the pandemic substantially impacted the total costs and consequently, there has been an increase in the demand for resources. Revising priority setting values and resource allocation shall be taken into consideration for timely adjustments to save lives, considering the scenario of a high burden of commodities versus resource constraints in Mozambican public health services. Additionally, it is highly recommended that the cost analysis be regularly updated to illustrate the current cost and contribute to informing the efficient allocation of resources.

Keywords: cost analysis, COVID-19, comorbidity, health services, Mozambique

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Introduction

The COVID-19 pandemic caused by the SARS-CoV-2 virus has had an unprecedented impact globally. The response to the pandemic intensified the demand for resources, which are already scarce in poor countries [1]. COVID-19 increased the demand for medical equipment and supplies such as ventilators, personal

protective equipment for healthcare professionals (PPE), and requirements for appropriate inpatient bed occupancy [1,2]. An estimation undertaken in the first 4 months of the pandemic (March – June 2020), in the United States of America, revealed that there was a monthly expenditure of about US$50 billion in PPE and other resources to respond to COVID-19 [2]. A modelling study projected approximately US$52 billion to fund resource needs to respond to COVID-19 in 73 low- and middle -income countries [3]. In general, the scarcity or lack of stock of needed resources was a major contributor to the increase in costs to respond to the pandemic [4].

As of February 11, 2021 (the time this article was being written), Africa had the lowest number of COVID-19 cases globally, (3%) and deaths (4%) [3]. However, the impact of COVID-19 on the health systems of the continent can be devastating mainly due to its economic vulnerability, poor access to healthcare, health system weaknesses, extreme poverty, and a high prevalence of comorbidities. Most African countries have a severe shortage of medical personnel (ranging from 20/10,000 in Mauritania to 2/10,000 inhabitants in Malawi) and have less than one intensive care hospital bed per 100,000 inhabitants [4]. Additionally, there is a severe shortage of ventilators, which are an essential resource for COVID-19 treatment assistance [4]. However, it is estimated that between 30% and 56% of patients hospitalized for COVID-19 require advanced ventilation support [5,6]. In addition, comorbidities, both chronic and infectious, are a risk factor for mortality due to COVID-19, and Africa bears a significant burden of chronic and infectious diseases globally [7,8].

As of February 11, 2021, Mozambique accounted for a cumulative 46,736 confirmed cases of COVID-19 that resulted in 436 deaths, this being an exponential increase in cases and deaths since the first case notifications in October 2020 [9]. Simultaneously, the country struggles to cope with the cumulative burden of infectious and chronic diseases. Like other African countries, Mozambique has a high prevalence of malaria, which accounts for 29% of all hospital deaths among the general population and 42% of deaths in children under five years of age; HIV, which has a prevalence amongst 13.2% of adults aged 15 to 49, is also of concern and additionally, 38% of HIV-infected patients have tuberculosis (TB). Non-communicable diseases including cardiovascular diseases, chronic respiratory diseases, and diabetes are also highly prevalent amongst young adults [10–13]

Additionally, Mozambique's health system is under-resourced. According to recent data, Mozambique has approximately 9 doctors per 100,000 inhabitants [14], and 7 beds for general hospitalization per 10,000 inhabitants, of which 41% of the beds are designated for maternity services [15].

Several factors, such as the prevailing weak health system, the high burden of comorbidities, the rapid increase in COVID-19 cases, and the consequent demand for hospital resources, dictate the need to estimate the cost of treatment of COVID-19 in a healthcare setting. The estimates are required to inform the efficient allocation of scarce resources. The purpose of this analysis was to estimate the cost of treating patients hospitalized for COVID-19 and to discern the cost to treat COVID-19 patients with comorbidities.

Few COVID-19 treatment centres were available in Mozambique during the time the research was conducted, so the Centro da Matola 1 (CM1) in Maputo Province (the only one in the province at the time of analysis) was deemed an appropriate study setting. A sample group of eight participants was not fixed in advance but was guided by the course of the disease and demand for admissions at the time of the analysis; from September to December 2021, CM1 admitted only eight inpatients.

The implementation of cost analysis methodologies for healthcare organizations is limited in Mozambique and similarly under-resourced countries. Considering the country's resource constraints, the results of this analysis may contribute to informing policy revisions and resource planning to meet COVID-19 response needs.

METHODOLOGY

Study Design

A retrospective cost analysis from the provider perspective was conducted, following the "ingredient" approach. All resource costs used to treat inpatients with COVID-19 at CM1 were identified, quantified, and validated, and assumptions made were tested for sensitivity analysis based on a consolidated cost analysis methodology [16].

Setting of Analysis

Maputo Province is located in southern Mozambique, with a population of 2,507,098, corresponding to approximately 7% of the total country population [17]. The baseline demographic and socio - economic characteristics of the province have been described elsewhere [18]. The latest National Cause of Deaths Survey points to HIV, TB, malaria, cardiovascular diseases, and chronic respiratory diseases as the main causes of deaths [19,20]. As a part of Mozambique's most metropolitan area, as of February 11, 2021, there were 4,215 confirmed COVID-19 cases with 24 deaths and a cumulative 65 hospitalizations. The COVID-19 epidemiological situation at the time of the research placed the province as the second with the highest number of confirmed cases, deaths, and hospitalizations [9]. The CM1 was, at the time of data collection, the only centre of its kind at the provincial level, designated for the treatment of COVID-19 patients in need of hospitalization.

Ethical Approval

Ethically, the study was reviewed and approved by the Institutional Ethics Committee of the Instituto Nacional de Saúde (Ref 87/CIBS/INS/2020). The Ministry of Health and the Provincial Health Service Directorate also approved the study. Informed consent was waived since the study anonymously retrieved retrospective data from clinical files after patients were discharged.

Cost Analysis Identification, Quantification, and Validation of Costs

Patient data were collected from September 1 to December 1, 2020, at the CM1, resulting in a period of 120 days total. According to data registered in the CM1's inpatient medical records, eight patients had been admitted with a total average inpatient time of six days. COVID -19 patient presentation per comorbidity status was as follows: HIV (38%), bronchopneumonia (25%), pneumonia (13%), diabetes and hypertension (13%), and patients without comorbidities (13%).

Even though the cumulative incidence of COVID-19 had an exponential increment in the study period, the daily cumulative incidence nationally was around 30 cases per 100,000 inhabitants during the same period. The total number of hospitalized COVID-19 patients was 25, placing Mozambique as one of the countries with the lowest COVID-19 cases in the African region and the world [9]. Moreover, at the time of the study, Mozambique had two COVID 19 treatment centres and CM1 was the second-largest despite having attended only eight inpatients. Entering the CM1 was largely limited to staff so visiting the centre was not allowed, causing access difficulties for research purposes. The CM1 was the only treatment centre allowing limited access for costing study purposes, therefore, data had to be collected as soon as the permission was given, even with a small sample. Increasing the study period and thus the sample was not deemed required for precise cost estimation. Thus, a sample of eight participants was not fixed in advance but was guided by the course of the disease at the time of the analysis. The comparability of study results with those from other countries [23-26], validates the study validity despite the small sample size.

Following Mozambique's national guidelines, the treatment of COVID-19 patients accounts for the clinical and laboratory profiles [21] and the comorbidities (if any) presented. The guidelines point to two major COVID-19 inpatient categories: severe patients, who show signs of pneumonia without other signs of severity, that is, without loss of consciousness and with slight changes in roentgenogram (X-ray), and critical patients, presenting one or a combination of severe pneumonia, fever above 38oC, altered state of consciousness, X-ray with notable abnormalities, those presenting acute respiratory distress symptoms irrespective of signs and symptoms of severe pneumonia, those with signs of respiratory failure, presentation of extensive X-ray abnormalities and those in need of assisted ventilation [21]. Patients with severe symptoms are admitted to a general ward within CM1, and those with critical symptoms go into an intensive care unit within the CM1.

Patients' clinical data were collected using data registered on the patients' medical records, while economic data was obtained from sources which included records of expenses for salaries, fuel, vehicle maintenance, drug prices, invoices, national marked prices in the year of analysis, and international standardized prices [22]. Additionally, information about interest rates and official exchange rates was

derived from publicly available information from the Central Bank of Mozambique.

The economic cost consisted of the financial costs of treatment resources paid by the state budget and other resources paid by donors and/or cooperation agencies. All costs were collected and calculated in the local currency, Metical (MZN), however for publication and comparison, they were converted into United States dollars (US$) using the official average exchange rate for the study period (1 US$ corresponds to MZN 65).

Costs were broken down into the following categories:

(I) recurrent, which included:

(a) intervention costs comprising medicines, personal protective equipment (PPE), transport (fuel, maintenance, and insurance), and stationery material.
(b) personnel costs including salaries and benefits, recruitment and selection, training, and community mobilization and supervision.
(c) overhead costs, which included electricity, water, and hygiene and cleaning materials;

(II) capital costs consisting of buildings, equipment, vehicles, and furniture and similar items.

To estimate intervention costs, resources consumed were listed and the quantities multiplied by the unit price of each resource. To estimate the cost of transportation, the total cost of fuel, maintenance, and insurance for the period of analysis was multiplied by the proportion of days (period of analysis) in which the vehicle was allocated to intervention. Estimating personnel costs included obtaining daily costs, and monthly wages were divided by the number of days worked per month; this unit, daily wages, was multiplied by the time spent in the intervention and the number of staff in the same category; overhead costs were estimated based on the total costs of the period under analysis.

To allow for the calculation of opportunity cost and depreciation, the cost of capital resources was valued based on the equivalent annual cost approach by annualizing the present value of the resources on the year of analysis over the annualized factor. The resulting annualized costs have been extracted from standardized references[16] and were based on data such as:

(i) the useful life of the capital resource, according to data extracted from WHO -CHOICE [22], 40 years for buildings, (4, 5, 6, 7, 8, 11) and 14 years for various accessories and equipment, and 7 years for vehicles;

(ii) the average official interest rate for the period under analysis (10%) provided by the Central Bank of Mozambique;

(iii) the purchase price of the resource in the year of analysis was extracted from the national and international market data based on data from the national suppliers and standardized international prices available on WHO-CHOICE

The results were presented as total economic cost and economic cost per capita per day to treat in patients with severe COVID -19. Additionally, we also assessed the total economic cost to treat inpatients with COVID-19 with severe symptoms according to comorbidities.

Sensibility Analysis

To test the main study assumptions, a "one-way" sensitivity analysis was performed on the study parameters, including:

(i) The course of the pandemic itself (increase in the number of cases).

(ii) Top-ups in health professionals' salaries since, at the study time, the government intended to provide a 30% increase in salaries as an incentive to face the pandemic. We assumed the costs without this incentive because at the time this study was undertaken, salary top-ups were not yet in effect.

(iii) The outlier analysis considering vehicles costs since this component consumed 69% of the total cost; nonetheless, we assumed that vehicles are a capital resource that the government may not need to incur recurrent expenses on.

Thus, we assumed that no vehicles needed to be purchased from September to December 2020. Thereafter, a 50% increase-decrease test was performed, except for salaries, of which the only costs were to account for the 30% salary incentive. We assumed that choice of the 50% increase and decrease variation must be able to identify significant changes in the selected costing parameters.

Results

Tables 1 and 2 summarises the results. The total economic cost to treat severe COVID-19 inpatients from September to December 2020 was 21,157,159 MZN, corresponding to US$334,501. The economic cost per capita per day was 22,039 MZN, corresponding to US$348. According to comorbidity, the costs of treatment were as follow: tuberculosis (176,122 MZN [US$2,785]), pneumonia (176,113 MZN [US$2,784]), and diabetes and hypertension (176, 087 MZN [US$2,784]). These costs were relatively higher compared to the costs of patients with other comorbidities, such as bronchopneumonia (88,085 MZN [US$1,393]) and HIV (88,053 MZN [US$1,392]). The cost for severe COVID-19 patients without comorbidities was 176,105 MZN (US$2,784).

Table 1: *Total Economic Cost and Economic Cost per Capita per Day*

Cost Category	Total Economic Cost (MZN)	Total Economic Cost (US$)	Economic Cost per Capita per Day	(MZN) Economic Cost per Capita per Day (US$)
Intervention	2,723,443	43,058	2,837	45
Personnel	1,928,989	30,498	2,009	32
Overhead	69,164	1,093	72	1
Capital	16,435,564	259,851	17,120	271
Total	**21,157,159**	**334,501**	**22,039**	**348**

Table 2: *Total Economic Cost per Capita per Day According to Comorbidity*

Comorbidity	Number of Patients	Economic Cost per Capita per Day According to Comorbidity (MZN)	Economic Cost per Capita per Day According to Comorbidity (US$)
HIV	2	88,063	1,392
Tuberculosis	1	176,122	2,785
Bronchopneumonia	2	88,085	1,393
Pneumonia	1	176,113	2,784
Diabetes + Hypertension	1	176,087	2,784
Without Comorbidity	1	176,105	2,784

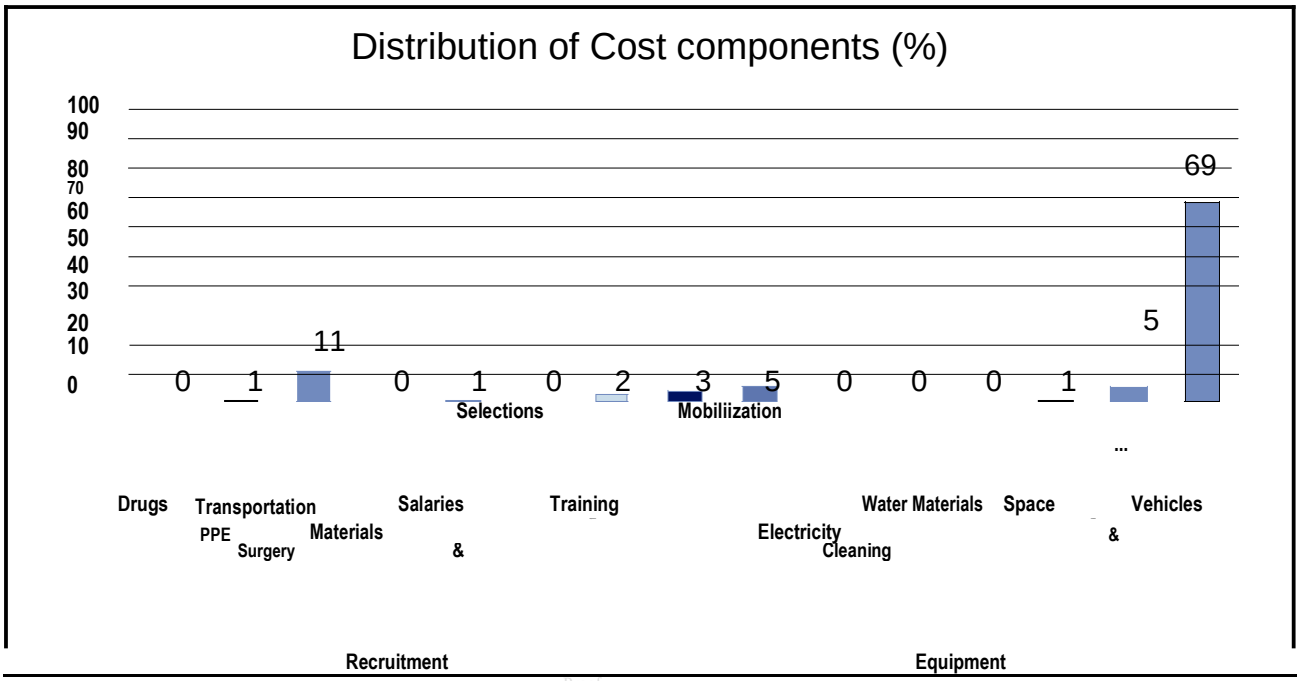
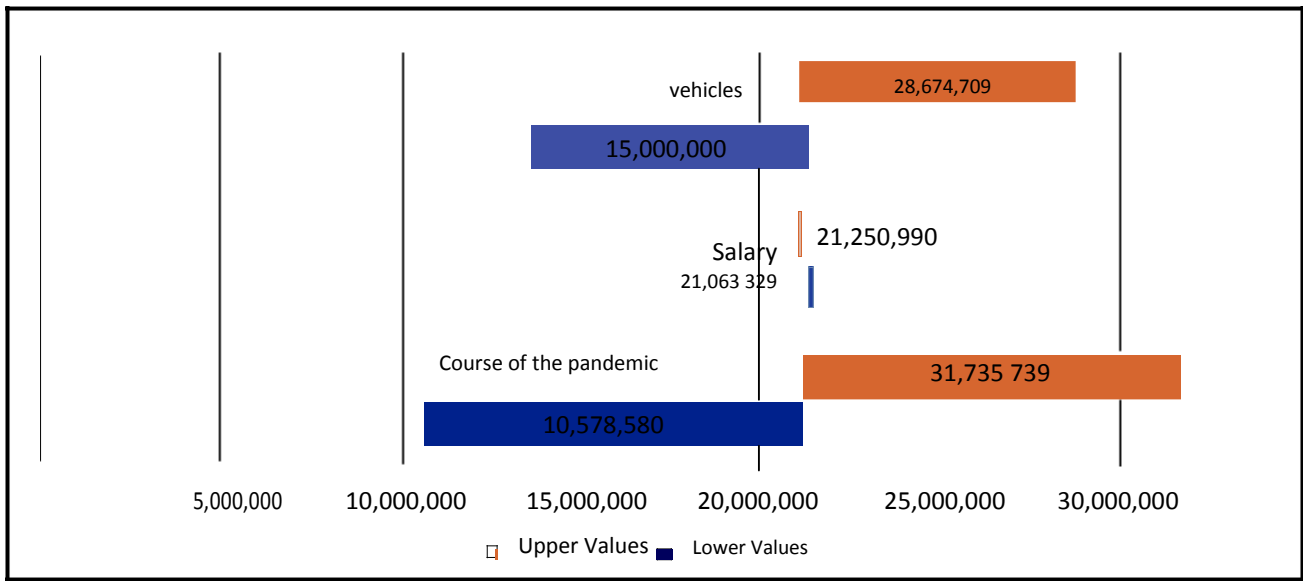


Figure 1: *shows the proportional distribution of cost components. Vehicle, transport, furniture and equipment, and mobilization costs were the major cost drivers accounting for 69%, 11%, 5%, and 5% of the total cost, respectively.*

Sensitivity Analysis

The figure below summarizes the results of the sensitivity analysis. Testing changes during the course of the pandemic had the greatest impact on the total cost. When testing a 50% increase of baseline costs, there was a considerable increase in the total economic costs. Testing the vehicle cost sensitivity resulted in the second parameter with the greatest impact. When vehicle costs were decreased by 50%, there was a negative variation of approximately 36% in the total economic costs. Conversely, the analysis shows that a 30% variation in salaries results in the total economic cost remaining relatively invariable, which means that there is no considerable impact from salary changes by ± 30% on the total cost.



F***igure 2:*** *"One-way" Sensitivity Analysis*

Discussion

This study was conducted to cover September 1 to December 1, 2020, and allowed an early estimation of the total economic cost to treat inpatients with COVID-19 presenting severe symptoms in a resource-constrained environment. The estimated total economic cost was 21,157,159 MZN, corresponding to US$334,501. The economic cost per capita per day was 22,039 MZN, corresponding to US$348.

The Gross Domestic Product (GDP) levels are an important factor in determining how much governments can allocate their budgets to attend to disease needs. Mozambique is a low-income country with a current GDP per capita of US$503. The study cost estimates show that COVID-19 inpatient treatment currently demands more than 68% of the GDP per capita among the Mozambican population. The results suggest that Mozambique can struggle to cope and to provide resources to respond to COVID-19 if severe cases emerge as a major pandemic feature in the country context.

Although it is important (and mainly for under-resourced health systems), few countries in Sub-Saharan Africa have estimated the cost of treating a severe COVID-19 patient. Some of those countries aimed to estimate treatment costs in hospital and home settings. Nonetheless, our study is hospital-based. Available reported results are from Kenya, Ghana, South Africa, and Ethiopia, and beyond African low-income countries, in Pakistan. Rueda and colleagues found that to treat a critical COVID-19 patient in Ethiopia, Pakistan, and South Africa the cost was US$506, US$221, and US$1,082, respectively [23].

Our estimates fall between the results from Ethiopia and Pakistan and are three times lower than the South African estimates. Two aspects are critical in comparing Rueda et al. with our study, namely: the length of hospital stay and the costing methodology. While we have used primary data to estimate per capita cost and considered a length of stay of six days, Rueda and colleagues extrapolated results from the large- scale costing exercises they undertook around either tuberculosis or general health services in the three abovementioned countries. These methodological aspects may have influenced estimate differences.

We found different results with estimates presented by Ismaila and colleagues in a Ghanaian study, where the cost of managing a critical patient was US$ 11,925. Considering the national protocol for the management of COVID-19 patients [24], this cost is 34.3 times higher than our estimate.

While PPEs and transportation were the major cost drivers in the Ghana study, in our study, PPE had a less significant contribution to the total cost (1%), while transportation had similar weight — it was the second major cost driver in our study (11%). Despite a considerable difference in results between our estimates and those from Ismaila et al., similarities were also seen in medication costs.

For Ismaila and colleagues, medications accounted for 1% of the total cost whereas, in our study, they contributed to less than 1%. Apart from having used a national protocol for the management of COVID-19 patients, Ismaila et al. considered a hospital stay length of 21 days for severe and critical patients, which is a difference of 15 days compared to our study inpatient period, and this average was drawn from both public and private providers in Ghana, while we studied only public providers. Consequently, the abovementioned factors may have heightened the treatment cost in Ghana.

Two other studies on COVID-19 treatment costs around Sub-Saharan Africa were found in Kenya and South Africa. In the Kenyan study, Barasa et al. found that for a severe patient managed in the general ward, the unit cost was US$124.53, while a critical patient admitted in intensive care had a unit cost of US$599.51 [25]. The cost found in the Mozambican study is 2.8 times higher than the one presented for severe cases, and 1.7 times lower than for the critical patients. The significant differences may be justified by the methodology used. Kenya used real-world data and augmented it with the Kenyan guidelines for treating COVID-19 patients, while we used clinical patient records.

Cleary et al. used secondary data to estimate the treatment cost in both the public and private sectors and found that the unit cost was US$254 [26]. This cost is 76.5% lower than the extrapolation presented by Rueda et al. for South Africa (US$1,082) [23] and 17% lower compared to the Mozambican result (US$348).

However, again, verified differences may lie in the methodologies used in the three studies; indeed, Rueda and colleagues extrapolated large-scale data from TB and general health services and considered a length of stay ranging from eight to 10 days, Cleary and colleagues used secondary data and considered a length of stay of 21.25 days, while we collected primary data and considered a length of stay of six days.

However, findings from Mozambique are overall within the range of the other study results in the continent. Also, it is important to consider the costs needed to respond to COVID-19 in contexts where other comorbidities are highly prevalent, such as in our study.

Thus, in line with published studies [26], we suggest that the following dimension be considered in priority settings, through clear strategy:

i. equity — equal treatment for equal
ii. need efficiency — in a scenario of scarce resources, it is essential to clearly establish priorities and continuously reprioritize as needed. *perspectives. 2020;35*

The latter dimension, technical efficiency, shall occur much more easily if society produces the most of their goods and services at the lowest cost; an allocative efficiency follows, in which the distribution of resources occurs to achieve the maximum possible and socially desired outcome, a consideration given decision-makers need to address the best goods distribution with the same fixed budget while adjusting to different diseases.

An equitable and efficient allocation of resources will help not only to better respond to COVID -19 treatment needs but more importantly, enables the distribution of resources per the need. The evidence brought by this study and others from an African context informs how much COVID-19 inpatient treatment costs and can help inform health policy planning. More importantly, results shall inform resource allocation to respond to COVID -19, while keeping public health attention toward other important public health threats.

This study also intends to inform cost savings. Evidence shows that it is important to consider the pandemic dynamic as it considerably impacts the total cost. In fact, since December 2020 the number of new cases has been increasing substantially. To illustrate, from March 22 to December 31, 2020, the studied province had a cumulative number of positive cases of 3,021, of which six resulted in death [9].

However, from January 1 to February 11, 2021, the province had an increase in cumulative cases to 4,215 and 24 deaths, less than two months later, totalling 7,236 confirmed cases and 30 deaths since the start of the pandemic; the studied province recorded a 58% increase in positive cases and 20% in deaths (9). If the uptrend rate of infection causes an increase in demand for treatment at healthcare facilities, our sensitivity analysis shows that the course of the pandemic will have a greater impact on total costs. Additionally, it is necessary to consider the high prevalence of comorbidities in the country that can increase the need for hospitalization, further increasing the economic impact of COVID-19 on the Mozambican health system.

Our evidence shows that the components with the greatest impact on total cost were the cost of vehicles, costing 15,035,100 MZN (US$237,709.09), corresponding to 69% of the total cost. This being a fixed resource cost that already existed for health service strengthening before COVID-19, the investment to meet the response to COVID-19 through some capital expenses should be sped up during the same period. The sensitivity analysis showed that by reducing vehicle costs by 50%, the total cost was reduced by approximately 36%. Assuming this cost is not incurred, at least in the years following an initial investment, these results show that the costs of treatment for COVID-19 were considerably lower in the period under analysis. The suggestion is to use all the available vehicles in the health system and avoid buying new ones, at least in the short term.

The study has several limitations. Some drug prices were extracted from different data sources. For example, the Medicines Supply Center of Maputo Province, our main source for medicine prices, did not have the price of some drugs on file, which led us to rely on standardized prices from the Global Fund, which is one of the main drug purchasers in Mozambique. the other limitation and perhaps the most important, limitation of the study is the course of the pandemic, and thus the costs of the current analysis may be considerably underestimated since cases of COVID-19 increased dramatically in the country after the study

was conducted. Thus, we assume that the information collected in CM1 of Maputo Province may be indicative but not represent a significant proportion of the current costs the treatment of COVID-19 inpatients incurs.

As the last study limitation, we acknowledge the small sample included in the study (n = 8). At the time of analysis, only eight inpatients were admitted at CM1; however, our methods generated data exceptionally to determine the per-capita costs to treat patients with COVID-19 in Mozambique.

Conclusion

This study estimated economic costs for treating COVID-19 inpatients presenting severe symptoms, from September 1 to December 1, 2020. The results show a substantial cost of US$348 per capita per day in Mozambique. Among all costs, vehicles, transportation, furniture, and community mobilization costs had the greatest impact on the total cost. Our findings identify opportunities to avoid increasing costs, especially through not purchasing new vehicles but instead mobilizing existing vehicles to attend the healthcare of COVID-19 patients. Indeed, in our estimate, vehicles have had the greatest contribution to the final cost. We concluded that the course of the pandemic, although more complex to manage, has also had a considerable impact on total costs but it is also necessary to consider the high prevalence of comorbidities in the country. The latter can increase the need for hospitalization, further increasing the economic impact of COVID-19 on the Mozambican health system.

We suggest that defining equity and efficiency as priorities allows the scarce resources of the Mozambican health system to be better used. Considering the small sample size included in the study and the significant impact of the pandemic on the total cost to run health services, it is highly recommended that the cost analysis be regularly updated to contribute to informing efficient resource allocations.

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Availability of Data and Materials

The supporting data for this article is available from the corresponding author upon reasonable request.

Competing Interests

The authors declare that there is no competing interest regarding the publication of this paper.

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Author's Contributions

NC conceived the topic for the study, collected data, performed all analyses, conducted the background literature review, and drafted the manuscript. JD provided substantive input to the protocol and revision of the literature review and discussion. NM conceived the topic for the study, provided relevant revisions of the background literature review, revised the methodology, and discussed the results. AN participated in data collection and reviewed the manuscript. IC reviewed the background literature review, especially on treatment protocols of hospitalized patients with COVID -19 in Mozambique. AOM conceived the topic for the study and substantially contributed to the revision of the manuscript. SC provided a substantive revision of the literature review, discussion, and analysis. All authors approved the manuscript submission.

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