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Authors

Torres-Toledano, Marisol
Granados-García, Víctor
López-Tapia, José de Jesús
et al.

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COVID-19 medical care direct costs during the first year of pandemic in a hospital converted for increasing bed capacity

Marisol Torres-Toledano,¹ Víctor Granados-García,^{2*} José de Jesús López-Tapia,³ Elizabeth T. Miguel-Tiburcio,⁴ Yvonne N. Flores,^{5,6,7} Belkis Aracena-Genao⁸ and Paula Ramírez-Palacios⁵

¹Internal Medicine Department, Zone 58 General Hospital, Instituto Mexicano del Seguro Social, State of Mexico, Mexico; ²Epidemiologic and Health Services Research Unit, Aging Area, Health Research Coordination, Instituto Mexicano del Seguro Social, Mexico City, Mexico; ³Director's Office, Zone 76 General Hospital with Family Medicine Unit, Instituto Mexicano del Seguro Social, State of Mexico, Mexico; ⁴Emergency Department, Zone 76 General Hospital with Family Medicine Unit, Instituto Mexicano del Seguro Social, State of Mexico, Mexico; ⁵Morelos Epidemiologic and Health Services Research Unit, Instituto Mexicano del Seguro Social, Morelos, México; ⁶Department of Health Policy and Management, Fielding School of Public Health, University of California, Los Angeles, United States of America; ⁷Center for Cancer Prevention and Control Research-Kaiser-Permanente Center for Health Equity, Fielding School of Public Health and Jonsson Comprehensive Cancer Center, University of California, Los Angeles, United States of America; ⁸Nutrition and Health Research Center, National Institute of Public Health, Morelos, Mexico

Abstract

Background: COVID-19 health emergency caused an increase in the demand for hospitalization and high costs for the health system. **Objective:** To estimate COVID-19 care direct costs from the perspective of the healthcare provider in a secondary care hospital that underwent conversion during the first year of health emergency. **Material and methods:** Retrospective, observational study. Information on quantities of goods and services was obtained from the SINOLAVE and CVOED platforms and from hospital administrative sources. Four cost groups were defined and estimated with 2021 unit prices in US dollars. **Results:** Mean hospital length of stay ($n = 3,241$ patients) was 10.8 ± 8.2 days. Average cost of care per patient was USD $6,557 \pm 4,997$. Respiratory therapy with assisted mechanical ventilation was used by 13% of patients. **Conclusions:** The costs of COVID-19 medical care represent a large amount of resources. Most part of the costs (95%) were derived from hospital stay, respiratory therapy without assisted mechanical ventilation and costs related to personal protective equipment, hygiene, infrastructure adaptation and payments to medical personnel.

KEYWORDS: Cost analysis. Costs. Health care costs. COVID-19. Hospitalization. Intensive care unit.

Costos directos de atención médica por COVID-19 durante el primer año de pandemia en un hospital reconvertido

Resumen

Antecedentes: La emergencia sanitaria por COVID-19 causó un aumento de la demanda por hospitalización y costos elevados para el sistema de salud. **Objetivo:** Estimar los costos directos de la atención por COVID-19 desde la perspectiva del proveedor de servicios en un hospital de segundo nivel que fue reconvertido durante el primer año de la emergencia sanitaria. **Material y métodos:** Estudio observacional retrospectivo. La información sobre cantidades de bienes y servicios se obtuvo de los sistemas de información SINOLAVE y CVOED, así como de fuentes administrativas del hospital. Se definieron cuatro grupos de costos y se valoraron en dólares norteamericanos con precios unitarios de 2021. **Resultados:** La duración promedio de la estancia hospitalaria ($n = 3241$ pacientes) fue de 10.8 ± 8.2 días. El costo promedio de la atención por paciente fue de USD $6\ 557 \pm 4\ 997$. La terapia respiratoria con ventilación mecánica asistida fue utilizada por 13 % de los pacientes. **Conclusiones:** Los costos médicos de atención por COVID-19 representaron una gran cantidad de recursos. La mayor parte

*Correspondence:

Víctor Granados-García
E-mail: vic.granados@gmail.com

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de los costos (95 %) se derivó de estancia hospitalaria, terapia respiratoria sin ventilación mecánica asistida, así como de costos relacionados con equipo de protección personal, higiene, adecuación a la infraestructura y pagos al personal médico.

PALABRAS CLAVE: Análisis de costos. Costos. Costos de la atención a la salud. COVID-19. Hospitalización. Unidad de cuidados intensivos.

Background

In countries of the Organization for Economic Cooperation and Development, COVID-19 caused a 16% increase in the number of expected deaths between the start of the emergency in 2020 and the first half of 2021.¹ The increase in the need for health services was of a large-scale, and a decisive response was activated that required additional resources to meet the population immediate needs.² One effect was an increase in the costs of medical care related to the treatment of COVID-19. It has been estimated that of a total of 5.48 billion dollars granted in 2020 for health care development, 13.7% was allocated to the COVID-19 emergency.³ In terms of disease severity, 14% of the patients were reported to present with severe disease, and 5% had to be admitted to intensive care units.⁴ In other countries, 5 to 20% of patients with COVID-19 were hospitalized, and of this proportion, 14 to 20% were admitted to intensive care units.⁵

It was necessary for health services to increase their immediate response capacity for outpatient, emergency and advanced medical care.⁶ Given that direct medical costs for the care of a symptomatic case can be substantially high, strategies were recommended for keeping the rates of infection at the lowest possible level.⁷ However, few investigations have estimated the economic effect that the health emergency represented for health systems.

In Mexico, COVID-19 was the second cause of death in 2020 (200,256 cases, which represented 18.4%), only after heart disease. The most affected group was that of men (64.3%), with an average age of 63.2 years; the highest mortality rates were concentrated in Mexico City and the State of Mexico, and 81.1% of the people who died received medical care.⁸ Moreover, the authors of a recent study identified similar risk factors for mortality in general hospitalization wards and intensive care units (ICU). In the case of those patients who did not survive (n = 241), admission to an ICU was found to be justified in 45% (n = 110), but did not receive mechanical assisted ventilation (MAV) owing to a lack of available beds.⁹ Due to the high demand for ICU beds, regular care

was replaced with the care of patients with COVID-19, for which the departments were reconverted after adapting the hospital areas with time and money restrictions. Despite the resources involved, the magnitude and behavior of costs are unknown.¹⁰

In Mexico, 16% of cases were reported to have required hospital care.¹¹ The Mexican Institute of Social Security reported that COVID-19 represented the sixth most common cause of hospitalization, the fifth in outpatient care, and the fourth in emergency care provision.¹² Care was provided to social security beneficiaries and non-beneficiaries who required hospitalization for severe COVID-19. For the provision of services, in June 2021, the number of beds was increased to almost 20,000 in 232 hospitals.¹²

The present study was carried out in a secondary care hospital with 144 regular beds and 85 non-regular beds, which in its entirety was transformed into a COVID hospital on April 14, 2020, and served as a regional referral hospital. The logistics and operation of care processes were carried out in accordance with the national and institutional guidelines for the conversion of medical units due to the COVID-19 pandemic issued in 2020.¹³⁻¹⁶ The purpose of this study was to analyze the use of hospitalization and respiratory therapy services, as well as to estimate the costs of COVID-19 care during the first year of the health emergency from the perspective of the health care service provider.

Material and methods

An observational, retrospective, longitudinal study was carried out with the purpose to collect information on the goods and services used for the care of COVID-19 between March 2020 and March 2021. The perspective of the study was that of the service provider. The study population consisted of adults cared for at the referred hospital. The main sources of information were the Online Notification System for Epidemiological Surveillance (SINOLAVE – *Sistema de Notificación en Línea para la Vigilancia Epidemiológica*) platform and the institutional service use platform CVOED.¹⁷

Table 1. Cost groups and sources of information in a hospital entirely dedicated to the care of patients with COVID-19

Cost category	Description	Unit cost ^a	Source
COVID-19 direct medical costs			
Hospitalization	Hospital stay in general ward	Cost per patient hospitalization day: USD 442	DOF 2021 unit price list
Assisted mechanical ventilation	Life support therapy – Respiratory therapy supplies (endotracheal tubes, mechanical ventilator circuits, and high-flow cannula circuits) – Medications – AMV equipment: intubation equipment, mechanical ventilators. (acquisition and maintenance)	Cost per day per patient who received AMV: USD 592	Own estimate with hospital internal information
Respiratory therapy without AMV	– Supplies for respiratory treatment (nasal prongs, simple masks and with reservoir bags, bubblers, wall pumps) – Medications	Respiratory therapy cost per patient per day: supplies + medications: USD 4	Own estimate with hospital internal information
Infrastructure and personnel costs			
Costs of hospital conversion for the care of patients with COVID-19	– Personal protective equipment – Hygiene and cleaning supplies – Oxygen – Infrastructure adaptation – Payment to personnel (temporary hiring, productivity bonuses, compensation for infectious-contagion risk and acknowledgements to COVID teams) – Medical monitoring equipment	Sum of costs per patient per day of hospital stay: USD 131	Own estimate with hospital internal information
Home oxygen and hospital transfer costs			
Home oxygen	– Tank rent – Oxygen	Cost per patient who received home oxygen per day: USD 2.1	Own estimate with hospital internal information
Hospital transfer	– Between hospitals or home-hospital transfer	Transfer cost for one delivery in patients with HT: USD 110	Subrogation bill cost
Costs not directly related to COVID-19			
Hospital dialysis	– Hospital dialysis session	Cost per hospital dialysis session: USD 6.5	DOF 2021 unit price list
Cost per operating room	– Cost per surgery	Operating room cost per performed surgery: USD 1,262	DOF 2021 unit price list

^aUnit prices in 2021 US dollars.

AMV: assisted mechanical ventilation; DOF (*Diario Oficial de la Federación*): Official Journal of the Federation; HT: hospital transfer.

The costs were classified into four groups (Table 1):

- Direct medical costs for COVID-19.
- Infrastructure and personnel costs.
- Costs of home oxygen and hospital transfer.
- Costs for other health reasons.

The first group included hospitalization, respiratory therapy with assisted mechanical ventilation (AMV) and respiratory therapy without AMV. The cost of respiratory therapy with AMV included the costs of supplies for respiratory therapy in general, controlled medications, costs of medical equipment (ventilators,

ultrasound, and electrocardiogram), and monitoring and mechanical ventilation equipment. To estimate the cost per day of respiratory therapy with AMV, the costs of supplies for respiratory therapy, medications, and equipment for AMV were added and divided by total number of patient-days with AMV accumulated in the year. The costs of respiratory therapy without AMV included the costs of respiratory therapy supplies in general and the cost of medications.

Infrastructure and personnel costs included personal protective equipment, hygiene and cleaning supplies,

oxygen, infrastructure adaptation, payment to personnel (temporary personnel, productivity bonuses, compensations to COVID-19 teams) and vital signs monitoring equipment. Cost estimation comprised the following steps:

- First, personal protective equipment, hygiene and cleaning supplies annual consumption amounts were multiplied by their unit costs (Table 1).
- Second, oxygen costs included hospital stationary oxygen supply and portable tanks.
- Third, the costs of infrastructural adaptations included the acquisition and installation of aluminum partition frame systems, modification of areas in the emergency room and the mortuary chamber.

The costs of payment to personnel were considered according to the compensation system and the category of the personnel. Cost allocation for this group was carried out using the same method, which consisted of dividing total costs by the number of patient-hospitalization days. Subsequently, each patient was assigned a cost per day according to his/her hospital stay.

The costs were estimated according to the Mexican Institute of Social Security internal prices. Unit prices for hospital stay in a secondary care hospital were obtained from the official list.¹⁸ The prices of supplies in the group of infrastructure and personnel costs were extracted from administrative data. Costs were expressed in US dollars for the year 2021 for purposes of comparability with other studies; for their transformation, an exchange rate of 20.98 Mexican pesos per dollar (USD) was considered, which corresponds to the daily average for the month of December 2021.

Costs were reported in terms of distribution parameters (mean, median, and 25th and 75th percentiles). In addition, a scenario with total costs increase was estimated if a unit cost higher than USD 2,104 was considered for care with respiratory therapy with AMV, instead of the unit price on Mexican Institute of Social Security official price list (USD 592).

Results

Of the total number of subjects (n = 3,241), 71% were confirmed cases and 39% were females; 47% were older than 60 years, 11% were younger than 40 years and 51% died (Table 2). Employees represented 38%; 17.5% were housewives and people with no occupation, and 17% were retirees. Hospitalized

Table 2. Characteristics of the patients included in the study (n = 3,241)

Variable	n	%
Dead	1,664	51.3
Alive	1,577	48.7
Men	1,976	61
Women	1,265	39
Beneficiary	2,598	80
Non-beneficiary	643	20
Age group (years)		
< 30	103	3.20
31-40	249	7.70
41-50	559	17.20
51-60	805	24.80
61-70	880	27.20
> 70	645	19.90
Occupation		
Employee	1,250	38.6
Homemaker	655	20.2
No occupation	569	17.5
Retiree	550	17
Laborer	77	2.4
Driver	62	1.9
Informal worker	30	0.9
Nurse	16	0.5
Doctor	12	0.4
Other (teacher 6, OHW 9, student 5)	20	0.6
Place of origin		
State of Mexico	2 954	91.2
Mexico City	269	8.3
Other	18	0.5
Medical history		
Diabetes	613	18.9
Hypertension	708	21.9
COPD	51	1.6
Asthma	22	0.7
Kidney disease	94	2.9
Obesity	217	6.7
Smoking	127	3.9

COPD: chronic obstructive pulmonary disease; OHW: other health worker.

doctors and nurses constituted 0.4 and 0.5%, respectively. The chronic diseases with the highest prevalence were hypertension, type 2 diabetes and obesity (Table 2).

Most patients (95%) used respiratory therapy services without AMV, which consisted of oxygen therapy and medication administration, while 13% required respiratory therapy with AMV. The patients who were discharged alive required longer hospital stay, respiratory therapy with AMV and respiratory therapy without intubation (Table 3). Average days of hospital stay and days of respiratory therapy with

Table 3. Days of hospitalization, days with AMV or respiratory therapy without AMV, according to COVID-19 patients' characteristics (n = 3,241)

Characteristics	Duration in days		
	Hospitalization (mean ± SD)	Assisted mechanical ventilation ^y (mean ± SD)	Respiratory therapy without AMV (mean ± SD)
Dead	7.5 ± 6.5	3.6 ± 3.2	6.5 ± 6.1
Alive	14.3 ± 8.4	4.1 ± 3.8	14.3 ± 8.4
Men	10.9 ± 8.5	4.1 ± 3.7	10.3 ± 8.6
Women	10.7 ± 7.9	4.1 ± 4	10.2 ± 7.9
Age (years)			
< 30	11.3 ± 8.9	2.3 ± 2	11 ± 8.9
31-40	11.7 ± 7.9	4.3 ± 4.7	11.4 ± 8
41-50	11.8 ± 8	3.5 ± 2.8	11.4 ± 8.1
51-60	11.3 ± 8.5	4.3 ± 4	10.7 ± 8.6
61-70	10.4 ± 8.2	4.5 ± 4.3	9.8 ± 8.2
> 70	9.4 ± 8	3.9 ± 3.5	8.9 ± 8.1
Medical history			
Diabetes	9.7 ± 7.5	3 ± 3	9.3 ± 7.5
No diabetes	11 ± 8.4	4.4 ± 4	10.5 ± 8.5
Hypertension	10 ± 8	3.7 ± 3.3	9.4 ± 8
No hypertension	11 ± 8.3	4.2 ± 4	10.5 ± 8.4
COPD	13 ± 10	6.7 ± 7.1	12.2 ± 10
No COPD	10.8 ± 8.2	4 ± 3.7	10.2 ± 8.3
Asthma	9 ± 7.8	2.5 ± 1.9	8.6 ± 8
No asthma	10.8 ± 8.2	4.1 ± 3.8	10.3 ± 8.3
Kidney disease	12.9 ± 11.6	3.3 ± 2.7	12.2 ± 12
No kidney disease	10.8 ± 8.1	4.1 ± 3.9	10.2 ± 8.2
Obesity	10.4 ± 7.4	3 ± 2.4	10 ± 7.6
No obesity	10.8 ± 8.3	4.2 ± 3.9	10.3 ± 8.4
Smoking	11.3 ± 8.2	3.3 ± 4.2	11 ± 8.3
No smoking	9.7 ± 7.5	4.1 ± 3.8	10.2 ± 8.3

^yThe number of patients with AMV is variable for each type of patient (Fig. 1). AMV: assisted mechanical ventilation; COPD: chronic obstructive pulmonary disease.

AMV and without respiratory therapy with AMV (without intubation) between men and women showed no significant differences ($p > 0.05$). The patients with the highest number of days of respiratory therapy without AMV were those with kidney disease and those who were smokers, followed by the group aged between 41 and 50 years. In addition, older patients had fewer days of respiratory therapy without AMV. Healthier and younger patients, such as those without diabetes and those aged 31 to 40 years also spent a higher number of days on respiratory therapy with AMV (4.4 and 4.3 days, respectively). Something similar was observed in patients without asthma and in non-smokers (Table 3).

The patients who died had the highest percentage of AMV use (although fewer days on therapy), followed by those with kidney disease, asthma, and hypertension (Fig. 1), although the differences between one-way proportions (kidney disease vs. asthma, kidney disease vs.

hypertension, and kidney disease vs. age older than 70 years) were not significant.

Total average cost per hospitalized patient for the entire sample was USD 6,557 ± 4,997 (Table 4). Costs empirical distribution is skewed to the right with a median of USD 5,571. Average direct medical costs corresponding to hospitalization, AMV, and respiratory therapy without AMV amounted to USD 5,124 ± 3,931 and represented the highest proportion (78.1%) of total average costs per patient. Furthermore, infrastructure and personnel costs (which include items such as personal protective equipment, supplies for hygiene, oxygen, infrastructure, personnel payment and acknowledgements, and medical monitoring equipment) accounted for 22% of total costs. If only the three most common services are considered (hospitalization, respiratory therapy without AMV, and infrastructure and personnel), average cost was USD 6,228 ± 4,754, which accounts for 95% of total average cost per patient.

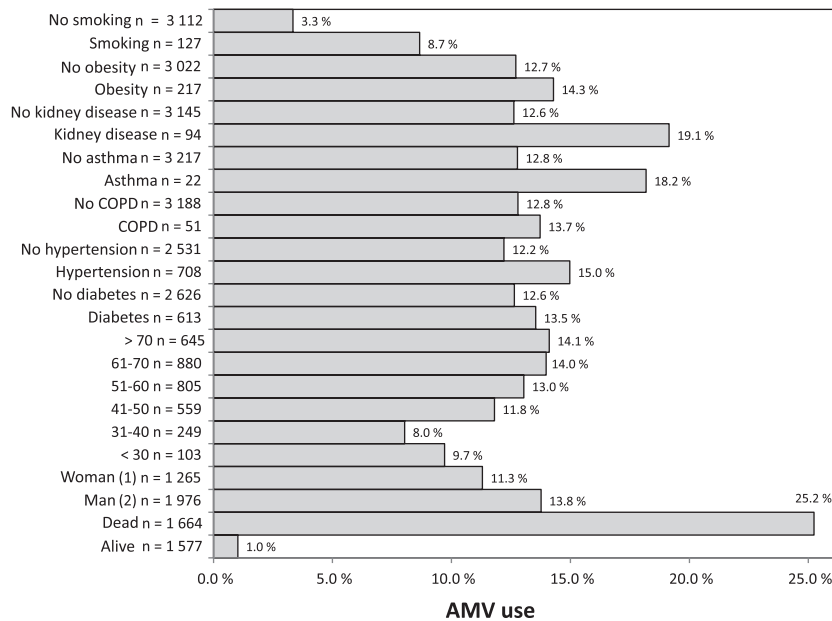


Figure 1. Use of assisted mechanical ventilation (AMV) by type of patient. COPD: chronic obstructive pulmonary disease.

Table 4. Patient number, average (standard deviation) and median (25th and 75th percentiles) according to costs empirical distribution*

Cost group	Patients with care (n)	Average cost/patient ± SD	Median (25 th -75 th percentiles)
Group 1, direct medical costs for COVID-19 care	3,241	5,124 ± 3 931	4,459 (2,229-6,688)
Group 2, costs of infrastructure and personnel	3,241	1,416 ± 1,081	1,181 (656-1,837)
Group 3, home oxygen and hospital transfer	291	41 ± 31	36 (19-54)
Group 4, costs unrelated to COVID-19 therapy	71	626 ± 848	5 (5-1 262)
Average total cost per patient† (sum of all four groups)	3,241	6,557 ± 4,997	5,771 (2,885-8,656)
Costs of three services: hospitalization, respiratory therapy with no AMV and infrastructure and personnel	3,241	6,228 ± 4,754	5,189 (2,885-8,079)

*In 2021 US dollars.

†Average total cost per patient was calculated as the sum of the costs of each group divided by total number of patients in each group.

Costs by patient characteristics suggest that the highest average costs corresponded to patients with kidney disease, chronic obstructive pulmonary disease, and smokers, although the three types of patient show high variability (Fig. 2). The highest costs that showed no significant variation were observed in survivors and in men. As regards age, the highest costs were documented in the age groups of 30 to 40 and 40 to 50 years (Fig. 3).

Discussion

The study reported that COVID-19 care average cost during the first year of the health emergency amounted to USD 6,542, with an average hospital stay of 10.8 ± 8.2 days (median: 9 days). Most part of this cost (95%) was constituted of three components: hospitalization, respiratory therapy without AMV, and infrastructural and personnel-related costs.

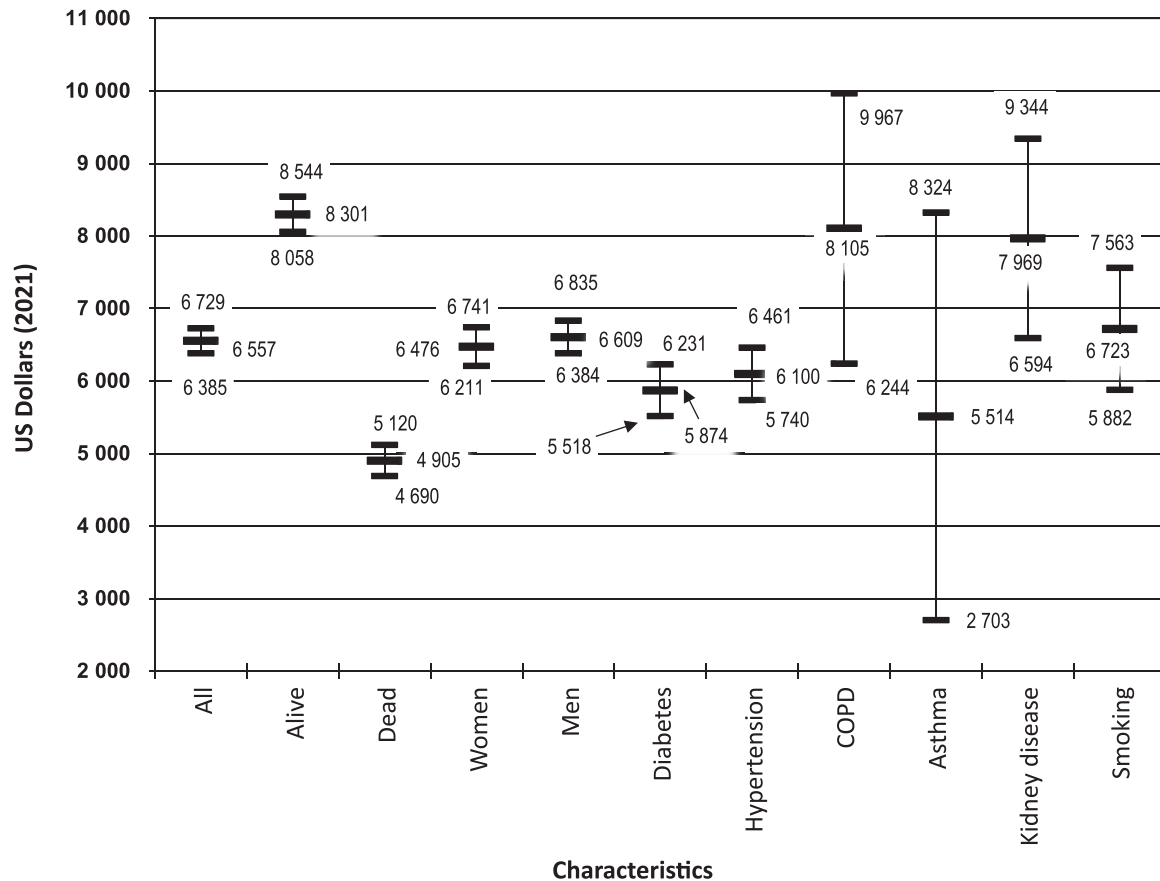


Figure 2. Average cost and confidence interval by patient characteristics. COPD: chronic obstructive pulmonary disease.

In other studies, the percentage of reported mortality significantly varied depending on the country and patient conditions.^{5,19,20} In the present analysis, the possible causes of the high mortality rate could be patient conditions at hospital admission (the hospital was a referral center, and a significant proportion of patients arrived in critical conditions) and the long transfer times from the onset of symptoms to final admission at the attending hospital.

Patients who survived reported longer hospitalization time compared with those who did not survive. In the case of comorbidities such as chronic obstructive pulmonary disease and kidney disease, patients had a higher average of hospitalization days in comparison with those who suffered from diabetes or hypertension. On the other hand, no statistically significant difference was found between the survival of patients with or without diabetes; when hospitalization days variation was explored by age group and diabetes, the differences were not significant. Furthermore, although respiratory therapy with AMV has a high cost per patient

(USD 592), the percentage of patients who received AMV was not high (13%), although, in some specific groups, the percentage of its use was higher, as in patients with kidney disease (19%) or asthma (18%).

In a study carried out in Brazil, a country with income levels similar to those of Mexico, the authors estimated an average cost per patient of USD 12,637, with 51.7% of ICU utilization in a sample of 3,254 individuals who were provided care.²¹ In addition, the cost of intensive care was USD 1,158, an amount higher than the USD 592 for AMV in the present study. In another analysis in the United States, a country with different health care prices, the authors estimated a national COVID-19 hospitalization median cost of USD 11,267, and a cost per day of stay of USD 1,772.²² Average stay per patient was six days, median cost of ICU stay and cost per day were USD 13,443 and USD 2,902, respectively. These costs are significantly higher than those reported in the present study. In another research in the United States, median cost of an hospitalization event was found to be USD 14,366.²³ This cost increases to USD 18,579 if the costs

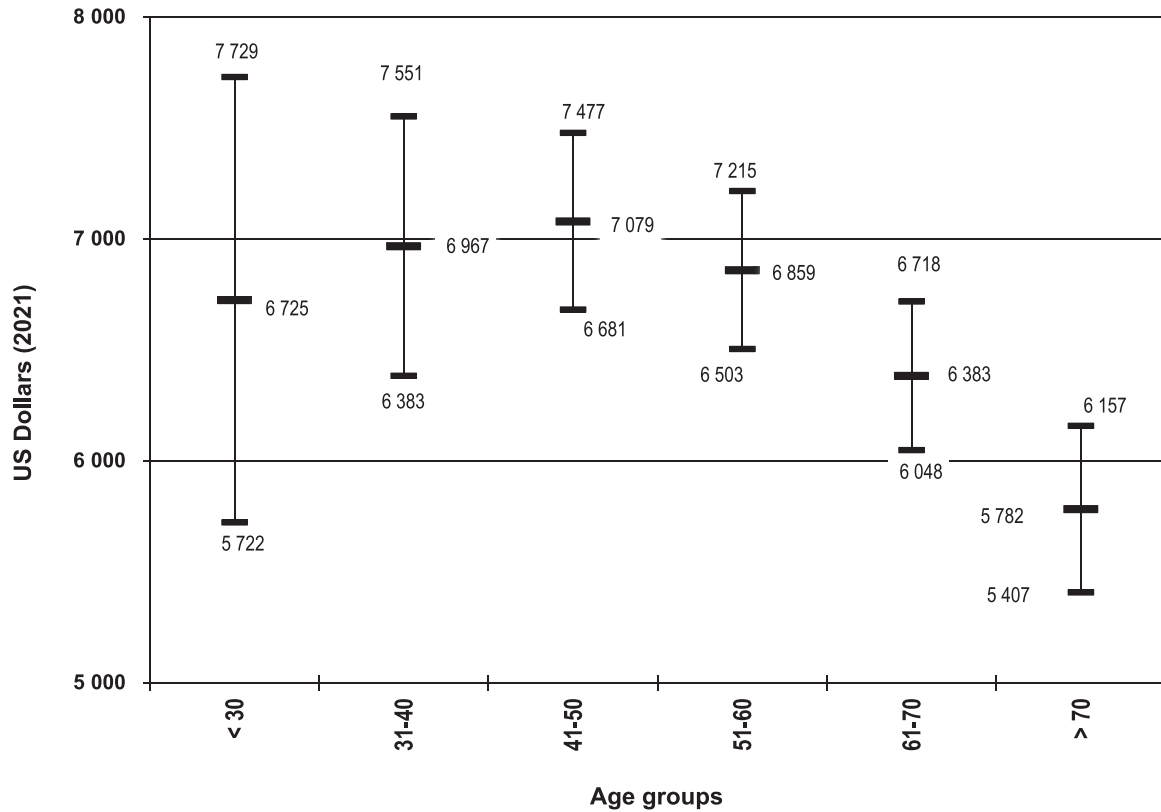


Figure 3. Average cost and confidence interval by patient age group.

of one year after hospitalization are included. The authors also reported that treating a symptomatic case with a single episode has a lower cost (USD 3,045), even if post-hospitalization costs such as outpatient visits and possible re-hospitalization are included (USD 3,994).

One limitation of the present study is that information on diagnostic tests during hospital care was not available, the omission of which may have caused an underestimation of the costs per patient. In the ICU costs estimates made by Bartsch, costs related to the diagnosis of sepsis or acute respiratory distress syndrome were included.²³

A second limitation of this study was related to the use of unit prices to estimate the costs of different internal services at the Mexican Institute of Social Security, which may cause for the costs not to be comparable with those reported in other investigations that use internal prices or market prices. Moreover, in some cases, the components included in the costs of services were not known in detail. This can also lead to duplication or disregarding of certain aspects that are considered in the care with and without AMV.

Another limitation of this study was that the costs during the care of the disease beyond hospitalization, such as outpatient costs (appointments, tests, medications, etc.), were not included, which would provide a more complete representation of the cost of care.

Conclusion

The results suggest that the magnitude of the costs resulting from hospitalization for COVID-19 was significant due to the scale and intensity of the medical care provided. Under the assumption of a total of 70,000 hospitalizations during the first year (at an average cost of USD 6,557), global cost of hospital care represented 37% of Mexican Institute of Social Security total outlay in 2021.²⁴

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Conflicts of interest

The authors declare that they have no conflicts of interest relevant to the content of the article.

Ethical disclosures

Protection of human and animal subjects. The authors declare that no experiments were performed on humans or animals for this research.

Confidentiality of data. The authors declare that no patient data appear in this article.

Right to privacy and informed consent. The authors declare that no patient data appear in this article.

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