How expensive are Intensive Care Units hospitalizations by COVID-19? Evidence from Uruguay.

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Abstract

Objectives: This study aimed to estimate the direct medical costs due to hospitalizations by COVID-19 in Uruguay and to identify their cost drivers.
Methods: This is a retrospective cost-of-illness study of COVID-19 in Uruguay. We estimated direct medical costs using data from patients in an intensive care unit [ICU] form a public hospital, between January 1st, 2019, and December 31st, 2021. Absolute and relative frequencies, averages, medians, and interquartile ranges (IQRs) were used to characterize the population and estimate the costs of hospitalized patients with COVID-19. We stratified the cost analysis by sex, age groups, comorbidities. Cost drivers were calculated from a generalized linear model. We expose the capacity cost to show the difference between pandemic period and previous.
Results: We studied 2876 patients, 56.2% men. On average, the hospital length of stay was 5.3 (4 5.2) days. A person hospitalized with COVID-19 reported median costs of $1898. In women, this cost was $1328; in men, this was 1.4 times greater. The median cost for ICU was $3118, estimated in 3.6 times higher than those hospitalized only in the general ward.
Conclusions: Our study provides an-idea of the magnitude of costs needed to hospitalize in an ICU a COVID-19 case in Uruguay. Other studies have assessed the costs of hospitalization for infectious diseases such as influenza, costs significantly lower than those described here. Even, expose the cost of capacity and the incidence of Fixed Cost in the total amount. The idle capacity is 40% post pandemic period.
Keywords: costs and cost analysis, COVID-19, direct cost, ICU Cost hospitalization.

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Introduction

Introduction And Background

COVID-19

The outbreak of COVID-19 has posed a severe global health threat with far-reaching implications for public health, society, and the global economy (Nicola et al. 2020) . Beyond the immediate health burden, the pandemic has had diverse and complex impacts on the global economy, making accurate assessments challenging. Economic growth has been negatively affected, and there are various risk factors that could impede a sustained global recovery, such as geopolitical developments, potential changes in monetary policy by central banks, resurgences of COVID-19 cases, supply chain and labor market issues leading to inflationary pressures, and pent-up consumer demand. Jackson et al 2020, suggest that the persistent disruptions in labor markets, manufacturing, supply chains, and transportation have resulted in supply shortages.

The COVID-19 pandemic has put immense strain on healthcare systems worldwide, leading to critical resource shortages, including hospital beds, intensive care unit (ICU) beds, ventilators, and healthcare staff, as Sen-Crowe et al 2020 put it in their study of hospital beds capacity and resource shortages during the COVID-19 pandemic. To meet the challenges posed by the pandemic, healthcare systems and hospitals have undergone radical changes, focusing on increasing ICU bed capacity, establishing COVID-19 wards for isolation and treatment, and setting up field hospitals (Haldane et al. 2021).

From an economic standpoint, the rapid spread of COVID-19 and the increasing number of patients have resulted in substantial direct medical and indirect costs for

patients, healthcare systems, and governments. Direct medical costs are influenced by factors such as the number of infected individuals, disease severity, length of hospital stay, and others (i.e., Warren et al 2006 or Cheung et al 2003). Studies such as the one by Bartsch et al. 2020 have shown that the medical costs associated with COVID-19 patients were significantly higher compared to other infectious diseases, primarily due to the higher likelihood of hospitalization and mortality. The specific care services required by COVID-19 patients have also contributed to additional costs (i.e., Rapoport et al.2003). However, due to the novelty of the disease, comprehensive cost data related to the burden of COVID-19 has been scarce.

Introduction to ICU – COVID 19 costs

In companies, the concept of capacity usually represents a limit or restriction. Theoretical capacity is a level of capacity that is based on the fact of always producing with all possible efficiency at a given time. Then, the practical capacity is the level of capacity that reduces the theoretical capacity considering unavoidable operational interruptions, such as scheduled maintenance and cleaning time between bed occupancy by one patient and the next, delays due to change of personnel between shifts or absences or holidays, etc. Both concepts measure capacity levels in terms of what they can supply, that is, their available capacity. Instead, normal capacity and budgeted capacity measure capacity levels in terms of demand for service delivery, the amount of capacity that is expected to be used based on demand. In many cases, the budgeted capacity is far less than the available capacity. The difference is found in seasonal, cyclical and trend factors. What depends on whether its analysis and subsequent treatment becomes more or less complex, in general, on the components of the general cost structure. If there is a significant relative weight of variable costs, the cost of unused capacity is probably of less importance, on the other hand, if the significant relative weight is in fixed costs, the analysis becomes critical.

The problems of unused capacity, or idle capacity, are relevant in many companies in the services sector. For example, when calculating the cost per day/patient or day/bed, you need to decide which level of capacity you will use: practical capacity,

normal capacity, or budgeted capacity. Your decision may have implications for capacity management, as well as for pricing and performance evaluation of various services units. Fixed capacity costs are linked to the long term, resulting in difficult or impossible control in the short term. The costs resulting from new infrastructures, necessary to care for patients in a pandemic, entailed high investments that, once the crisis was over, have been left with low occupancy, that is, facilities that are mostly idle. Although they could be used in other related pathologies, they currently require maintenance outlays to make them available -eventually- in operational conditions soon. Due to their rigidity, they are called costs of not producing, since they exist whether or not the installed capacity is used. The most common fixed costs of capacity correspond to rent or amortization of property or equipment, preventive maintenance, salaries of security personnel or general services required, etc.

It is relevant to differentiate from the operating costs that are usually constant for the level of activity planned, if this is modified, the fixed operating costs will also vary. They are not variables because they do not respond to the real rate of service, but rather to the decision to reach a given level of care. They are usually a function of the time of use of the factors and are related to the planned time horizon. Its increase is not necessarily constant when moving from one level of activity to another. The most common fixed costs of operation are the salaries of supervisory personnel, electricity, services, maintenance and reconditioning, among others, etc. Idle capacity represents that part of the unused fixed structural and operational resources.

In particular, exposing the cost of unused capacity has to provide opportunities for decision-making, it should prompt management to search for alternative strategies to take advantage of or eventually reduce them.

In Uruguay, the total number of ICU beds at the country level is 753 beds active surveyed by SUMI reports (2022) and now 956 provided by Health Minister (MSP, 2023). In the winter season of recent years, an average occupancy rate of around 60% was recorded. At the end of 2021, there were approximately 1000 ICU beds

available (considering an expansion due to pandemic contingency plans). An active and available bed is understood to be one that has all the necessary equipment (cardiovascular monitoring, artificial ventilator, capacity for acute hemodialysis, etc.). In addition, for these beds to be operational, there must be a staff of trained human resources, both from the medical and nursing point of view. All these aspects must also be considered when considering the expansion of beds in any unit.

Doctors specialized in Intensive Medicine have been a scarce resource since before the pandemic. The same happens with the Graduates in Nursing specialized in the ICU. This situation has worsened due to the pandemic due to the expansion of beds in some units and the need for greater coverage due to organizational changes in them (creation of COVID areas, triage areas, etc.). Medical and nursing multiple employment is a characteristic phenomenon of the sector that weakens the system since each lack of certification or license of any kind is replicated in 2 or 3 workplaces.

Suarez-Clement *et al.*, (2022) introduced direct costs as those directly related to patient treatment (medications or drugs, food, consumable medical supplies, and other material resources associated with the activity that is carried out, complementary exams, water, electricity, maintenance, depreciation and other services). On the other hand, indirect costs are those that are executed in order to support the activities carried out by the institution.

For the purposes of this paper, cost is understood to be the sum of expenditures incurred for the acquisition or production of a good or service, considering, for example, resources such as hospital infrastructure, equipment, drugs or medicines, resource salaries -medical and non-medical human resources, consumable medical supplies, among others.

Methods and Methodology

This is a retrospective cost-of-illness study of COVID-19 in Uruguay. We estimated direct medical costs using data from patients in an intensive care unit [ICU] form a

public hospital, between January 1, 2019, and December 31, 2021. Absolute and relative frequencies, averages, medians, and interquartile ranges (IQRs) were used to characterize the population and estimate the costs of hospitalized patients with COVID-19. We stratified the cost analysis by sex, age groups, comorbidities. Cost drivers were calculated from a generalized linear model. We expose the capacity cost to show the difference between pandemic period and previous.

The present work carries out a measure the costs per patient, with the added pathologies and bed days of intensive treatments, which includes direct costs, costs associated with human resources and indirect costs. The indirect costs related to business support or operating structure of the health center that are usually added and distributed on some basis, have not been considered. The qualitative representativeness is structural, that is, it represents the reality of the patients of any ICU at a national level. The study was carried out between May and December 2022.

The variables of direct, indirect, unit and total cost, patient days, bed days, drugs, salaries for medical and non-medical personnel, expendable material and specific long-term equipment and instrumentation were collected. The quantity of medicines or drugs used by the patient during the hospitalization period was identified based on the unit's registration system (Pharmaceutical Commissary system), based on the prescriptions issued for each patient and their corresponding application. Medications were valued based on actual recorded cost. The amount of medical supplies or consumables were identified from the monitoring and recording of their consumption in the care of each patient for the period of analysis. The Commissary unit records consumables, like gloves, different catheters (jugular, percutaneous, arterial), inhalation chamber, syringes, needles, 3-way keys, surgical gowns, cannulas, masks, among others, can be highlighted. Recorded consumables, patient by patient, are valued at actual recorded costs.

Table 1. ICUs occupancy monitor in Uruguay

Source: Ministerio de Salud Pública (2023)

Background of the distribution of Costs in the ICU

Carrera-Hueso et al. (2021) conclude that the impact of the pandemic on the health budgets of the public sector in Spain has been, in terms of cost, greater than multiple sclerosis, cancer or diabetes. They identify that the ICU consumed 5.3% of the available resources, the average per patient being between €14,693 to €16,524. In turn, they present that the average for the ICU is €10,744 per patient.

Gedik (2020) studies in Istanbul that the average stay represents 14.74 days with a cost per patient of €9,682. Along the same lines, Ohsfeldt et al. (2021) for the United States present patients with a mean stay of 5 days in the ICU, the cost of which represents $13,443 US dollars. These costs reach levels of $47,454 US dollars and an average stay between 11 and 16 days when mechanical ventilation is required, or in patients with hypertension or obesity.

For his part, Popescu (2022) for Romania determined a daily cost of stay in the ICU of €598.40, with an average of €10,319 per patient.

On the other hand, other studies identify only medical costs, as is the case of Alvis-Zaksuk et al. (2022) for Colombia, who present the average cost of medical fees per patient at $4,118 US dollars and an average stay of 7.3 days per patient in the ICU.

In the case of Uruguay, Table 2 shows the cost by type of resource measured in US dollars on the date of use of the resource.

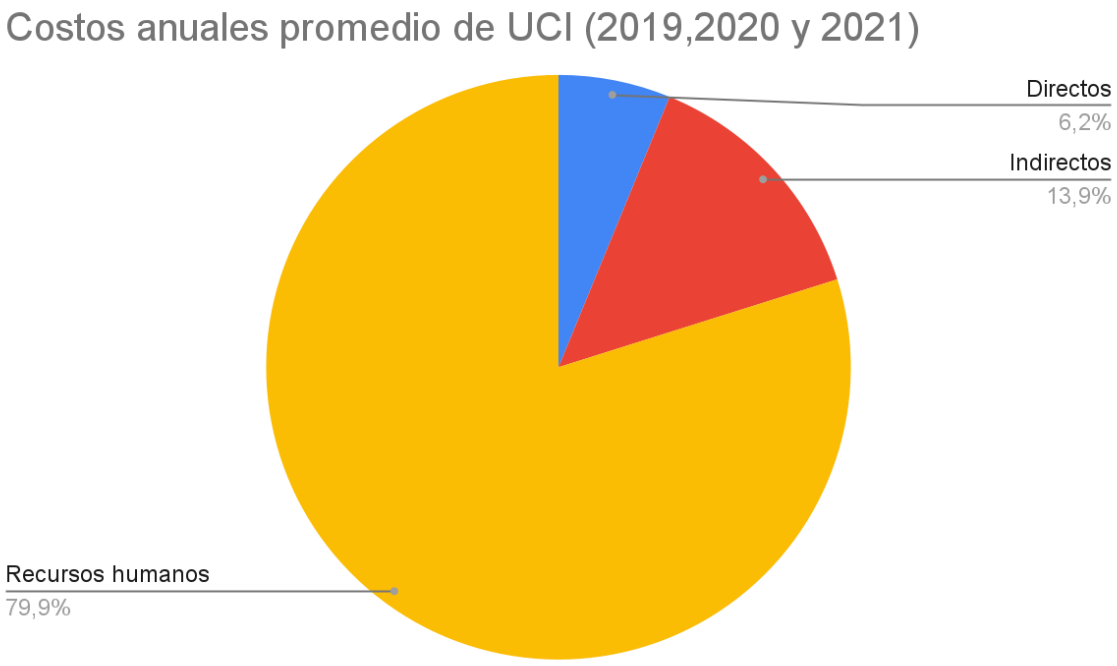
Table 2. Annual costs of the hospital stay in the ICU (n=2876).

Costs *	**2019**	**2020**	**2021**	**Average**	**%**
Direct	$728.239	$834.578	$1.553.671	$1.038.829	6,2%
indirect	$2.543.542	$1.858.897	$2.593.082	$2.331.840	13,9%
Human Resources	$13.603.327	$12.891.960	$13.600.620	$13.365.302	79,9%
Total	$16.875.108	$15.585.435	$17.747.372	$16.735.972	100,0%
*In US dollars					

Source: prepare by authors

For comparative purposes, the relative weight of the cost components for the Uruguayan case is illustrated in Graph 1.

Graph 1. Cost components % identified in the Uruguayan case



Source: prepare by authors

It is considered pertinent to explain the two direct cost components, identifying the medicines or drugs and the consumables used. The opening is illustrated in Table 3 and 4.

The direct cost are open in the principal components for the same months in 2019 and 2020. Average use the annual. The % vary between 2019 and 2020 because the capacity level was use in more. In others words, the unused capacity, or idle capacity was used better than the previous year.

Table 3. Direct monthly costs of the hospital stay in the ICU 2019 (n=281)

Costs *	**Mayo**	**June**	**July**	**Average**	**%**
Drugs	$28.444	$29.020	$28.407	$28.624	44,97%
expendables	$34.106	$36.547	$34.427	$35.027	55,03%
Total	$62.550	$65.567	$62.834	$63.650	100,00%
*In US dollars					

Source: prepare by authors

Table 4. Direct monthly costs of the hospital stay in the ICU 2020 (n=221)

Costs *	**Mayo**	**June**	**July**	**Average**	**%**
Drugs	$27.214	$26.166	$31.675	$28.352	39,77%
expendables	$45.751	$41.766	$41.282	$42.933	60,23%
Total	$72.964	$67.931	$72.958	$71.284	100,00%
*In US dollars					

Source: prepare by authors

If we analyze the 2021 year, we have 9 months with pandemic and 3 months without pandemic period.

Table 5. Direct costs of the hospital stay in the ICU 2021 (n=893)

Costs *	2021 without pandemic	2021 with pandemic	Average w/pandemic	Average w/pandemic	% s/pandemic	% c/pandemic
Drugs	$70.944	$244.298	$28.378	$25.716	53,53%	34,80%
expendables	$61.580	$457.754	$24.632	$48.185	46,47%	65,20%
Total	$132.524	$702.052	$53.010	$73.900	100,00%	100,00%
*In US dollars						

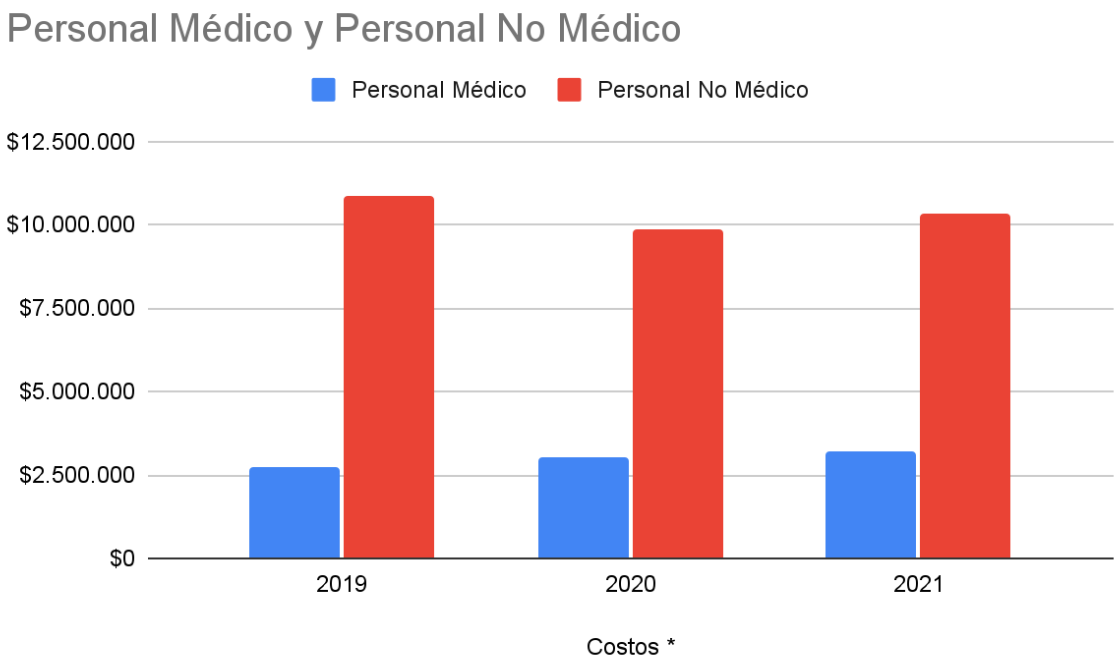
Source: prepare by authors

On the other hand, although the distinction between fixed and variable costs has not been made (sensitivity analysis), it should be noted that fixed costs correspond to the independent component of the quantity produced. In UCI they constitute the expenses of personnel, amortizations and maintenance. Variable costs correspond to the component that depends on the quantity produced. The quantitatively most important sections are drugs and complementary tests.

Altawalbeh*et al.*, (2018), identified within the areas related to diagnosis, the laboratory as the area of greatest expenditure, like the study by Kilic*et al.*, (2019), results that differ from what is reported in the present. Identifying the imaging department as a diagnostic area may be due to different factors, including the availability of diagnostic tests and equipment; as well as its indication according to the protocols of the centers. In turn, in Agrawal's *et al.*, (2017) research, a high use of catheters was found, in which 65% was for therapeutic purposes. In the present investigation these were indicated to a large extent. Catheters are of great importance in the care of critically ill patients because they allow maintaining a route

for the administration of medications, as well as for performing procedures, especially deep venous approaches.

Graph 2. Cost Workforce medical and non-medical staff 2019-2021



Source: prepare by authors

Del Campo Rivas*et al.*, (2020) for a study carried out in Chile, shows that Human Resources in ICUs imply 73% of Direct and operational Costs, while Evans*et al.*, (2018) show that in Canada they represent 65%. In turn, Carrasco, et al. (2007) for Spain stated that they imply 75% of the total.

This structure is similar to the pre-pandemic structure, therefore, a comparison is made between countries visualizing the relative weight presented in the different components.

Carrasco *et al.*, (2007) shows that in Spain the daily cost per occupied bed is $1,200 US dollars, while Aguilar and Martinez (2017) present for Mexico a daily cost per bed of $1,700 US dollars. For his part, along the same lines, Evans*et al.*, (2018) study that for Canada the daily cost is $2,880 US dollars. The variability between the different studies, although it may have explanations in the different calculation

periods, is also explained by the costs or resources considered in the calculation. Not all studies consider cost components in a comparable way, which could be treated as a limitation.

Conclusions and reflections

Our study provides an-idea of the magnitude of costs needed to hospitalize in an ICU a COVID-19 case in Uruguay and how was the increase per day and per pacient. Other studies have assessed the costs of hospitalization for infectious diseases such as influenza, costs significantly lower than those described here. Even, expose the cost of capacity and the incidence of Fixed Cost in the total amount.

First time, never develop the idea of capacity, but in pandemic period we show that the idle capacity was used and that it’s the cause of the minimum cost per day.

Fixed Operating Costs arise as a consequence of the decision to operate. They are constant for the expected level of activity, if this is modified, the fixed operating costs will also vary. They are not variables because they do not respond to the rhythm of actual production, but to the decision to reach a given production. They are usually a function of the time of use of the factors and are related to the planning horizon.

Its increase is not necessarily constant when moving from one level of activity to another. The most common fixed costs of operation are the salaries and social charges of supervisory personnel, electricity, telephone services, corrective maintenance and reconditioning, etc.

Idle capacity represents that part of the structural or operational fixed factors not used in production. The operational idle capacity arises from comparing the expected level of activity with the capacity actually used.

Faced with a given level of production capacity, there may be excess capacity, defined as idle capacity, that is, that part of the structural or operational fixed factors not used in production.

It is important to track the costs of used and unused capacities separately, as this leads to a better understanding of the costs associated with each. In particular, it is necessary to expose the cost of unused capacity, since it constitutes a cost of the company, and not a cost of the units resulting from the value-generating process, since it was not used in the production process. In turn, exposure to idle costs should prompt managers to seek alternative strategies to reduce them.

We studied 2876 patients, 56.2% men. On average, the hospital length of stay was 5.3 (4 5.2) days. A person hospitalized with COVID-19 reported median costs of $1898. In women, this cost was $1328; in men, this was 1.4 times greater. The median cost for ICU was $3118, estimated in 3.6 times higher than those hospitalized only in the general ward.

The name of the ICU and the health unit to which it belongs are kept confidential, given the confidentiality required by the health provider.

The day-bed in the ICU analyzed has an average cost of $1,585 US dollars, a value similar to that reported by a previous study. The average stay of users is 8 days, being higher than that registered in periods prior to the pandemic, which were 5 days as presented by Alvear et al. (2013). If the hospital stay is increased, the total cost of maintaining a user will increase, due to the multiple direct and indirect costs and human resources that this phenomenon implies. The decrease in stay through the strengthening of the professional team and the execution of medical, nursing and other professional practices could contribute to generating economic savings, a topic that should be empirically investigated in future works. It is important to consider a relationship of higher costs within the first three to five days of hospitalization of the critically ill patient, given the need to perform complex diagnostic and/or surgical procedures.

Although the data collection was obtained from 2876 patients out of a total of 3101 discharged from the ICU during the study period, they are a sample that does not differ from the total universe of patients in terms of epidemiological profile, origin and score APACHE. Given that patients with mechanical ventilation are essentially more severe, it can be assumed that the patients included here do not represent a less

complex group. Although no studies have been identified that characterize the ICU user population at the national level, it is relevant to have an approximation of the costs involved in the ICU.

The cost associated with human resources, which represents 68.7% globally, a figure that is not far from other studies carried out internationally. It becomes imperative to conduct longitudinal studies to explore causality and better understand the risk factors associated with a long hospital stay, to carry out randomized controlled clinical trials that offer evidence regarding the effectiveness of treatments and to advance in the economic evaluation towards studies of cost-effectiveness and/or cost-utility, in order to provide relevant information in the management of the ICU.

In our opinion, it is necessary to generate uniform cost measurement instruments, standardize and apply them in different ICUs, and publish results. The management must allow processes of comparison, learning, and continuous improvement between the different ICUs at the country level.

Analyze the impact of Fixed Costs on the monthly cost and its evolution, we find in post-pandemic idle capacity of unused available resources. Evaluate the identification of the cost of that unused capacity more than 40%. Identifying occupied beds and available beds and calculate cost per available bed vs. cost per occupied bed and determine the gap. We must discuss how this information could provide issues to improve the managerial operations in the Healthy Systems. Actions to take advantage or concentrate treatments in units by specialist in adults or in children seeking specialization by medical centers. Incorporating managerial logic into the decision-making process becomes paramount in the context of healthcare operations. Utilizing cost data and resource utilization metrics allows healthcare administrators to make informed decisions regarding capacity planning, staffing, and resource allocation. By identifying areas of inefficiency and underutilization, managers can implement targeted interventions to optimize costs and enhance the overall effectiveness of the healthcare system.

One of the main limitations of the study is its own design, since it is not a complete economic evaluation, but rather a partial economic evaluation type description of costs. Similarly, carrying it out in a single ICU and in a small sample constitutes a limitation.

On the other hand, the imaging, microbiology and clinical laboratory studies necessary for the diagnosis and follow-up of seriously ill patients, which are sources of high costs, have not been included in the direct costs. In turn, the costs of the company/organization structure have not been included in the indirect costs, since they could only have been estimated without having the information of the organization. Therefore, the researchers' decision was to do without them. In turn, in our opinion and based on knowledge from medical practice, it is expected that the cost-day of obese patients is higher than the cost-day of non-obese patients; however, this requires a patient-by-patient study, not only through the number of days of hospitalization in the ICU, but rather an individual costing that could not be carried out in the present work.

It is considered that a comparative study with disaggregated data could help to understand the cause of the efficiency levels achieved and explain, specifically, the level of leverage of the fixed cost structure.

Even so, it offers basic information that can be used as a reference for the projection of future studies related to cost effectiveness or cost utility regarding specific health interventions or technologies. The data reported by this research cannot be generalized to other ICUs, without considering the complexity and/or the epidemiological profile of the population they care for, considering the territorial and population heterogeneity observed in the different care units.

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