

# A critical review of estimation of disease costs of COVID-19 pandemic in Low and Lower middle-income countries

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## Abstract

### Background

COVID-19's emergence created a worldwide disaster, hitting nations of all income levels and causing catastrophic health and socioeconomic destruction. Due to differences in healthcare systems, demography, and containment measures, low and lower-middle-income nations (LMICs) had distinct problems in coping with the epidemic.

### Objectives

This review synthesizes the existing evidence on the cost of treating COVID-19 in low and middle-income countries, including direct and indirect expenses and the methods employed in cost assessment.

### Methodology

The review includes studies published after 2019, concentrating on COVID-19 patients in low and lower middle-income countries. Four studies complied to the inclusion criteria, demonstrating various methodological approaches, perspectives, cost components and regional variation across the healthcare system.

### Results

Four studies from Iran, Kenya, Ghana and Ethiopia were included. Average direct medical costs per inpatient ranged from \$321 to \$3,755, with ICU care consistently 2–4 times more expensive than general ward care. Key cost drivers included ICU services (up to 41%), staffing (up to 46%), medications (up to 35%), and PPE (up to 79%). Indirect costs, where reported, added substantially to the total burden.

### Conclusion

COVID-19 imposed a significant economic burden in low- and lower-middle-income countries, with costs escalating sharply in severe and critical cases. ICU care, staffing, medications, and PPE are the primary cost drivers. These findings emphasized the need for cost-efficient

strategies—such as early detection, home-based care, and targeted ICU use—to optimize resource allocation and reduce financial strain on health systems.

### Highlights

1. The study assesses the economic burden in terms of costs borne by the low and lower middle-income countries for the treatment of COVID-19 illness.
2. The study included a narrative synthesis by segregating the cost parameters (direct and indirect costs) of the existing studies conducted in the low and lower middle-income countries.
3. There are limited number of cost studies of COVID-19 illness whereas it has been talked a lot in the epidemiological aspects of the COVID-19 pandemic. This assessment can help governments, healthcare professionals and international organizations manage the complicated public health and financial landscape carved out by COVID-19.

### Abbreviations

LMICs: Lower and Lower Middle income Countries

DC: Direct cost

IC: Indirect cost

HTA: Health Technology Assessment

WHO: World Health Organisation

DOAJ: Directory of Open access journals

PROSPERO: International Prospective Register of Systematic Reviews

PRISMA: preferred reporting items of Systematic Reviews and Meta Analysis

HIS: Hospital information system

ICU: Intensive care unit

## Introduction

A global catastrophe affecting all nations was triggered by the emergence of the new Coronavirus Disease 2019 (COVID-19). The pandemic unleashed widespread health and socio-economic devastation on a global scale, rapidly spreading with severe consequences for patients, healthcare workers, health systems, and economies worldwide.<sup>[1]</sup> While the burden of the disease has had a worldwide impact, low and lower-middle-income countries (LMICs) have faced unique challenges.<sup>[2]</sup>

The variation in COVID-19 treatment costs across different low and LMICs is influenced by a range of factors. The various economic challenges experienced by low and LMICs during the pandemic are a result of variations in healthcare systems, population demography, illness severity and the efficacy of containment measures.<sup>[3]</sup> This has been accentuated by the increased demand for resources

and its effect on the broader healthcare infrastructure.<sup>[4]</sup> The financial consequences of COVID-19 in these environments go beyond the direct costs of healthcare to include indirect costs like lost productivity, income and social effects on affected individuals and communities.<sup>[5]</sup> It is essential to comprehend the economic impact of COVID-19 in various environments to ensure efficient resource allocation, policy development and future pandemic preparedness.<sup>[6]</sup> The assessment of the cost of illness studies plays a crucial role in understanding the economic implications of the novel coronavirus disease 2019 (COVID-19) and its impact on various stakeholders. By examining user costs, provider costs, and different modes of financing, cost of illness studies provide valuable insights into the economic burden on households and health systems, as well as the overall efficiency of healthcare interventions.<sup>[7]</sup> Additionally, assessment of the provider costs, including healthcare infrastructure, personnel and treatment expenses, is vital for understanding the strain on health systems and the allocation of healthcare resources.<sup>[8]</sup> With an emphasis on user and provider costs in low and LMICs, this systematic review attempts to thoroughly investigate and synthesize the available research on the cost of treating COVID-19 disease. The findings of this review will inform policymakers, healthcare professionals, and international organizations, facilitating evidence-based decision-making and resource allocation to effectively address the economic challenges posed by the pandemic. Furthermore, cost of illness studies has implications for health technology assessment (HTA) and the evaluation of intervention efficiency.<sup>[9]</sup>

## COVID-19

The fast worldwide spread of SARS-CoV-2 prompted the World Health Organisation (WHO) to declare the COVID-19 outbreak, a pandemic in March 2020. The virus spreads largely by respiratory droplets produced by coughing, sneezing, or talking, as well as through direct contact with infected surfaces. COVID-19 symptoms include fever, cough and shortness of breath, which can range from moderate to severe. While most people have moderate symptoms, particular populations, such as the elderly and those with comorbidities, are more likely to suffer severe respiratory distress and other consequential effects. The pandemic spurred massive public health measures, such as lockdowns, travel restrictions, masking and double masking, sanitization, and vaccination drives, aimed at preventing the virus's spread. This led to a loss of employment, availability of healthcare resources, cost of hospitalization, deaths, and non-availability of definite treatment options. The virus and the measures taken have profoundly impacted people's lives.

## Cost of illness

The cost of illness is considered an important tool for evaluation. This review will examine the studies that have calculated the cost of COVID-19 disease which will help in estimating the direct and indirect costs incurred during the pandemic. Consequently, this review will include cost of illness studies that cover various elements of treatment costs including direct and indirect costs in the hands of users as well as providers.

## Low and Lower-middle-income countries

The study is aimed at understanding the cost of treating COVID-19 in low and lower-middle-income countries. In such settings, COVID-19 hospitalization and home quarantines or quarantine facilities impose higher financial constraints on households leading to asset depletion and loss of income. The cost of diagnostic instruments and various medical technologies poses a financial burden in resource-poor settings. For the purpose of this study, low and lower-middle-income countries are classified as per the classification of the World Bank.<sup>[10]</sup> In this review, low- and lower-middle-income countries are defined based on the World Bank's 2023 fiscal year classification, which categorizes economies by gross national income (GNI) per capita as follows: low-income ( $\leq \$1,135$ ) and lower-middle-income ( $\$1,136-\$4,465$ ).<sup>[10]</sup> In summary, cost of illness studies are necessary to comprehend the economic consequences of COVID-19 on households, health systems and overall resource allocation.<sup>[11]</sup>

## Methodology

To undertake this review, a study protocol was prepared and registered on the PROSPERO database (CRD42023432680). Various electronic databases such as Medline, ProQuest and Scopus and Directory of Open access journals (DOAJ) were searched. We also looked for pertinent literature in the chosen publications' citation lists. The study search is updated through July 2023. The results of this review were reported using the most recent Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) criteria.<sup>[12]</sup> The cost information from the selected studies have been summarised using 2023 US Dollar value using the EPPI currency converter.<sup>[13]</sup>

## Keywords and Inclusion criteria

Studies were chosen based on keywords created from the conceptual framework pertinent to the study subject. These were utilized for the first level database search and then the studies were further screened in accordance with the first-level inclusion criteria. Studies chosen at this level were put through a second-level screening pro-

cedure. The studies that were chosen from this list was then methodically mapped for narrative extraction of data ([Annexure Table 1, 2](#)).

### Data synthesis and extraction

A pre-tested data extraction table was used to collect key information from each included study, including authorship, study location, year of study and publication, provider type, illness category, methods of cost data collection, analysis, presentation, and reported cost outcomes. Given the variability in costing approaches and outcome indicators, meta-analysis was not appropriate; instead, cost data were reported individually to reflect study-level detail, while costing methods were synthesized to present a consolidated range of reported costs. ([Table 1](#))

### Assessment of quality of selected studies

Study search and selection was conducted by two reviewers and results were matched for completeness and correctness. Any difference of opinion was settled through mutual discussion with the Principal Investigator. The quality of the selected studies was assessed using the checklists for health cost analysis proposed by the British Medical Journal (BMJ) and Consolidated Health Economic Evaluation Reporting Standards (CHEERS) 2013 by the International Society for Pharmacology and Outcomes Research (ISPOR).<sup>[18]</sup> Three grades were used to rate the items (YES, NO and NOT APPLICABLE), the end goal being to check the “YES” percentage for each question. The quality assessment was undertaken by two independent reviewers and disagreements were resolved by consensus or after consultation with a third author. Each study parameter was graded according to the type of risk. An overall bias assessment, as well as the risk of bias summary for each individual study, was also presented as part of the results of the review.

## Results

A total of 69 records were identified through database searches—PubMed (n=29), ProQuest (n=15), DOAJ (n=8), ScienceDirect (n=6)—along with additional references (n=11). After removing 11 duplicate entries, 53 records were screened at the title and abstract level. Of these, 42 studies were excluded for not meeting the inclusion criteria, primarily due to methodological limitations or the absence of cost analysis. Eleven full-text reports were sought for retrieval; one could not be accessed. Among the remaining 10 studies, six were excluded because they derived cost estimates from secondary data sources, which did not satisfy the review’s eligibility criteria. The distinctiveness of this review lies in its focus on studies that estimated COVID-19 illness costs using primary

data sources. Ultimately, four studies met the inclusion criteria and were incorporated into the final synthesis. The search and selection process is detailed in the PRISMA 2020 flow diagram ([Figure 1](#)), following the updated guidelines of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses 2020 statement.<sup>[12]</sup>

The quality check of each of the four studies included in this review was done. The detailed graded checklist has been provided in ([Annexure Table 3](#)) presents the results of the quality assessment of the selected studies. While the quality of the selected studies seems to be adequately good there were inadequacies in the description of unit costs and evidence of quality assessment done by the authors of the reported studies. The research quality of all the papers is judged sufficient, providing a strong basis for further analysis. Key sections like describing population characteristics, mentioning study perspective and disclosing different parts of cost estimation show a consistent 100% adherence. Nevertheless, there are differences inadequacies. Only 75% of studies report ethics approvals and disclose conflicts of interest. Furthermore, just half of the research reported having received funding, indicating a possible lack of funding. The need for more specific documentation supporting methodological robustness is highlighted because only 25% of the studies offer quality evidence, despite costs and related details being reported up front. Overall, the evaluation reveals areas of strength and points out areas that needs improvement to guarantee financial transparency and complete assessment of cost of illness.

### Setting, location and perspective

The studies were conducted in low and lower-middle-income settings. The countries in which the selected studies were undertaken were Ethiopia, Iran, and Kenya.<sup>[14-17]</sup> Among the selected studies, three were conducted from a health care payer perspective, which were also referred to as health systems perspective when expanded to beyond direct cost of care.<sup>[14,15,17]</sup> Only one study was conducted from a societal perspective.<sup>[16]</sup>

In their Ethiopian study, Solomon T. M. et al. (2022) focused on the viewpoint of healthcare providers, primarily analysing costs from the provider perspective.<sup>[14]</sup> This perspective delved into direct medical costs, such as treatments, procedures and the utilization of resources within the healthcare system, thus revealing insights into the financial pressures borne by healthcare institutions. In Ghana, Hamza Ismaila et al. (2021) adopted a health systems perspective, offering a broader panorama of costs and repercussions encompassing the entire healthcare system.<sup>[15]</sup> This perspective extended beyond direct medical costs to encompass administrative and infrastructure expenses, as well as the coordination and delivery

of healthcare services. In Iran, Mohsen G. D. et al. (2021) opted for a societal perspective, encompassing not only healthcare-associated costs but also wider economic and societal impacts.<sup>[16]</sup> This entailed accounting for indirect costs like productivity loss, absenteeism, and intangible expenses, thus providing a holistic comprehension of the overall societal burden. Meanwhile, Edwine B. et al., (2021), conducting their study in Kenya, employed a health system perspective.<sup>[17]</sup> This approach emphasized costs and ramifications within the healthcare system, comprising resource allocation, infrastructure and management considerations. (Table 1)

### Source of data and methods

Solomon Tessema Memirie et al. (2022) conducted a retrospective analysis of the cost of illness.<sup>[14]</sup> Hamza Ismaila et al. (2021) examined the cost of illness associated with the clinical management of COVID-19 based on the suggested protocol of treatment in Ghana.<sup>[15]</sup> The third study, authored by Mohsen Ghaffari Darab et al. (2021), employed an incidence-based approach.<sup>[16]</sup> Lastly, Edwine Barasa et al. (2021) conducted an economic evaluation using an incidence-based cost-of-illness approach.<sup>[17]</sup>

The study by Hamza Ismaila et al. (2021) did not include any patients. Data were collected using a resource template, which was directed by frontline doctors, to describe resources used to treat patients with diverse illness severity and locations. Cost of sample collection tools, test kits for SARS-COV-2, complete blood count, blood gases, chemistries, imaging, medications, supplies and consumables were included in the study. Supplies and consumables included oxygen, mechanical ventilation and associated supplies such as syringes and masks provided as part of in-patient treatment. The study assessed treatment expenses per patient based on illness severity levels using quantifiable resources for each patient group and related unit costs. Cost comparisons were made across resource consumption categories within the same severity level as well as between severity levels and treatment settings (home-based or institutionalized care). Particularly, neither the estimated costs nor the actual costs were reduced or changed.<sup>[15]</sup>

The study by Mohsen Ghaffari Darab et al. (2021), was conducted as a partial economic assessment and a cross-sectional cost-description study and it targeted patients with COVID-19 who sought care at a primary referral medical centre in Fars province, Iran, up to July 2020. Data was collected using forms that included patient demographics, attributes and cost information. The study took a societal approach, incorporating both direct and indirect medical expenses. Counselling, nursing services, drugs, medical consumables, rehabilitation, dialysis, imaging, electrography, laboratory testing and other

associated goods were all factored into direct medical cost estimations.<sup>[16]</sup>

The expenses of housing, overheads, staffing, medicines, non-pharmaceuticals, personal protective equipment (PPE), oxygen, laboratory and radiology tests and capital expenditures were also assessed. The information came from a variety of sources, including healthcare institution expenses, government guidelines and market pricing. A cost study of healthcare institutions was used to determine accommodation and administrative charges. Staffing was determined using data from COVID-19 treatment centres and Ministry of Health recommendations. Pharmaceutical costs have been estimated using market pricing, while oxygen expenses were determined using the cost of producing oxygen plants. Clinical guidelines and billing information were used to calculate laboratory and radiology expenses, while capital expenditures were annuitised using a discount rate. Sensitivity analysis was performed by altering staff time and PPE expenses, employing both actual and recommended staff ratios and cutting PPE expenditures by 30%.<sup>[16]</sup> (Table 2)

Calculation of direct and Indirect Costs

### Direct Cost

The study by Mohsen Ghaffari Darab et al. (2021) employed electronic medical data retrieved from the hospital information system (HIS) to determine direct medical expenditures associated with COVID-19 patients. The data was divided into nine categories, which included services such as intensive and routine bed care, physician visits, counselling, nursing services, medicine, rehabilitation, dialysis, imaging, electrography, laboratory testing, and other services. By adding expenditures from each category, the average total direct medical costs for each COVID-19 patient were calculated. The study also looked at the cost differences between inpatient care for severe illnesses requiring intensive care unit (ICU) treatment and milder cases, offering distinct direct medical cost data. All service costs utilised in the calculations were based on official pricing approved by national health authorities.<sup>[16]</sup>

In the study, by Solomon Tessema Memirie et al. (2022), direct cost has been calculated. Total direct costs comprised of different spending components such as people, pharmaceuticals and supplies, laboratory and diagnostic services, food and utilities and capital assets such as building, medical equipment and vehicles. The study evaluated the entire building area in the facility and multiplied the result by the estimated local market rental rate, which was determined by averaging the rental prices of other nearby buildings, to estimate the cost of the buildings. The cars' respective rental costs were used to estimate their costs. The study used the initial

capital outlay across the asset's lifetime to establish the comparable annual cost of the equipment, adjusted for the duration. The Ekka Kotobe finance department and the World Health Organization's (WHO) COVID-19 vital supplies forecasting tool were the sources of the equipment costs. Due to a lack of local data, information on the usable life of assets, such as medical equipment, was gathered from other sources. Following that, for each severity level, the cost per treated patient and the cost per bed day were calculated. Furthermore, the study computed both the average and monthly bed occupancy rate (March to November, 2020). This rate, given as a percentage ( $BOR = \text{total number of inpatient bed-days times } 100 / \text{available bed-days over the period}$ ), was used to assess the health-care centre's resource utilization.<sup>[14]</sup> Edwine Barasa et al. analysed costs for a complete economic evaluation, which included both monetary input values and financial outlays.<sup>[17]</sup> The direct cost was computed by the study using real data from COVID-19 treatment facilities. This cost included all direct and indirect inputs linked to the provision of case management, including facility-related costs, staff time, interventions at the patient level, fees for radiography and laboratory work and the cost of personal protective equipment for the assessment of resource consumption.<sup>[17]</sup>

Programs for home-based care were combined with information gathered from COVID-19 recommendations. Taking into consideration different patient categories and care methods, the study calculated unit costs for per-patient treatment completion and per-patient case management per day. Asymptomatic patients receiving home-based or institutional care, symptomatic patients with mild-to-moderate COVID-19 symptoms getting either home-based or institutional care, and patients with severe or critical COVID-19 symptoms admitted to hospitals or ICUs were included in these groups.<sup>[17]</sup> (**Annexure Table 4**)

### Indirect costs

The Mohsen Ghaffari Darab et al. (2021) study used income-based human capital method to evaluate indirect costs. Indirect costs were calculated using two dimensions: earnings lost owing to absenteeism while hospitalisation or home rehabilitation and productivity loss due to early mortality between the ages of 15 and 65. Individuals under the age of 15 and above the age of 65 who were economically inactive were omitted from the analysis. The Forgone Labour Output (FLO) equation was used to calculate possible economic output losses owing to early deaths, considering parameters such as expected future income, working years, present income, societal discount rate and income growth rate.<sup>[16]</sup> (**Annexure Table 4**)

### Calculation of wages lost and Productivity loss

Mohsen Ghaffari Darab et al. (2021) employed the Ministry of Cooperative Labour and Social Welfare's 2020 average income per capita, amounting to 288,000,000 Rials, for determining the minimum annual wage due to the absence of accurate wage data. The real income per capita (g) growth rate was set at 3% annually. Additionally, a 6% discount rate was used. Lastly, the estimated economic loss resulting from each premature COVID-19 mortality is 2,677,698,726 Rials or \$196,838.<sup>[19]</sup> The average indirect costs per inpatient were calculated using only 4% of this amount (129,870,974 Rials or \$11,634), which is based on the death rate among hospitalised cases derived from the study.<sup>[19]</sup> The economic burden of the study by Mohsen Ghaffari Darab et al. (2021) was assessed by combining total expenses (direct medical and indirect) with the projected number of infected inpatient patients.<sup>[16]</sup> Individual study results have been summarised and reported in **Annexure 2 and 3**. A summary of the results is presented in this section.

### Summary of costs

This study abstained from undertaking a meta-analysis, as such an approach would have proven ineffective given the fluctuation in expenditures across diverse study contexts. A summary measure would not be useful in practice. However, to facilitate comparison and implementation in comparable circumstances, the costs given in the chosen research have been condensed and presented. Using the EPPI cost converter, the base costs stated in the research were converted to US dollars for 2023.<sup>[13]</sup> **Table 2** present the cost of treating COVID-19 illness. Direct non-medical and indirect costs have been categorised as user costs, while direct medical costs have been presumed to be provider costs in as all the studies were conducted in Government settings. The direct and indirect costs for both providers and users for each category among the four studies that were selected are shown in **Figures 2**. An overview of the cost estimations is shown in **Figure 3**, which shows the total cost per patient as well as the direct costs. Despite the considerable variation in costs across different settings, which makes comparisons challenging, it is possible to observe the distribution of expenses among categories within a country's context.

Across the four included studies, the dominant cost drivers in the management of COVID-19 were consistently intensive care unit (ICU) services, healthcare workforce (staffing), medications and medical consumables, and personal protective equipment (PPE). These components were responsible for the majority of direct medical costs, especially in hospitalized and severe cases. In Iran, the average cost per inpatient was \$3,755, with ICU and general bed services alone consuming 41% of total costs, and

medications contributing an additional 28%. The Kenya study highlighted extreme cost escalation for critical cases, with daily ICU costs reaching \$599.51, driven by staffing (46%) and PPE (32%), while even asymptomatic home-based care had PPE as its largest component (up to 79%). In Ghana, with an average inpatient cost of \$620, the most resource-intensive elements were oxygen therapy, diagnostics, and staff time, reflecting similar pressure points in facility-based care. The Ethiopia study reported the lowest average cost (\$321), but even there, medications, laboratory investigations, and hospital stay duration were the leading cost elements. (Figure 3)

## Discussion

The distinctiveness of this review lies in its exclusive inclusion of studies that estimated the cost of COVID-19 illness using primary data sources. Using the average cost per hospitalized patient and the number of hospitalizations reported in the respective studies, the total estimated expenditures were as follows: Ghana – USD 69.2 million, Kenya – USD 7.5 million, Ethiopia – USD 3.7 million and Iran – USD 1.8 million.<sup>[20]</sup> The significantly higher burden in Ghana was attributed to its elevated unit cost per patient (USD 11,925), whereas the burdens in Kenya and Ethiopia were driven more by larger volumes of hospitalized patients. When contextualized as a share of national economic output, these expenditures represented 0.096% of GDP in Ghana, 0.0074% in Kenya, 0.0039% in Ethiopia and 0.00077% in Iran.<sup>[21]</sup> The key cost components across settings were ICU services, staff salaries, medications, and personal protective equipment. This analysis highlights the considerable fiscal implications of COVID-19 management in low and lower middle-income countries which underscores the need for strategic planning to allocate resources efficiently.

The financial burden brought on by COVID-19's high cost of disease is a significant and complex issue that has affected healthcare systems and economies all around the world.<sup>[22]</sup> The pandemic's ongoing effects on society include a wide range of direct and indirect consequences for the economy.<sup>[23]</sup> This study captures the broader societal costs, such as lost productivity, lost income, and the burden on the healthcare infrastructure, in addition to the direct medical expenditures incurred during the prevention, diagnosis, treatment and management of COVID-19. Cost of illness studies offer crucial insights into resource allocation, assist policymakers in developing successful solutions and offer a greater knowledge of the entire burden of the condition by evaluating the complex web of financial repercussions.<sup>[24]</sup> Fayolah Richard et. al (2022) estimates that the COVID-19 pandemic in the United States resulted in a total direct medical expenditure of \$163.4 billion throughout the length of the pandemic. Patients

and the public are now facing a significant financial burden because of the COVID-19 pandemic. It is essential to put additional preventative measures in place to minimise direct and indirect medical expenditures, loss of productivity and GDP losses. One such strategy is widespread immunization.<sup>[25]</sup> For instance, Gökler et al. (2023) reported the direct costs of treating hospitalized COVID-19 patients in a tertiary hospital in Türkiye, a country classified as upper-middle-income, where the average cost per case was significantly lower than figures reported in many high-income settings, but higher than those in the lowest-income countries.<sup>[26]</sup> This finding highlights a gradient in cost structures that reflects differences in healthcare financing models, unit cost of labour, health system capacity, and service delivery norms.

In HICs, the cost per COVID-19 hospitalization is markedly higher—driven by elevated labour costs, advanced technologies, and more intensive care unit (ICU) utilization. These differences underscore the importance of health system context when interpreting economic burden. For example, studies from the United States estimated average hospitalization costs exceeding USD 20,000–40,000 per severe COVID-19 case, significantly higher than the USD 1,000–12,000 range observed across LMICs in this review.<sup>[27]</sup>

Personnel costs has the highest contribution to the direct costs across all studies. While some of them report high personnel costs of 25%, 46% and 64% Solomon et al. (2022), Barasa et al.(2021)<sup>[14,28]</sup> the others report personnel costs ranging from 14% to 18% of the direct costs. The next biggest contributor to direct costs were drugs and diagnostics. While Barasa et al. (2021) reported costs by severity of diseases reported 88% and 12% of drugs and diagnostic costs for severe and critical cases<sup>[28]</sup>, most of the other studies reported a drugs and diagnostics cost share of 6% to 12%. Comparing costs across studies will not add value as costs are dependent on individual study settings. Ghaffari et al. (2021) measured the potential productivity losses caused by premature death, this highlights the potential economic losses caused by COVID -19 which caused high mortality worldwide.<sup>[19]</sup> The variability in direct medical costs across income settings also suggests differing policy levers. LMICs may benefit from strategies that emphasize early detection, decentralized and home-based care models, and better procurement of personal protective equipment (PPE). In contrast, HICs might focus more on optimizing high-cost services such as ICU management, given the higher resource intensity and labour costs associated with their systems.<sup>[29]</sup> Recognizing these differences allows for more targeted, context-specific preparedness planning. Importantly, understanding cross-country cost differentials can help international donors, governments, and global health agencies better allocate resources, structure universal health coverage

packages, and prepare for future health emergencies in an equitable and economically efficient manner.<sup>[30,31]</sup>

Collectively, these studies present a range of methodological strengths and limitations that, when considered together, deepen our understanding of the multifaceted economic impact of COVID-19 and highlight the importance of context-specific approaches in health economic evaluations. While their strengths—robust datasets, cost differentiation, and real-world data—increase the validity and applicability of their conclusions, their weaknesses—possible bias, constrained timeframes and omission of some cost components—remind us of the complexity involved in determining the true financial consequences of the pandemic. These disparities underscore the need for tiered policy responses: LMICs may benefit from early intervention, community-based care, and investment in essential services, while HICs could focus on optimizing high-cost interventions and efficiency in advanced care settings. Governments and global health agencies can use this cost stratification to develop preparedness strategies tailored to country income levels, ensure equitable financing, and improve resilience across health systems.

### Limitations

First, the number of eligible studies were less in number, reflecting the limited availability of cost-of-illness analyses from low- and lower-middle-income countries during the COVID-19 pandemic. This constrained the geographic diversity and generalizability of findings. Second, heterogeneity in study design, cost components included (e.g., some reporting only direct medical costs, others including indirect or societal costs), costing methods, and perspectives (provider vs. societal) made direct comparisons challenging and precluded meta-analysis. Third, while some studies reported costs in USD, others only used local currencies, requiring conversions using historical exchange rates or purchasing power parity estimates, which may introduce imprecision. Fourth, most studies focused on hospitalized patients, often in tertiary care centres, potentially underrepresenting the cost burden in community or primary care settings and for milder cases managed outside hospitals. Also, due to emergency conditions during the pandemic, many studies relied on administrative data or assumptions from guidelines rather than real-time micro-costing, which may have limited accuracy or completeness.

## Conclusion

In conclusion, the findings of the study highlight the enormous financial burden that the COVID-19 pandemic has placed on our society. These studies include thor-

ough evaluations of direct medical costs, resource utilization and broader economic effects from the perspectives of providers, health systems, and society. These studies demonstrate the importance that it can help in making well-informed decisions, allocating resources effectively and developing specific approaches to handle the ongoing and changing financial issues brought on by COVID-19. The findings from this study provide valuable guidance for formulating effective responses and ensuring access to high-quality healthcare services during the ongoing global crises as governments, healthcare professionals and stakeholders navigate these challenges.

### Authors' Declaration

**Conflict of Interest:** The Authors declare that there is no conflict of interest.

**Ethics Approval:** This study was conducted after taking necessary ethical approval from the Institutional Ethics Clearance (IEC) committee of the Indian Institute of Public Health Delhi (IIPH-D).

**Consent to participate:** Not Applicable

**Availability of data and material:** This study exclusively relies on secondary data from published sources, with no primary data collection involved

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### Author's Contribution:

Shubhanjali Roy and Shomik Ray contributed to the conceptualization of the study. Shubhanjali Roy developed and finalized the review protocol, conducted the literature search, performed study selection, data extraction, quality assessment, and prepared the initial manuscript draft. Anugraha Radhakrishnan contributed to the literature search, study selection, and data extraction. Alveena Malik and Alka Singh contributed to the quality assessment and revision of the manuscript. Shomik Ray supervised the study, provided critical input throughout the process, and approved the final version of the manuscript. All authors have reviewed and approved the manuscript for publication.

## Tables and figures

Table 1: Study summary of each of the selected studies

First author, Year, Country	Study population	Perspective	Approach	Data Source	Types of Cost	References
Solomon Tessema Memirie et al. (2022), Ethiopia	Clinical and cost data were retrospectively collected. The study included all patients admitted.	Healthcare Provider Perspective	Top-down approach	Data on staff salaries, allowances, duty payments, and fuel for transport and utility costs were collected from the finance department of the centre.	Direct Cost	[14]
Hamza Ismaila et al. (2021), Ghana	Identified and quantified resource use for each patient type based on disease severity.	Health systems perspective	Bottom-up approach	The resource template was used to collect data, with the assistance of frontline clinicians, on the resources used to treat (by the level of disease severity and treatment setting), and the quantity of the resources used.	Direct Cost	[15]
Mohsen Ghaffari Darab et al. (2021), Iran	COVID-19 patients referred to a primary referral university hospital.	Societal perspective	Bottom-up / Micro-costing approach	Patient records and accounting information	Direct Cost and Indirect Cost	[16]
Edwine Barasa et al. (2021), Kenya	Three public health facilities designated as COVID-19 treatment centers and program staff responsible for implementing home-based care	Health system perspective	Bottom-up approach	Input prices from a recent costing survey of 20 hospitals in Kenya and from market prices for Kenya.		

Table 2. Cost estimates for each of the selected cost of COVID-19 illness studies [USD \$ (2023)]

Cost Components (Direct cost/ Indirect Cost)	Solomon Tessema Memirie et. al. 2022	Hamza Ismaila et al. 2021	Mohsen Ghaffari Darab et al. 2021	Edwine Barasa et al. 2021					
				Asymptomatic		Mild to Moderate		Severe	Critical
				Home Based Care	Hospital /Isolation Centre	Home Based Care	Hospital / Isolation Centre		
<b>Provider Cost (Direct)</b>									
Personnel	581.74	1709.67	631.36	32.04	141.02	32.04	141.02	195.9	3461.69
Drug Supplies	168.03	135.44	1114.77			0.26	0.26	545.4	710.55
Medical equip- ment	136.13								127.28
Diagnostics	27.65	288.59	464.66	17.94	17.94	17.94	47.2	154.04	262.67
Inpatients Care		4236.14	461.54					132.47	154.83
Provider over- heads & Bed charges		8069.09			225.47		225.47	225.47	474.05
Consumables				186.22	411.71	186.22	411.71	462	2446.32
Total Provider Direct cost	913.55	12424.00	3912.13	236.20	796.14	236.46	796.40	796.40	7495.11
<b>User Cost (Direct)</b>									
Food	646.61								
Others	6.38								
Total User Direct Cost	652.99								
<b>User cost (Indirect)</b>									
Lost income (hos- pitalization)			393.82						
Lost income (Re- covery at Home)			1109.56						
Potential produc- tivity Loss (pre- mature death)			10616.40						
Total User Indi- rect cost			12120.82						
Total per patient Cost	1566.54			236.20	796.14	236.46	796.40	796.40	7495.11

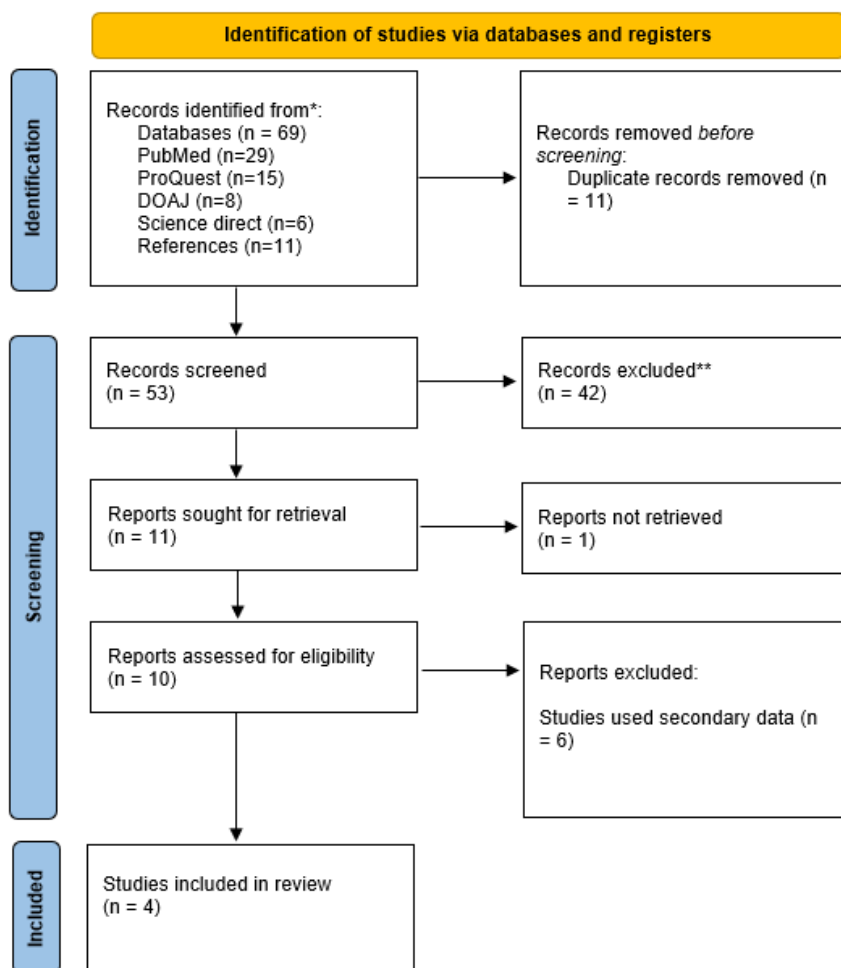
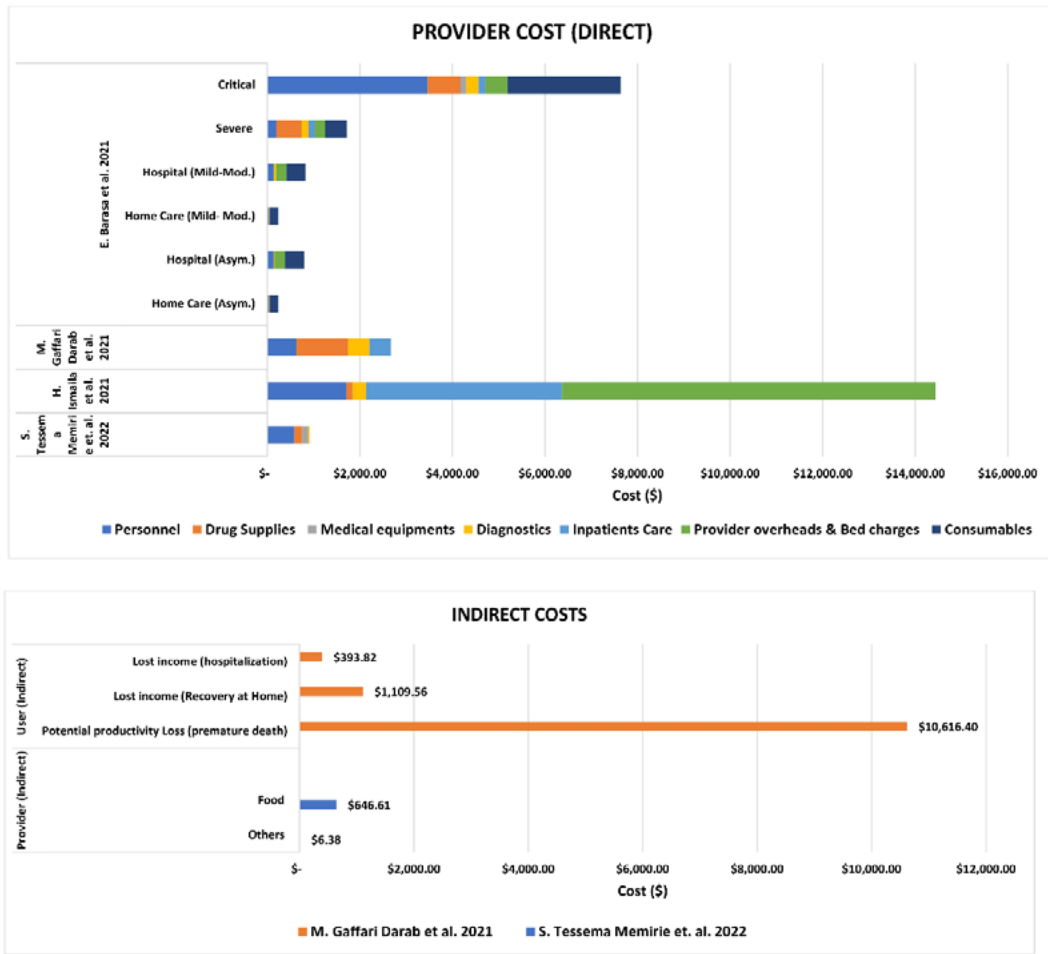


Figure 1. PRISMA-Based Flow Diagram of Study Identification and Inclusion



Asym.: Asymptomatic Mod.: Moderate

Figure 2. Direct costs (Provider) and Indirect costs for the selected studies USD \$ (2023)

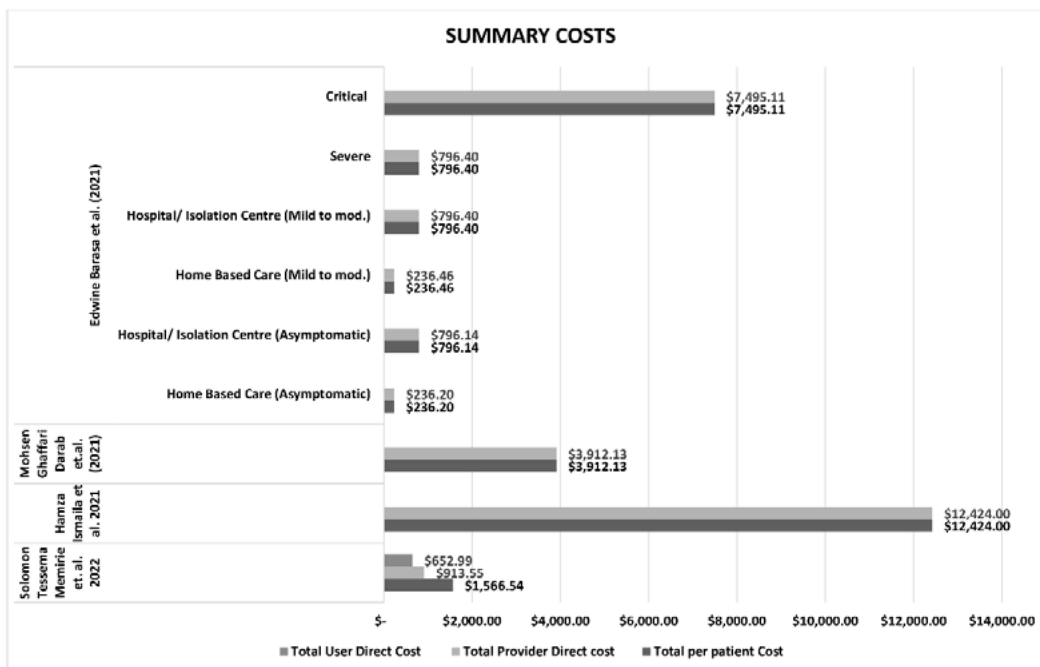


Figure 3. Summary of User, Provider, and Total Direct Costs in Selected Studies (USD, 2023)

## Annexure

Table 1. List of key words used for study selection

Key concept	Controlled words	Search words
COVID-19	COVID-19	COVID-19 Disease and SARS COV-2, symptomatic, asymptomatic
Cost of illness	Cost of illness or disease cost	Cost of illness, cost of COVID-19 Diseases, treatment cost, Quarantine cost, Hospitalization cost, Medication cost, Testing lab cost, direct cost, indirect cost, productivity loss
Low Middle-Income Countries	Low Middle-Income Countries	Low and Lower Middle-Income Countries, India

Table 2. List of inclusion criteria for the selected studies

	Level one Inclusion criteria	Level two Inclusion criteria
1.	Population: Patients tested positive for COVID-19, irrespective of location and type of treatment.	Full text available
2.	Intervention: Study evaluating the cost of illness for COVID-19 illness.	All costs related to the disease must be reported
3.	Context: Study must be based in a low and lower middle-income country.	
4.	Study design: The study must be a form of cost analysis independently or as part of a larger study.	
5.	Study year: Studies conducted and published in and after 2019.	
6.	Studies published in English language.	

**Table 3. Quality assessment checklist for the selected cost of COVID-19 illness studies (Item questions graded as YES, NO, NOT APPLICABLE [N/A])**

SI.	ITEM	STUDY AUTHOR/ COUNTRY			
		Solomon Tessema Memirie, et al. (2022)/ Ethiopia	Hamza Ismaila. et al. (2021)/ Ghana	Mohsen Ghaffari Darab. et al. (2021)/ Iran	Edwine Barasa, Angela Kairu. et al. (2021)/ Kenya
1.	Research is adequate	Yes	Yes	Yes	Yes
2.	Describe characteristics of population	Yes	Yes	Yes	Yes
3.	Study perspective (mentioned)	Yes	Yes	Yes	Yes
4.	The study was approved by an institution authorized in ethics in research	Yes	NA	Yes	Yes
5.	Conflicts of interest (mentioned in the study)	No	Yes	Yes	Yes
6.	Study funded	Yes	No	No	Yes
7.	The source(s) of cost estimates used are stated	Yes	Yes	Yes	Yes
8.	The costs were clearly described	Yes	Yes	Yes	Yes
9.	The valuation method is stated	Yes	Yes	Yes	Yes
10.	Type of cost is stated	Yes	Yes	Yes	Yes
11.	Currency, price date, and conversion	Yes	Yes	Yes	Yes
12.	Unit costs are described in	Yes	Yes	Yes	Yes
13.	The measurement of costs is adequate	Yes	Yes	Yes	Yes
14.	Evidence of quality	No	Yes	No	No
15.	Outcome measures in health were clearly described, relevant to the study question	Yes	Yes	Yes	Yes
16.	Conclusions follow from the data reported	Yes	Yes	Yes	Yes

## Individual study results

### 4.1. Solomon Tessema Memirie et al. (2020) Cost results

A total of 2,543 COVID-19 cases, ranging in severity, were treated at Ekka Kotebe. Out of these instances, 235 were classified as critical, 515 as severe and 1,841 as intermediate. The duration of patient stays in the facility averaged 9.2 days for less severe cases and extended to 19.2 days for more serious cases.

The costs have been reported in USD as per the year 2020. The average cost per treated episode was USD 1,473. The costs varied according to the classification of the disease severity. The average cost per episode for mild cases was USD 1,266. The average cost increased to USD 1,545 for each episode for severe cases. The average cost for serious cases was the highest, with USD 2,637 per episode. The costs of treating patients with various levels of COVID-19 severity at the Ekka Kotebe Centre were revealed by these data, which can be very helpful for allocating resources and making healthcare management decisions.

Food for the patient comprised of 41% of the total cost of treatment followed by personnel (37%). Drugs, supplies, laboratory, and diagnosis contributed to only 12% of the

total treatment costs. The study analyses costs associated with food, people, pharmaceuticals and supplies, capital investments, laboratory and diagnostic services, and other miscellaneous expenditures. Notably, the average cost per treatment episode varies by component, ranging from \$608 for meals. the personnel cost is \$547, which includes all expenditures connected to human resources involved in healthcare operations. Furthermore, the cost of pharmaceuticals and supplies is \$158, which covers expenses related to prescriptions and medical requirements. Capital costs are stated as \$128, which includes investments in critical infrastructure and equipment.

Furthermore, laboratory and diagnostic services, which include medical testing and analysis, cost \$26. Finally, “Other” miscellaneous expenses total \$6, potentially signifying supplemental costs that contribute to the overall healthcare system. The scope of the investigation goes beyond specific occurrences to include the full study period, indicating a total cost of \$3,725,484. Furthermore, the study delves into the cost ramifications of individual bed days (\$137) and each patient (\$1,473). In essence, this thorough analysis provides useful insights into the varied nature of healthcare spending, shining light on the economic complexities of patient care within the defined era. (Table 3.1).

Further evaluation of costs across various bed occupancy rates (BORs) and illness severity levels reveals significant variations in cost per treatment episode and cost per bed day. The cost per bed day was USD 1,533 (with a range of 885-2,180) at the lowest observed BOR (6%), whereas the cost per treated episode for critical care was USD 8,926 (with a range of 7,363-10,488). In contrast, the expenditures per bed day and each treatment episode were much lower for the highest recorded BOR (75%), totalling to USD 158 (with a range of 67-249) and USD 2,141 (with a range of 1,808-2,475), respectively. (Table 4.1)

#### 4.2. Hamza Ismaila et al. (2022)

##### Cost results

In Ghana, the average cost of treating COVID-19 patients was found to be around US\$11,925. It has been observed that when a patient transitioned from home management to receiving care at a specialized treatment centre, there was a significant increase in costs, approximately 20 times higher.

The study also showed that administrative charges, which accounted for roughly 63–71% of the overall cost, were a significant factor in the costs associated with institutionalized care. As only 6% of the total expenses, overhead costs had a less significant impact on home-based care. Overhead costs accounted for 55% (6-71%) of the cost of clinical management COVID-19 cases in Ghana, with in-patient care accounting for 19% (17-22%). The third cost driver in all cases was staff time, which accounted for 18% (4-42%) of the treatment cost, followed by investigations, which accounted for 11% (1- 47%) of the overall cost. Interestingly, drugs accounted for just 2% (0.02-5%).

The analysis found COVID-19 testing staff time for follow-up as a significant element contributing to the total cost when determining the primary cost drivers for home-based care. On the other side, personal protective equipment (PPEs) and transportation costs were identified as the main cost drivers within the overhead category. The findings highlight the significance of considering both the treatment setting and overhead costs in healthcare planning and resource allocation strategies to effectively manage the financial burden associated with the pandemic. These findings highlight on the key factors influencing the cost of COVID-19 treatment in Ghana. (Table 4.2).

#### 4.3. Mohsen Ghaffari Darab et al. (2021)

##### Cost results

The disease had a substantial financial burden on the nation for inpatient cases, totalling to \$1,439,083,784. This substantial financial burden was made up of both direct

and indirect medical expenses. The direct medical costs came to 28,240,025,968 Rials, or \$1,791,172, with a cost per person of 59,203,409 Rials, or almost \$3,755. The study considered both direct and indirect expenditures. The average indirect cost per person was 129,870,974 Rials (\$11,634).

The study calculated indirect costs by taking two things into account: lost wages from patient absenteeism while hospitalisation or home rehabilitation, and productivity loss from early death between the ages of 15 and 65. The Forgone Labour Output (FLO) equation was used, which took into account variables such as predicted future income, working years, present income, societal discount rate and income growth rate, while omitting individuals under 15 and over 65, as well as those who were economically inactive. The productivity loss and wages lost as a result of absence brought on by the sickness are covered by these indirect costs.

According to the study, the total direct medical costs were 28,240,025,968 Rials (\$1,791,172). The majority of these costs (41%) were ascribed to acute and general care beds, totalling 11,596,217,487 Rials (\$735,510). Following that, pharmaceuticals and medical consumables accounted for 28% of expenditures at 8,044,070,257 Rials (\$510,209), physician visits accounted for 12% of prices at 3,422,848,975 Rials (\$217,100), and electrography and laboratory tests accounted for 9% at 2,645,752,049 Rials (\$167,811). Nursing and consulting services accounted for just 2% of overall expenditures.

The study reported a 6.5% fatality rate among treated patients, with 4% of the deceased falling within the productive age group, dying 11 years before reaching the age of 65. COVID-19 patients were hospitalised for an average of 7 days (up to 38 days in severe instances), resulting in an income loss of 5,950,524 Rials (\$378) owing to hospitalisation and 16,800,000 Rials (\$1065) due to recovery-related absenteeism. Using a calculation that considered yearly income growth, discount rate, and average age of death, premature death resulted in a production loss of 2,677,698,726 Rials (\$169,838). Only 4% of this loss, or 129,870,974 Rials (\$11,634), was included into the average indirect expenses per inpatient owing to death rate. (Table 4.3)

#### 4.4. Edwine Barasa et al. (2021)

##### Cost results

The per-day unit costs for managing asymptomatic patients and those with mild-to-moderate symptoms at home are respectively 1993.01 KES (US\$18.89) and 1995.17 KES (US\$18.991). In comparison, the expenses of treating these patients in a general hospital ward or isolation centre are 6717.74 KES (US\$63.68) and 6719.90 KES (US\$63.70), respectively. Given the low requirement for medical

treatments, personal protective equipment (PPE) is the primary cost driver for asymptomatic and mild-to-moderate cases. Home-based treatment is much more cost-effective because of lower hospital-related charges, fewer health professional encounters, lower staffing and housing costs. The per-day unit expenditures for case management for patients with severe and critical COVID-19 illness are 13,137.07 KES (US\$124.53) and 63,243.11 KES (US\$599.51), respectively, with greater expenses related to medications, specialized staff and intensive care.

The **Table 3.4** compares the unit costs for handling COVID-19 instances in patients with mild-to-moderate symptoms at home to care in a hospital or isolation centre. In home-based care, health professional transportation costs 9.48% of the overall cost, personnel costs 21.27%, medications account for 0.25% and the COVID-19 test costs an extra 17.22%. Hospital/isolation centre care, on the other hand, comprises housing and administrative expenditures at 28.31%, staffing at 17.71%, radiography at 1.53% and a significant part of 51.70% for personal protective equipment (PPE). Overall, the overall cost per patient in home-based care is 226.96 US dollars, whereas it is 764.41 US dollars in hospital/isolation centre care.

Accommodation and overheads contribute 216.41 KES (14.48%) to severe COVID-19 cases, whereas staffing expenses contribute 188.03 KES (12.58%). Pharmaceuticals account for the majority of costs, accounting for 523.49 KES (35.03%), followed by non-pharmaceuticals at 23.58 KES (1.58%), COVID-19 testing at 17.22 KES (1.15%), other laboratory tests at 102.55 KES (6.86%), radiology at 28.08 KES (1.88%), personal protective equipment (PPE) at 419.86 KES (28.10%) and oxygen therapy at 127.15 KES (12.82%). In urgent situations, equipment costs and ICU monitoring are present, but not in severe instances. Staff-

ing at 3322.65 KES (46.19%), medications at 682.01 KES (9.48%), PPE at 2305.14 KES (32.04%) and equipment and monitoring in the ICU at 122.17 KES (1.70%) are the key cost drivers for severe patients. The overall cost per patient for severe conditions is 1494.38 US dollars, while critical cases cost 7194.07 US dollars. The cost per patient unit for COVID-19 care for asymptomatic patients is 1993.01 Kenyan shillings (KES), or roughly US\$18.89 per day. The per-patient unit expenses for patients with mild to moderate COVID-19 disease receiving home-based care total 1995.17 KES, or about US\$18.99 a day. The cost per episode for asymptomatic patients receiving home-based care is \$226.71, while those in isolation centres incur a cost of \$764.16. Similarly, the cost for patients with mild to moderate symptoms receiving home-based care is \$226.96, whereas the cost for hospital isolation centre care is \$764.41. The per-day unit expenses for asymptomatic patients and those with mild-to-moderate disease, however, increase to 6717.74 KES (US\$63.68) and 6719.90 KES (US\$63.70), respectively, when patients getting care in hospitals or isolation centres are considered. The projected daily unit cost for patients with severe COVID-19 disease admitted to general hospital wards is 13,137.07 KES, or roughly US\$124.53. The daily unit cost for individuals with severe COVID-19 disease, on the other hand, rises dramatically to 63,243.11 KES (US\$599.51). The cost per episode for individuals with severe and critical COVID-19 illness is \$1494.38 and \$7194.07, respectively. (**Table 4.4**)

**Table 4.1. Average cost (in 2020 USD) per treated episode across cost categories and Average cost (in 2020 USD) per treated patient and per bed day at different bed occupancy rates and by level of disease severity**

Solomon Tessema Memirie et. al.		
Cost component	Direct cost – Provider	Indirect cost – Provider
Food		608
Personnel	547	
Drugs and supplies	158	
Capital	128	
Laboratory and Diagnostics	26	
Others		6
Total	859	614
Total cost per patient		1473

**Table 4.2. Estimated cost of COVID-19 treatment by the level of severity and treatment setting (in United States Dollars, USD)**  
Hamza Ismaila et al. / 2021

Cost Components	Direct cost (Provider)	Average				
	Home based care	Institutionalized care				
Total Direct Costs		Mild	Moderate	Severe	Critical	
Inpatients Care		\$1259	\$1269	\$3546	\$4587	\$4066
Investigations	\$132	\$147	\$340	\$277	\$489	\$277
Medications	\$14	\$14	\$89	\$199	\$335	\$130
Overheads	\$17	\$4072	\$6701	\$13,276	\$14,660	\$7745
Staff Time	\$118	\$215	\$1552	\$3007	\$3312	\$1641
Total Costs	\$282	\$5707	\$9952	\$20,305	\$23,382	\$11,925

**Table 4.3. Indirect and Direct Medical Costs of studied patients (in USD)**  
Mohsen Ghaffari Darab et al. / (2021)

Cost Components	Direct Cost (user)		
Direct Costs	Per patient	Per non severe patient	Per ICU Patient
General and Intensive Care Beds	\$1542	\$1171	\$6083
Physician Visit Costs	\$455	\$446	\$563
Consultant and surgeon	\$72	\$60	\$229
Nursing services	\$79	\$64	\$265
Drugs and Supplies	\$1070	\$786	\$4541
Rehabilitation and Dialysis	\$48	\$23	\$342
Imaging	\$94	\$87	\$178
Electrography and Laboratory	\$352	\$300	\$987
Other Services	\$43	\$40	\$80
Total Direct Cost	\$3755	\$2979	\$13,267
Indirect Costs	Indirect Cost (User)		
Lost income (hospitalization)	\$378		
Lost income (Recovery at Home)	\$1065		
Potential productivity Loss (premature death)	\$10,190		
Total Indirect Cost	\$11,634		

**Table 4.4. COVID-19 case management unit costs for asymptomatic patients and patients with mild to moderate symptoms**  
Edwine Barasa et al. / (2021)

Cost Components	Asymptomatic patients Direct cost (Provider)	Mild to Moderate Symptoms Direct cost (Provider)	Severe Direct cost (Provider)	Critical Direct cost (Provider)		
	Home based Care unit costs per case	Hospital/isolation centre care costs per case	Home based Care unit costs per case	Hospital/isolation centre care costs per case		
Health worker transport cost	\$9.48		\$9.48			
Accommodation and overheads		\$216.41		\$216.41	\$216.41	\$455.01
Starting	\$21.27	\$135.36	\$21.27	\$135.36	\$188.03	\$3322.65
Pharmaceuticals (medicines, etc)			\$0.25	\$0.25	\$523.49	\$682.01
Non-pharmaceuticals (Fluids, devices, etc)					\$23.58	\$42.92
COVID-19 test	\$17.22	\$17.22	\$17.22	\$17.22	\$17.22	\$17.22
Other laboratory tests					\$102.55	\$206.82
Radiology				\$28.08	\$28.08	\$28.08
Personal protective equipment	\$178.74	\$395.17	\$178.74	\$395.17	\$419.86	\$2305.14
Oxygen Therapy					\$127.15	\$148.61
Equipment costs (including ventilator) and monitoring in ICU						\$122.17
Total cost per patient	\$226.71	\$764.16	\$226.96	\$764.41	\$1494.38	\$7194.07
Patient cost per day	\$19	\$63.68	\$18.91	\$63.70	\$124.54	\$599.51

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