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# Unveiling the truth: is COVID-19 reimbursement in Colombia a flawed design? A cost-of-illness analysis for moderate, severe and critical infections

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## ABSTRACT

**Purpose** This study examines the financial impact of the COVID-19 pandemic on the Colombian Health System, focusing on the adequacy of reimbursement rates for inpatient stays. The study, based on a cost of illness analysis, aims to evaluate the effectiveness of the reimbursement scheme and identify potential economic losses within the health system.

**Patients and methods** The study protocol outlines the inclusion criteria for patients >18 years with confirmed COVID-19 infection and moderate to critical disease. Patients hospitalised between June 2020 and June 2021 for at least 24 hours were included. Exclusion criteria involved pregnant patients and those initially hospitalised for non-COVID-19.

**Results** The study included 781 patients contributing to 790 hospitalisations. Demographic and clinical characteristics were analysed, with critical illness being the most prevalent category (61%). The overall mortality rate was 20.3%, primarily observed in critically ill patients. In the general ward for moderate cases, the reimbursement rate saw a substantial increase from US$3237 in 2020 to US$6760 in 2021, surpassing median resource utilisation. However, for severe cases in the intermediate care unit, reimbursement rates decreased, indicating potential insufficiency in covering costs. In the intensive care unit for critical cases, despite improved reimbursement rates, median resource utilisation still exceeds the 2021 rate, suggesting financial insufficiency in reimbursement rates.

**Conclusion** Our study underscores the inadequacies of the previous reimbursement system in addressing the varying resource utilisation and costs associated with COVID-19 inpatient care. Our analysis reveals substantial discrepancies between estimated costs and actual resource utilisation, particularly for severe and critical cases. We advocate for government flexibility in revising reimbursement baskets, supported by pilot studies to assess effectiveness. The use of real-world evidence forms a crucial basis for informed adjustments to reimbursement levels in preparation for future pandemics. This proactive approach ensures alignment between reimbursement policies and the actual costs associated.

### WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ The COVID-19 pandemic placed immense strain on global healthcare systems, necessitating the provision of care to a large number of patients. Prior to this study, the adequacy of the reimbursement system for COVID-19 patient care, especially in the context of varying disease severity, was not well understood.

### WHAT THIS STUDY ADDS

⇒ This study contributes vital insights into the reimbursement challenges faced by the Colombian healthcare system during the COVID-19 pandemic. It evaluates the alignment of reimbursement rates with actual resource utilisation for patients with moderate, severe and critical illnesses. The findings highlight significant disparities between estimated costs and real-world resource utilisation, particularly in severe and critical cases.

### HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ This study highlights the imperative for a more nuanced approach to healthcare reimbursement systems, particularly crucial during public health crises such as pandemics. By unveiling the intricacies of setting reimbursement rates for treatments with uncertain outcomes, it accentuates the potential financial risks faced by payers and providers. The findings strongly advocate for a comprehensive reassessment of reimbursement strategies to ensure an equitable and effective allocation of resources during the future healthcare emergencies. Policy-makers are urged to leverage these findings in designing and implementing adaptive reimbursement frameworks, thereby enhancing the overall resilience of healthcare systems in responding to unforeseen challenges. Additionally, the study emphasises the critical role of strengthening health information systems to better inform policy decisions and improve healthcare resource planning.

## INTRODUCTION

The Colombian Health System operates on a framework of managed competition,[1] where health maintenance organisation (HMO)

insurance firms receive a risk-adjusted premium to fund a government-defined health benefits package (HBP). This inclusive package spans health services from promotion to palliative care, with specific criteria set through a negative list that applies universally. Diverse payment mechanisms, including the capitation payment unit (UPC by its Spanish acronym), maximum budgets (MBs) and reimbursements, contribute to the financing structure. The UPC serves as the insurance premium that comprehensively covers various services and technologies for each health condition, including oral health conditions. This premium is calculated through actuarial methods, considering the frequency and severity of different types of care, with further considerations for age, sex and geographical area.[2] Several factors influence the determination of the UPC, including consumer price inflation, the national government budget, demographic changes and the regular updating of services and new technologies. Annually, at the year's end, the Ministry of Health (MOH) defines the UPC for the following year, drawing on historical information on care as a foundational basis. In contrast, the MBs serve as an additional budget, complementing the UPC. This budget is calculated annually and aims to cover services and technologies not financed by the UPC. Such exclusions may arise due to uncertain conditions, high price variability or if they are complementary social services mandated by a judge. The MBs play a crucial role in covering or financing various aspects, including some drugs for orphan diseases, complementary social services, most new drugs, certain supplements and nutritional supplements, and drugs used for indications other than those approved by the regulatory agency.

By the end of 2022, Colombia recorded a staggering 6.34 million cases of COVID-19.[3] Among these cases, 181 447 required hospitalisations in general wards, 26 907 in intermediate care unit (IMCU) and 70 566 in intensive care units (ICUs).[3] The global healthcare infrastructure faced unprecedented challenges in delivering swift and precise medical attention to the substantial influx of COVID-19 patients, all while addressing the ongoing health needs of the broader population. This challenge proved, especially daunting in developing countries such as Colombia, marked by disparities in healthcare access and a noticeable shortage of hospital beds, quantified at approximately 1.7 beds per 1000 inhabitants as of 2018.[4] Colombia, in comparison to other nations, notably stands out for enduring one of the highest years of life lost due to the pandemic,[5] indicating a profound impact on the population and the urgency of addressing the healthcare challenges posed by the virus.

In response to the WHO declaring COVID-19 a pandemic, the Colombian National Government, recognising the gravity of the situation, declared a state of economic, social and ecological emergency through Decree 417 of 2020. The UPC for the year 2020, determined in December 2019, did not foresee possible changes in the health expenditure that could be generated by the pandemic. In response to the financial challenge posed by the pandemic, the initial government strategy was to permit insurers to use funds allocated for the HBP. This decision was based on the rationale that, during the lockdown period, the demand for healthcare services had decreased. Within this emergency framework, the MOH devised a comprehensive action plan aimed at mitigating the spread of the pandemic. This plan, among its multifaceted objectives, included strengthening the health system to ensure optimal conditions for care and prevention across healthcare, public health and service delivery.

However, as restrictions were lifted, the government established a reimbursement rate for inpatient stays associated with COVID-19. Considering the financial mechanisms of the health system, especially the sustainability of the UPC, the MOH implemented a measure called the 'basket of health services and technologies intended for the care of the COVID-19'. This initiative empowered the MOH to define two aspects: first, the creation of care baskets tailored for patients with COVID-19, and second, the determination of values at which the National Health Fund (ADRES in Spanish) should directly compensate institutions providing health services. This compensation was based on information reported by HMOs or subnational governments.

In the execution of this measure, the MOH, as outlined in Resolution 1161 of 2020, identified the health services and technologies constituting the baskets for the care of COVID-19. This determination arose from a rapid study evaluating potential applications of health technologies for the direct care of the disease. However, a notable limitation surfaced during this study while many treatments were documented, their effectiveness in comparison to alternative treatments was not well established. For instance, distinguishing the impact of treatments from the natural progression of the disease proved challenging.

Subsequently, based on the information reported by the HMOs to the MOH of the services provided during 2020, it was evident that the UPC was sufficient to finance the services and technologies derived from COVID-19 care, which got to be compensated enough by the lessening of other services that had to be cancelled or postponed because of the quarantine periods. Thus, that reimbursement rate was used rather as a reference, but no disbursement was made based on it. Taking into account, (1) the peak of cases presented in 2021 for the months of May, June and July where the number of cases was twice above the average and (2) the statistics on hospitalisations that revealed the high demand for care derived from COVID-19 and the risks of deviation in the sufficiency of the UPC, Resolution No. 1585 of 13 October 2021 and 2390 of 28 December 2021 were issued, which established the reimbursements of the baskets for these periods and thus prevent possible imbalances in the sufficiency of the UPC, and therefore, the emerging of debts with Health Provider Institutions.

HMOs and healthcare providers raised concerns about the reimbursement rate that it was not accurately determined. The HMO association estimated a deficit in this financing scheme and formally requested the government to address the resulting economic loss.[6]

In this study, we evaluate whether the reimbursement rate for COVID-19 inpatients stays was well defined. We accomplish this by conducting a cost of illness study of patients with moderate, severe and critical illness between June 2020 and June 2021 based on the institutional registry of patients with COVID-19 from a high complexity institution in Colombia,[7] and comparing median cost to actual with the actual reimbursement rates.

## METHODS

### Study population

We included adult patients with a confirmed COVID-19 infection, determined through RT-PCR, antigen test or both, who were treated during the acute phase in our institution between June 2020 and June 2021 with moderate, severe or critical disease, as defined by on the Colombian national consensus,[8] and hospitalised in the general ward or ICU for at least 24 hours.

The decision to limit our study to this time frame was influenced by several factors. Prior to June 2020, including patients would introduce high variability due to the novelty of the virus and the evolving approaches to treatment during those early stages. Post-June 2021, a substantial proportion of the population had received vaccinations, potentially impacting resource utilisation and altering direct health costs.

The exclusion of vaccinated patients from our study was primarily dictated by the timeline of our research, which did not align with the commencement of the SARS-CoV-2 vaccination campaign in Colombia. Vaccination initiatives in our setting began on a limited scale in February 2021 for specific population groups and only gained widespread momentum from July 2021.[9]

Pregnant patients were excluded due to the physiological distinctiveness of pregnancy, which can introduce complexities in resource allocation and clinical outcomes related to COVID-19 and those who were initially hospitalised by other causes different to COVID-19 and were under mechanical ventilation, renal replacement therapy, or ECMO throughout their hospital stay and prior to the contraction of the virus. This exclusion criterion was employed to ensure that our analysis is centred on patients whose hospitalisation was primarily attributed to COVID-19 and its associated treatments.

### Setting and location

This cost-of-illness study used data from an institutional registry of patients with COVID-19 treated at a high-complexity hospital in Colombia. The hospital, a non-profit teaching hospital, serves as a reference healthcare institution for the Southwestern region of Colombia. Functioning as a fourth-level institution, it has played a crucial role in treating a significant proportion of COVID-19 patients in this region throughout the pandemic, making it an ideal setting for our study.

Given the methodological nature of this study, the ethics committee waived the requirement for an informed consent from participants; the study adhered to all ethical principles. It is crucial to highlight that strict data confidentiality protocols were observed throughout the research process.

### Variables

Demographic and clinical variables regarding disease diagnosis, hospitalisation site, transfers between hospital units, specialist's consultations, medications and procedures, status at the end of hospitalisation and hospitalisation days were collected from the COVID-19 institutional registry.

To describe the direct costs of treating a patient with COVID-19 infection, we generated the following categories: hospitalisation, medications, clinical laboratory, materials and supplies, imaging, consults and interconsultations, therapies, medical fees and surgical room rights and equipment.

### Perspective

This study was developed under the third-party payer perspective.

### Outcome measurements

To ensure the generalisability of our findings beyond our institution, we initiated the process by scrutinising the national guidelines for diagnosing and managing COVID-19 in patients with moderate, severe and critical conditions (online supplemental table 1).[8] This meticulous review allowed us to include only those procedures and management strategies endorsed by the guidelines in our resource utilisation analysis. We deliberately excluded any additional procedures that might have been conducted due to advanced technologies available exclusively at our institution, such as extracorporeal membrane oxygenation (ECMO). ECMO is not widely accessible in Colombia and is only offered at a limited number of experienced cardiovascular centres.[10]

The billing report for the episodes under analysis was generated, and information on all services provided for the care of these events was extracted based on disease severity. Each participant's unique billing report was used for data extraction. Patients meeting the inclusion criteria were referred to the billing department, which provided detailed resource utilisation for that hospitalisation. The hospital follows institutionally the activity-based costing methodology.

The report detailed the number of resources, supplies and devices contributing to resource utilisation. Procedures and medications not directly related to managing COVID-19, according to national guidelines,[8] were excluded from the analysis. To compare our use of resources with the reimbursement rates set by the government, we used the same fee schedule: the SOAT (Compulsory Traffic Accident Insurance) 2021 tariff manual.[11]

### Reimbursement

These MOH estimated the reimbursement rate after an evaluation of procedure and medication frequency, with dosing recommendations sourced from scientific communities. The pricing of medications was referenced from the Sistema de Información de Precios de Medicamentos, and the prices of procedures were obtained from SOAT. The MOH reviewed the national guidelines to define the baskets of services and procedures for COVID-19 patient care, including their maximum reimbursement values. It is important to note that these reimbursements were directed to the care providers, namely clinics and hospitals, and were subject to a value ceiling established by the MOH (online supplemental table 2).[12]

While the reimbursement rates were categorised by hospitalisation setting (general ward, IMCU and UCI) the national guidelines used disease severity. Therefore, we linked the severity levels with the specific hospitalisation setting. For example, the ICU was designated for critical COVID-19 cases, the IMCU for severe COVID-19 disease and the General Ward for patients with moderate severity.

### Data analysis

Descriptive statistics were used to summarise the demographic characteristics of the study population, including age, gender and comorbidities. The median total resource utilisation and inter quartile range (IQR) were calculated for each severity category. The minimum and maximum resource utilisation were also reported.

To assess the impact of disease severity on hospitalisation resource utilisation, we opted for a generalised linear model (GLM). Given the nature of our healthcare cost data, which often exhibits a skewed distribution, the GLM is better suited for handling non-normally distributed outcomes and provides meaningful estimates without the need for log-transformations and back-transformations.[13] Throughout the analysis, a $p<0.05$ was considered statistically significant.

We have revised our costing methods in accordance with established guidelines, specifically adhering to the Consolidated Health Economic Evaluation Reporting Standards statement.[14] Despite our study not involving the comparison of two interventions, we prioritised comprehensive reporting and transparency in presenting the economic aspects of COVID-19 hospitalisation across different severities.

**Table 1** Demographics and clinical characteristics

| Characteristics | |
|---|---|
| Age, mean (SD) | 61.0 (15.5) |
| Sex, n (%) | |
| Female | 290 (36.7) |
| Male | 500 (63.3) |
| Disease severity (COVID-19), n (%) | |
| Moderate | 204 (25.8) |
| Severe | 104 (13.2) |
| Critical | 482 (61.0) |
| Mortality, n (%) | |
| Overall | 160 (20.3) |
| Moderate | 3 (1.9) |
| Severe | 5 (3.1) |
| Critical | 152 (95.0) |

### Currency, price date and conversion

The data were originally obtained in Colombian pesos and then converted to USD unit based on a purchasing power parity (PPP) for the year 2020 using CCEMG–EPPI-Centre Cost Converter' (V.1.6 last update: 29 April 2019) considering International Monetary Fund dataset for PPP values.[15]

## RESULTS

### Demographic and clinical characteristics

Of the patients registered in the COVID-19 institutional registry during the study period, 781 met the inclusion criteria and contributed to 790 hospitalisations. It is noteworthy that some participants experienced multiple incidents without formal readmission due to worsening of the initial discharge. The male sex predominated in 63.3% (500) and the age range was 51–70 years corresponding to 48% of all patients. Patients were diagnosed with critical illness in 61% (482) of the cases, followed by moderate illness in 25.8% (204) and severe illness in 13.2% (104). In the study group, a mortality rate of 20.3% was found; 95% of these occurred in the critically ill group (table 1).

### Economic analysis

The median total resource utilisation of moderate disease was US$4372 (IQR 1425). The minimum resource utilisation registered was US$1425, and the maximum resource utilisation was US$82 170. The median resource utilisation in severe disease was US$10 197 (IQR 11 502). The minimum resource utilisation registered was US$1924, and the maximum resource utilisation was US$166 611. The median resource utilisation in critical illness was US$24 337 (IQR 32 885). The minimum resource utilisation registered was US$832, and the maximum resource utilisation was US$527 648 (table 2).

Table 2 Direct medical costs of inpatients with COVID-19 by severity (costs were adjusted into purchasing power parity 2020)

| | Moderate | Severe | Critical |
|---|---|---|---|
| Number of hospitalisations | 204 | 104 | 482 |
| Mean (SD) | 7304 (10 106) | 16 169 (21 867) | 36 393 (39 396) |
| Median (IQR) | 4372 (3824) | 10 197 (11 502) | 24 337 (32 885) |
| Minimum value | 1425 | 1924 | 832 |
| Maximum value | 82 170 | 166 611 | 527 648 |

The GLM model (online supplemental table 3), incorporating various factors such as disease severity, age-related terms, gender, discharge status and month indicators, demonstrated significant variation in the resource utilisation of COVID-19 hospitalisation (p<0.001). Compared with patients with moderate disease, those with severe disease exhibited an additional average resource utilisation of US$9538 (SE=3816, p=0.01), while those with critical disease showed an average additional resource utilisation of US$26 303 (SE=2819, p<0.001)

Age was a significant predictor of hospitalisation resource utilisation, with a decrease of US$480 in resource utilisation for each additional year of age. Gender was also a significant predictor of resource utilisation, with female patients displaying an average resource utilisation US$543 lower than male patients. Discharge status significantly influenced resource utilisation, with patients discharged to their homes showing an average resource utilisation US$4122 lower than patients who died.

Finally, the month of hospitalisation was a significant predictor of resource utilisation. Compared with December, patients hospitalised in February had an average resource utilisation US$19 658 higher, while patients hospitalised in June, July and August had average resource utilisations US$8023, US$9062 and US$6221 lower, respectively.

## Reimbursement

In the general ward for moderate cases, the median resource utilisation was US$4372. The maximum reference value to be paid in 2020 was US$3237, resulting in an absolute difference of −US$1135 and a relative difference of −35% (absolute difference over maximum reference value to be paid). In 2021, the maximum reference value increased to US$6760, yielding an absolute difference of US$2389 and a relative difference of 35%. In the IMCU for severe cases, the median resource utilisation was US$10 197. In 2020, the maximum reference value to be paid was US$11 774, resulting in an absolute difference of US$1577 and a relative difference of 13%. In 2021, the maximum reference value decreased to US$9227, resulting in an absolute difference of −US$970 and a relative difference of −11%. In the ICU for critical cases, the median resource utilisation was US$24 337. In 2020, the maximum reference value to be paid was US$22 082, resulting in an absolute difference of −US$2256 and a relative difference of −10%. In 2021, the maximum reference value increased to US$23 001, resulting in a smaller absolute difference of −US$1336 and a relative difference of −6% (table 3).

## Resources use categories

In all severities of the disease, it is observed that hospitalisation represented 56% of the resource utilisation of

Table 3 Comparison of median resource utilisation and reimbursed costs of inpatients with COVID-19 by severity in Colombia (costs were adjusted into purchasing power parity 2020)

| | | 2020 | | | 2021 | | |
|---|---|---|---|---|---|---|---|
| Setting | Median resource utilisation in our study | Maximum reference value to be paid | Absolute difference | Relative difference (vs reference) | Maximum reference value to be paid | Absolute difference | Relative difference (vs reference) |
| Attention in the general ward (moderate) | US$4.372 | US$3.237 | −US$1.135 | −35% | US$6.760 | US$2.389 | 35% |
| Attention in the IMCU (severe) | US$10.197 | US$11.774 | US$1.577 | 13% | US$9.227 | −US$970 | −11% |
| Attention in the ICU (critical) | US$24.337 | US$22.082 | −US$2.256 | −10% | US$23.001 | −US$1.336 | −6% |

ICU, intensive care unit; IMCU, intermediate medical care unit.

Table 4 Median direct medical costs of inpatients with COVID-19 by severity (costs were adjusted into purchasing power parity 2020)

| Categories | Moderate | Severe | Critical | Total |
|---|---|---|---|---|
| Hospitalisation | 2385 | 5963 | 13 301 | 8397 |
| Medications | 235 | 588 | 3497 | 1238 |
| Clinical laboratory | 1137 | 2066 | 3535 | 2552 |
| Materials and supplies | 61 | 314 | 1620 | 731 |
| Imaging | 186 | 377 | 1074 | 684 |
| Consults and interconsultations | 221 | 312 | 632 | 346 |
| Therapies | 0 | 51 | 120 | 69 |
| Medical fees | 0 | 0 | 55 | 32 |
| Surgical room rights and equipment | 0 | 0 | 52 | 52 |
| Total | 4372 | 10 197 | 24 337 | 15 001 |

illness due to COVID-19, being slightly higher in severe disease, followed by clinical laboratory at 17% and medications at 8%. The remaining health benefits have a smaller representation in the overall resource utilisation (table 4).

## DISCUSSION

In this study, we aimed to evaluate whether reimbursement for healthcare services rendered to COVID-19 patients in Colombia was financially sound, looking at the three reimbursement rates defined by the Colombian government. In the general ward for moderate cases, the reimbursement rate escalated from US$3237 in 2020 to US$6760 in 2021, indicating an absolute difference of US$3523. This substantial increase in reimbursement effectively covers and even exceeds the median resource utilisation. For severe cases in the IMCU, there was a shift in reimbursement rates. In 2020, the maximum reference value was US$11 774, and it decreased to US$9227 in 2021, resulting in an absolute difference of –US$2547 indicating that the reimbursement was not sufficient. In the ICU for critical cases, the maximum reference value increased from US$22 082 in 2020 to US$23 001 in 2021. This change amounted to an absolute difference of US$919 and a relative difference of 4%. While this signifies a positive change in reimbursement rates, the median resource utilisation still surpasses the 2021 reimbursement rate, indicating that there might be a remaining financial gap for covering critical cases in the ICU.

It is important to account for the variations in costs observed during different periods of our study. Notably, February coincided with the onset of the second wave of the pandemic[16] in Colombia, a phase marked by significant uncertainty surrounding treatment protocols. This uncertainty may have contributed to the higher utilisation of resources during this period. In contrast, the months of July and August align with the implementation and publication of national guidelines,[8] potentially leading to a more standardised approach and, consequently, a reduction in the overall use of resources.

Additionally, the observed relationship with age, where younger patients seemingly had increased resource utilisation, may be attributed to the specific triage guidelines implemented during the pandemic. Many triage protocols considered age as one of the determining factors for ICU admission.[17] This triage strategy aimed to allocate limited resources judiciously, prioritising younger patients with potentially better prognoses. Consequently, the increased resource utilisation in younger patients might reflect a deliberate and intensive treatment approach by healthcare professionals, aligning with the triage guidelines. Furthermore, the willingness of doctors to pursue more aggressive treatments or interventions with younger patients could contribute to the higher resource utilisation observed in this age group. This treatment-intensive approach could lead to increased resource utilisation among younger COVID-19 patients.

To validate the consistency of our cost estimates, we conducted a comprehensive literature review. Five published studies directly align with the focus of our study on resource utilisation associated with inpatient care for COVID-19. It is noteworthy to emphasise the limited availability of research addressing the extent of resource utilisation in Latin America during the pandemic. Despite this scarcity, our efforts yielded two significant studies, Alvis-Zakzuk[18] *et al* in Colombia and Miethke-Morais *et al*[19] in Brazil, both of which were included in the systematic review conducted by Gholipour *et al*[20] on the costs of inpatient care and out-of-pocket payments for COVID-19 patients.

When comparing the retrospective resource utilisation study conducted by Alvis-Zakzuk *et al*[18] with our own findings regarding resource utilisation, Alvis-Zakzuk *et al*[18] reported a total cost per patient of US$6552,[20] which is lower than our mean of US$15 001. This suggests that their study likely included a population with a more moderate disease, considering the initial differences in sociodemographic variables. Furthermore, the length of

Table 5 Average length of stay (days) according to unit of hospitalisation and disease severity

| | Moderate (n=204) | | | Severe (n=104) | | | Critical (n=482) | | | Total (n=790) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Use | | | Use | | | Use | | | Use | | |
| Unit | n | % | ALOS | n | % | ALOS | n | % | ALOS | n | % | ALOS |
| General ward | 50 | 25 | 1.2 | 21 | 20 | 1.8 | 46 | 33 | 0.8 | 229 | 29 | 2.3 |
| IMCU | 197 | 97 | 4.8 | 98 | 94 | 5.7 | 309 | 65 | 3.9 | 604 | 77 | 3.8 |
| ICU | 17 | 8 | 0.8 | 54 | 52 | 4.7 | 442 | 92 | 12.8 | 513 | 65 | 9.1 |
| Total | | | 6.8 | | | 12.1 | | | 17.5 | | | 15.2 |

ALOS, average length of stay; ICU, intensive care unit; IMCU, intermediate care unit.

stay (LOS) in the general ward was 7.3 days in their study, contrasting with the 2.3 days observed in our study, while in the ICU, it was 8.1 days compared with our 15.2 days, indicating less severe cases of COVID-19. LOS was identified as the primary driver of resource utilisation in both studies (table 5). Gholipour *et al*'s[20] systematic review indicates that the average cost of hospitalisation, categorised based on ICU hospitalisation and hospitalisation inwards, was US$18 741, which provides valuable context for our own findings with a mean cost of US$15 001.

Health systems across the globe reacted differently to the financial challenge posed by inpatient hospital care for COVID-19 patients. Some countries adjusted or kept an existing payment rate (ie, a night at the ICU) while others defined a new payment.[21] In Colombia, reimbursement rates for hospital care hinge on market forces, entailing bilateral negotiations between HMOs and healthcare providers. In a context of uncertain treatment costs, the Colombian government introduced a new payment system. Regrettably, this system proved underfunded for severe and critical patients while being overfunded for moderate cases. Adding to the burden, given that approximately half of Colombia's HMOs (representing 11.6 million affiliates) reporting loss ratios exceeding 100% in 2021.[22] This underscores insufficient resources for the effective operation of health insurance. Our paper provides evidence on the complexity of estimating such reimbursement rates for unknown treatments and on the risk to financially underfund payers and providers unnecessarily.

### Generalisability and limitations

The inclusion of a large patient population treated at our institution enhances the representativeness of our results. The substantial number of patients provides a robust foundation for extrapolating our findings to the broader Colombian population. Additionally, our focus on capturing costs directly related to COVID-19 treatment and adherence to national guidelines ensures the relevance and applicability of our findings in healthcare settings that follow similar practices. Nevertheless, it is crucial to recognise a potential limitation in our study design. The inherent presence of comorbidities among most COVID-19 patients, necessitating additional interventions that could not be charged and reimbursed by the HMO, might have led to an underestimation of the total resource utilisation. While we have strived to ensure comprehensive analysis, this aspect highlights a potential avenue for further exploration and refinement in future research endeavours. We opted to exclude indirect costs and the out-of-pocket share from our analysis, as our primary objective was to assess the accuracy of hospital reimbursement in compensating health services provided. In the specific context of the Colombian health system, COVID-19 patients were exempt from cost-sharing mechanisms such as copayments and deductibles. Including these components, which do not apply to COVID-19 patients in our study, could potentially introduce inaccuracies in our assessment of hospital reimbursement practices. This decision reflects the unique characteristics of the Colombian healthcare reimbursement model and should be considered when interpreting the economic impact of COVID-19 within our study.

## CONCLUSION

Our study underscores the inadequacies of the previous reimbursement system in addressing the varying resource utilisation and costs associated with COVID-19 patient care. Our analysis reveals substantial discrepancies between estimated costs and actual resource utilisation, particularly for severe and critical cases. Considering our findings, we strongly recommend that the government possesses the flexibility to revise reimbursement baskets for healthcare services. This adaptive process should be thoughtfully accompanied by pilot studies to rigorously evaluate its effectiveness and implications. Utilisation of real-world evidence, as elucidated in our analysis, provides a valuable foundation for informing and potentially revising reimbursement levels in anticipation of future pandemics.

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## Appendices

**Table. 1** Summary of the Colombian National Guidelines for Diagnosis and Management of COVID-19 by Severity

| **Severity** | **Moderate** | **Severe** | **Critical** |
|---|---|---|---|
| **Definition** | **1.** Mild pneumonia with mild dyspnea and oxygen saturation > 90% with supplemental oxygen (2 liters/minute) | **1**. Respiratory rate > 30 or **2.** Oxygen saturation < 93% or **3.** PaO2/FiO2 <300 or pulmonary infiltrates >50% in 24 to 48 hours. | **1.** Respiratory failure, septic shock and multiorgan failure. |
| **Blood component** | Red blood cell transfusion in the case of hypoperfusion secondary to anemia. | | |
| **Laboratory tests** | Every 48-72 hours or less | | |
| **Medical Staff** | X | | |
| **Supplies** | X | | |
| **Surgery room** | X | | |
| **Hospitalization** | X | | |
| **Diagnostic images** | X | | |
| **Medications** | 1. Analgesics<br>2. Opioids<br>3. Antipsychotics | **Additionally,**<br>1. Antibiotics | **Additionally,**<br>1. Anesthetics<br>2. Neuromuscular blocking agents<br>3. Atropine in case of resuscitation |

| | | | |
|---|---|---|---|
| | | | 4. Vasoactive or inotropic drugs<br>5. Thromboprophylaxis |
| **Specific procedures (materials):** | | | 1. Orotracheal intubation<br>2. Hemodynamic and/or ventilator monitor<br>3. PICCO<br>4. Catheters |
| **Other procedures** | X | X | |
| **Surgery procedures** | | | X |

**Abbreviations:** PaO2/FiO2, partial pressure of oxygen in arterial blood / fraction of inspiratory oxygen concentration; PICCO, Pulse contour cardiac output

**Table. 2** COVID-19 Baskets: Treatment Categories and Resource Utilization Estimates (Costs were adjusted into Purchasing Power Parity (PPP) 2020)

| Setting | Definition | Estimated Days | Maximum reference value to be paid |
|---|---|---|---|
| **General ward** | Estimated hospitalization of 5 days in a regular ward for general and specialized medical care, interdisciplinary care, performance of diagnostic tests, and medication. As per medical instruction and in compliance with INS guidelines, a repeat RT-PCR test will be conducted. With a daily cost of US $231, payment for days 1 to 5 will be covered at 100%, days 6 to 10 at 75%, and day 11 onwards at 65%. | 5 | **3,237** |
| **IMCU** | Estimated hospitalization of 10 days in the intermediate care unit for general and specialized medical care, interdisciplinary care, performance of diagnostic tests, medication, and ventilatory support. As per medical instruction and in compliance with NIH guidelines, a repeat RT-PCR test will be conducted. With a daily cost of US $ 421, payment for days 1 to 7 will be covered at 100%, days 8 to 10 at 75%, and day 11 onwards at 65%. | 10 | **11,774** |
| **ICU** | Estimated hospitalization of 14 days in the intensive care unit for specialized medical care, interdisciplinary care, performance of diagnostic tests, medication, and mechanical ventilation. As per medical instruction and in compliance with INS guidelines, a repeat RT-PCR test will be conducted. With a daily cost of US $ 666, | 14 | **22,082** |

| | | | |
|---|---|---|---|
| | payment for days 1 to 7 will be covered at 100%, days 8 to 10 at 75%, and day 11 onwards at 65%. | | |

**Abbreviations:** RT-PCR, reverse transcription polymerase chain reaction; IMCU, intermediate medical care unit; NIH, national institute of health; ICU, intensive care unit

**Table. 3** Adjusted direct medical costs of inpatients with COVID-19 (Costs were adjusted into Purchasing Power Parity (PPP) 2020)

| Variables | Final Adjusted Model | Standard Errors |
|---|---|---|
| **Severe** | 9,538* | 3,816 |
| **Critical** | 26,303** | 2,819 |
| **Age** | -1,343 | 1,891 |
| **Age$^2$** | 34.6 | 33.6 |
| **Age$^3$** | - 0.252 | 0.19 |
| **Gender** | -1,518 | 2,373 |
| **Discharge status** | -4,122 | 3,208 |
| **January** | 12,440 | 11,190 |
| **February** | 55,003 | 32,544 |
| **March** | 8,070 | 16,492 |
| **April** | -9,213 | 31,897 |
| **May** | -21,913 | 31,842 |
| **June** | -22,449** | 6,792 |
| **July** | -25,355** | 5,480 |
| **August** | -17,406** | 5,500 |
| **September** | 7,531 | 5,816 |
| **October** | -12,748* | 5,528 |
| **November** | -11,493* | 5,805 |
| **December** | - | (omitted) |
| **Constant** | 40,655 | 34,367 |
| **Observations** | 789 | |
| **AIC** | 23.57 | |

** p<0.01, * p<0.05

Model regressed on several predictor variables, including disease severity, age-related terms, gender, discharge status, and month indicators.

STROBE Statement—Checklist of items that should be included in reports of ***cohort studies***

| | Item No | Recommendation | Page No |
|---|---|---|---|
| **Title and abstract** | 1 | (*a*) Indicate the study's design with a commonly used term in the title or the abstract | 1 |
| | | (*b*) Provide in the abstract an informative and balanced summary of what was done and what was found | 2 |
| **Introduction** | | | |
| Background/rationale | 2 | Explain the scientific background and rationale for the investigation being reported | 4 |
| Objectives | 3 | State specific objectives, including any prespecified hypotheses | 4 |
| **Methods** | | | |
| Study design | 4 | Present key elements of study design early in the paper | 5 |
| Setting | 5 | Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection | 5 |
| Participants | 6 | (*a*) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up | 5 |
| | | (*b*) For matched studies, give matching criteria and number of exposed and unexposed | NA |
| Variables | 7 | Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable | 6 |
| Data sources/ measurement | 8* | For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group | 6-8 |
| Bias | 9 | Describe any efforts to address potential sources of bias | 6 |
| Study size | 10 | Explain how the study size was arrived at | 6 |
| Quantitative variables | 11 | Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why | 8 |
| Statistical methods | 12 | (*a*) Describe all statistical methods, including those used to control for confounding | 8 |
| | | (*b*) Describe any methods used to examine subgroups and interactions | 8 |
| | | (*c*) Explain how missing data were addressed | 8 |
| | | (*d*) If applicable, explain how loss to follow-up was addressed | NA |
| | | (*e*) Describe any sensitivity analyses | NA |
| **Results** | | | |
| Participants | 13* | (a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed | 8 |
| | | (b) Give reasons for non-participation at each stage | Fig1 |
| | | (c) Consider use of a flow diagram | Fig1 |
| Descriptive data | 14* | (a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders | 8 |
| | | (b) Indicate number of participants with missing data for each variable of interest | 8 |
| | | (c) Summarise follow-up time (eg, average and total amount) | 8 |
| Outcome data | 15* | Report numbers of outcome events or summary measures over time | 9 |

| | | | |
|---|---|---|---|
| Main results | 16 | (*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included<br>(*b*) Report category boundaries when continuous variables were categorized<br>(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period | 9<br>9<br>NA |
| Other analyses | 17 | Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses | NA |
| **Discussion** | | | |
| Key results | 18 | Summarise key results with reference to study objectives | 11 |
| Limitations | 19 | Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias | 11-12 |
| Interpretation | 20 | Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence | 11-12 |
| Generalisability | 21 | Discuss the generalisability (external validity) of the study results | 13 |
| **Other information** | | | |
| Funding | 22 | Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based | 14 |

*Give information separately for exposed and unexposed groups.

**Note:** An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at http://www.strobe-statement.org.