The cost-effectiveness of imaging examinations as a parameter of efficiency in a health service in the diagnosis of community acquired pneumonia

A relação custo/efetividade de exames de imagem como parâmetro de eficiência em um serviço de saúde no diagnóstico da pneumonia comunitária adquirida

La rentabilidad de los exámenes de imagen como parámetro de eficiencia en un servicio sanitario en el diagnóstico de la neumonía adquirida en la comunidad

RESUMO

Objetivo: Analisar a relação custo-efetividade de métodos de imagem radiológica, radiografia e tomografias, no diagnóstico de pneumonias adquiridas na comunidade em unidade de saúde na cidade de São Luís, Maranhão, durante a epidemia da COVID-19. Desenvolveu-se revisão de literatura sobre estudos de custo-efetividade no Brasil e no mundo, dando enfoque para relação custo e acurácia entre métodos de imagem radiológica e o diagnóstico de infecção pulmonar. Realizou-se pesquisa, de natureza quantitativa, com coleta de dados diagnósticos do agravo estudado e os custos efetivos com os exames solicitados. Foram utilizados os bancos de dados de um serviço de saúde e diagnóstico na cidade de São Luís/MA. Ao final, foi discutida a necessidade de exames de baixo e alto custo no diagnóstico com vistas `a qualificação da Análise de Custo-Efetividade (ACE). Na presente pesquisa foram analisados 511 laudos. E nesta análise comparativa radiografia/tomografia, para as grandes opacidades, a concordância entre as duas técnicas ocorreu em 177 laudos, sendo 103 (58,19%) do gênero masculino e 74 (41,8%) do gênero feminino, com idades entre 13 e 93 anos, com predominância nas idades entre 33 a 53 anos (51,4%). A guiza de conclusão, podemos observar que, mesmo diante de tantos questionamentos, ao comparar as duas técnicas de exame de imagem, radiografia/tomografia, o sistema de radiografia é tão eficaz quanto a tomografia. Disso decorre, baseado nessa análise de custo efetividade, que ainda precisamos avançar muito, não apenas na produção de evidência, mas sobretudo no uso dessa metodologia, para reduzirmos o custo do sistema de saúde e ampliarmos sua cobertura, em quantidade e qualidade.
DESCRITORES: Custo-Efetividade; Economia da Saúde; Sistema Único de Saúde; Radiologia, Pneumonia.

ABSTRACT

Objective: To analyze the cost-effectiveness of radiological imaging methods, X-rays and CT scans, in the diagnosis of community-acquired pneumonia in a health care facility in the city of São Luís, Maranhão, Brazil, during the epidemic of COVID-19. A literature review was developed on cost-effectiveness studies in Brazil and worldwide, focusing on the relationship between cost and accuracy of radiological imaging methods and diagnosis of pulmonary infection. A quantitative research was carried out, with collection of diagnostic data of the grievance studied and the actual costs of the exams requested. We used the databases of a health and diagnostic service in the city of São Luís/MA. At the end, the need for low and high cost exams in the diagnosis was discussed in order to qualify the Cost-Effectiveness Analysis (CEA). In the present research 511 reports were analyzed. In this comparative radiography/tomography analysis, for large opacities, the agreement between the two techniques occurred in 177 reports, being 103 (58.19%) male and 74 (41.8%) female, with ages ranging from 13 to 93 years, with a predominance in ages between 33 and 53 years (51.4%). By way of conclusion, we can observe that, even in the face of so many questions, when comparing the two imaging exam techniques, radiography/tomography, the radiography system is as effective as tomography. Based on this cost-effectiveness analysis, it follows that we still need to advance a lot, not only in the production of evidence, but especially in the use of this methodology, in order to reduce the cost of the health system and expand its coverage, in quantity and quality.
DESCRIPTORS: Cost-effectiveness; Health Economics; Unified Health System; Radiology, Pneumonia.

RESUMEN

Objetivo: Analisar a relação custo-efectividade de métodos de imagem radiológica, radiografia e tomografias, no diagnóstico de pneumonias adquiridas na comunidade em unidade de saúde na cidade de São Luís, Maranhão, durante a epidemia da COVID-19. Se desarrolló una revisión bibliográfica sobre estudios de costo-efectividad en Brasil y en el mundo, centrándose en la relación entre el costo y la precisión de los métodos de imágenes radiológicas y el diagnóstico de infección pulmonar. Se realizó una encuesta cuantitativa, con recogida de datos diagnósticos del agravio estudiado y de los costes reales incurridos con las pruebas solicitadas. Se utilizaron las bases de datos de un servicio de salud y diagnóstico de la ciudad de São Luís/MA. Al final, se debatió la necesidad de realizar exámenes de bajo y alto coste en el diagnóstico con el fin de matizar el Análisis Coste-Efectividad (ACE). En la

presente investigación se analizaron 511 informes. En este análisis comparativo radiografía/tomografía de grandes opacidades, la concordancia entre ambas técnicas se produjo en 177 informes, 103 (58,19%) de pacientes varones y 74 (41,8%) de pacientes mujeres, con edades comprendidas entre 13 y 93 años, con predominio de 33 a 53 años (51,4%). Como conclusión, podemos observar que, incluso ante tantos interrogantes, al comparar las dos técnicas de investigación por imagen, radiografía/tomografía, el sistema de radiografía es tan eficaz como el de tomografía. A partir de este análisis de coste-efectividad, es evidente que todavía tenemos que avanzar mucho, no sólo en la producción de evidencias, sino sobre todo en el uso de esta metodología, para reducir el coste del sistema sanitario y aumentar su cobertura en cantidad y calidad.
DESCRIPTORES: Coste-efectividad; Economía de la Salud; Sistema Único de Salud; Radiología, Neumonía.

RECEBIDO EM: 22/12/2022 **APROVADO EM:** 03/04/2023

Nivaldo Borges Nunes Junior
Médico Radiologista. Mestre em Gestão de Programas e Serviços de Saúde da Universidade CEUMA.
ORCID: 0000-0002-6484-4902

Marcos Antônio Barbosa Pacheco
Médico. Mestre e Doutor em Políticas Públicas. Universidade Federal do Maranhão.
ORCID: 0000-0002-3566-5462

INTRODUCTION

Health financing is an issue that always generates debates in order to better determine the use and allocation of resources for society as a whole. When it comes to health care, most countries face rising costs, both in absolute and relative terms, regardless of whether the financing model adopted is public or private, based on tax collection or through direct funding from users. [1]

Since the 1980s, emphasis has been placed on better stewardship of health care resources in the United States through a range of activities designed to reduce the cost of providing health services, in addition to improving the quality of this service, known as managed care, which has been the basis of the health system. This system emphasizes that health professionals must always bear in mind the concern with both the cost and the benefit of providing services. Vassalo [2] and Eldenburg [3] argue the defensive line of managed-care, arguing that cost control reduces the high prices previously imposed on society. While Baker [4] criticizes managed-care, considering that it is detrimental to the quality of patient care and can limit technological progress.

The relevant findings found in this research on community-acquired pneumonia (CAP) will contribute to a better understanding and identification of the costs and benefits of imaging methods - Computed Tomography (CT) and X-ray (RX) - of this pathology. It is intended that the investigation of the prevalence, radiological and clinical findings in a sample of the population of Maranhão arouse the interest of health services at the regional and national level, in the sense that greater efforts are made for the correct balanced use of the diagnosis and treatment of this entity.

The problem to be addressed is: How can the SUS exercise its constitutional role of contributing to a better cost-effectiveness ratio of imaging tests - X-ray and CT - as a parameter of efficiency in health services for diagnosis and treatment of community-acquired pneumonia (CAP), with rational use of resources?

CAP has an eminently clinical and imaging (radiological) diagnosis, through chest X-rays, as mentioned. Chest tomography is considered a high-cost exam for the Unified Health System (SUS), being performed in few public imaging services in Maranhão.

The previous review of published articles, master's dissertations and doctoral theses carried out on the subject in question in the postgraduate programs in Public Health and Health Sciences in the State of Maranhão from 2009 to 2019 has shown that there is no scientific production on the cost/effectiveness of imaging tests as a parameter of efficiency in SUS health services in Maranhão, hence its relevance.

Furthermore, it is intended to contextualize this master's work, providing the SUS with valuable information on the frequency of this pulmonary disorder in a reference service in the State, contributing to the strategic planning of the SUS in the field of epidemiological surveillance of pulmonary diseases.

The objective of this study is to highlight the cost-effectiveness of imaging tests for the diagnosis of Community Acquired Pneumonia, to carry out a bibliographical review on health economics based on the efficiency of imaging tests; diagnose foci of pneumonia using different methods and show the accuracy between them and discuss the likely consequences of using a cost-effectiveness parameter in the incorporation of technologies in the SUS.

LITERATURE REVIEW

The health economy plays a very important role worldwide, whose resources used in the provision of medical care show increasing action in the role of new actions that

the procedure offers, thus justifying the need for studies and practices in the area. [5] In the political and financial scenario of Brazil, the health sector sought new alternatives for management, focusing on the need for health organizations to adapt to an increasingly competitive market. The need to ensure positive outcomes and satisfied customers requires organizations to learn to associate low costs with excellent quality for their customers. [6]

The high rate of healthcare costs led professionals to need to invest in this knowledge, to rationalize the resource allocation process, balance financial resources and optimize results. [7]

On the other hand, the exponential increase in these costs is entirely related to a series of factors, such as the use of new technologies; demand growth; the shortage of skilled labor, leading to low productivity; the poor management of organizations due to the administrative inability of health professionals; the non-implementation of control systems; waste in the production chain, among others.[8]

At the end of the 1990s, in the context of State reform, driven by the neoliberal wave, some states of the Federation adopted the policy of social health organizations (OSS - organizações sociais da saúde). The OSS are non-profit private entities, with recognized expertise in health management, which manage public hospitals and outpatient clinics, with State resources and control. [9] The OSS were formalized by Complementary Law n. 846, of June 4, 1998.

It is true to say that when the health institution is well managed, it begins to offer classified and controlled responsibility in order to achieve goals in the most skillful and effective way. It is at this time that the health professional is extremely necessary to monitor decisions in technical areas, offering a quality service so that the institution has improvement in expense counting, specialization, economics, in finance and organizational assumptions, containing understanding and human relationship. [7]

In our research, a comparative study was carried out between the effectiveness of chest radiography and computed tomography in the diagnostic evaluation of pulmonary inflammatory/infectious process (pneumonia), which is the proposal of the objectives of this research. A retrospective review of medical records and reports (reports) of examinations of patients with a clinical diagnosis of pneumonia was also carried out, comparing the cost-effectiveness of imaging methods. [9]

> Pneumonia is an infection that settles in the lungs, caused by various infectious or irritating agents (bacteria, viruses, fungi and allergic reactions). The symptoms are varied, and fever, runny nose, shortness of breath, apathy, costal pain, among others, can be individualized.

Unlike viruses, which are highly infectious, the other infectious agents in pneumonia are not easily transmitted. The diagnosis must be made through anamnesis, physical examination with pulmonary auscultation and through the aid of diagnostic tests, primarily with chest X-rays and, in selected cases, with chest computed tomography. [11] However, an absolutely new scenario arises with the COVID-19 epidemic among us. Considering viral pneumonia the main cause of the disease. [12]

Community-acquired pneumonia (CAP) continues to be an ongoing challenge for primary health care services around the world. [13] In the context of increasing expectations that health systems provide care based on a rational relationship between cost-effectiveness and the financial burden of CAP diagnosis, especially in the local use of imaging methods, has attracted the attention of health professionals and managers. [14] Several measures have been proposed and implemented to contain the costs related to the care of patients with CAP, while preserving satisfactory clinical outcomes. [15]

Cost assessment is, therefore, a fundamental element for decision support in the health area. Thus, the assessment of the costs of adverse events is relevant for two essential reasons: [16]

a) On the one hand, together with the assessment of the prevalence of these events, it highlights the economic burden of the disease for society and, therefore, its preferential character for health policies. In practice today, it is not enough to prove the strong prevalence or incidence of a disease to persuade policy makers to intervene; its economic weight is also evident, in terms of costs for the State and society, and losses, related to economic growth and development.

b) On the other hand, the evaluation of the cost of adverse events (AEs) represents a fundamental column to be able to evaluate alternative interventions allowing to reduce AEs, or to compare these interventions with others within the health area.

The chest X-ray (PA + profile) can be charged with a variation of R$ 45.00 to R$ 90.00 (from popular clinic to private clinic). At CT, the values range from R$ 400.00 to R$ 600.00. Evidences show that CAP is also a pathology whose curative treatment is clinical. The values for the SUS are R$ 6.88 for the Chest X-ray in Pa and R$ 136.41 for the Chest CT. [17]

It is assumed that the health services

market has its flaws, which implies the need for intervention. Savedoff [18] supports Kenneth Arrow in the discussion on the adoption of cost-effectiveness, with the publication of the article "The welfare of health economics", in 1963, considered the landmark for the creation of the discipline of Health Economics. About Arrow's article, Savedoff considers it to be very up-to-date for touching on the central characteristic of public health policy debates, as market and non-market institutions that play their role in the provision and distribution of health care services, evaluating that the essence of uncertainty regarding the incidence of diseases and the effectiveness of treatment can lead to an inefficient allocation of resources, even in competitive (health) markets.

Faced with the need to justify health care, aiming at efficiency, economic evaluations of health interventions emerge as an important tool to support decision-making, as they allow the comparative analysis of optional actions in terms of costs and consequences. [19]

METHODS

The proposed research design was a retrospective observational study, with data from medical records and other documents related to imaging tests, such as reports, opinions and requisitions.

The research was carried out at the Imaging Unit of Hospital UDI, located at Avenida Prof. Carlos Cunha, 2000 – Jaracati. It is part of Rede D'Or in São Luís and has an adult and pediatric emergency room, a humanized Intensive Care Unit (ICU) and 24-hour care in medical and surgical clinics. Performs high-tech exams, such as cardiac exams, endoscopy, hemodynamics and diagnostic imaging. Of particular note is the special IT and management system (TASY) through which all patient medical records and test results and images are available online for all UDI Team physicians.

Inclusion criteria were: reports of patients who obtained CAP results. As for the exclusion criteria, we opted for patients who underwent X-ray and CT examinations, but who did not meet the diagnosis of pneumonia through different methods and the accuracy between them was not confirmed.

Data collection referred to exams carried out from March 1 to May 30, 2020. In a first phase, all the reports and images of the CT and X-rays performed in the period were analyzed, verifying the diagnoses and main radiological findings, seeking to identify patients with the diagnosis of CAP through the image. All patients whose reports and images from the respective CT and X-ray exams exams that demonstrated the presence of CAP were placed in the database. Specifically, in those individuals who had the diagnosis of CAP demonstrated by X-ray or CT.

As for the reason for the examination, all the indications were verified, not excluding any of them, in order to base ourselves on whether the professional's conduct was consistent with the result. The presence of the following radiological signs was collected from the reports and images: consolidation, lung extension, pleural effusion and alveolar opacities. These collected data relating to the above radiological signs, associated with the main pathology, were likewise transported to the database.

In the last phase of data collection, the medical records of patients who underwent CT and X-ray in the period were analyzed, in search of clinical and epidemiological data. The following information was actively searched in the records: age; gender; pre-hospital medication; clinical complaints; hospitalization; death and testing for COVID-19. All these data obtained were consecutively stored in a digital data sheet.

At first, a descriptive analysis of the data found was carried out, which could be presented in tables or graphs. For the evaluation of the results obtained, throughout the development of the study, it was carried out through descriptive statistics of data. For data storage, calculations and making graphs and tables, this project used Microsoft Excel 2003® software.

After sampling, the collected data were summarized in Microsoft Office Excel® spreadsheets. Due to the research period being the same period as the COVID-19 pandemic, the variables, gender, age, occurrence of CT and X-ray findings, testing for COVID-19, hospitalization, death and lung extension were investigated. The age range was analyzed using the mean and standard deviation.

The other variables were studied through the absolute and relative frequency of occurrence. A table was structured containing the data of the age and gender variables related to the pulmonary extension of the patients.

To draw an overview, albeit succinct, of gender inequalities, the study bases on seeking to cover a series of essential information, in order to contemplate the domains established by the research. [20] Thus, a principal component analysis was performed in order to understand the ordering of patients through the impacts on lung findings and the extent of the lungs affected.

All CT and chest X-rays and their respective reports were analyzed only after approval of the project by the Research Ethics Committee of the University of Ceuma and duly authorized by the governing body responsible for the institution, where the research was carried out and by its respective local Ethics Committee, whose Opinion number is 4,657,170. Likewise, the review of the medical records of patients who underwent examinations at the research site was only carried out after approval and authorization by the person in charge of the institution.

RESULTS AND DISCUSSION

The clinical and demographic characteristics of the 177 hospitalized CAP cases are shown in Table 1.

Cases were categorized by severity, with 103 (58.19%) male patients, of which 92 (51.98%) were aged between 33 and 53 years (45.71%). Of these 177 patients, 117 underwent X-ray (+) covid. PCR (+) was requested for 157 (88.70%) patients, and 156 (88.14%) were positive.

The health resources and the respective amounts used by the 177 patients with

CAP are detailed in the continuation of Table 1, where it is verified that 30 (16.95%) patients were intubated. During the period prior to hospitalization, 109 (61.58%) patients received more than one medication, and the most prescribed medications were Azithromycin (28.81%) and Chloroquine (61.58%). As for the clinical outcome, 12 (6.78%) evolved to death.

When evaluating each variable individually, it is noticed that male patients were more prevalent (Graph 1).

Gender is a relevant characteristic and in a review carried out by Li et al.[21] in China, about 60% of those infected with SARS-CoV-2 were men. The same occurred in research presented by Zhou et al. [22] in which both patients who were discharged (59%) and patients who died (70%) were men. However, the relationship between gender and COVID-19 is still unclear, however, it can be mentioned that the worst outcome in males may be related to the greater number of comorbidities present in males or an immune system response different from that observed in the female population.

It has been observed that the highest recorded mortality rates are among males compared to females. This notification is observed in reports from a significant number of countries and raises important questions about the spread and clinical impact of this pandemic. [23] According to Scully et al, [24] data collected in 38 countries reveal that mortality among men is 1.7 times higher than among women. Thus, gender can be considered a risk factor for greater severity and mortality in patients with COVID-19, regardless of age and susceptibility, as well as greater disease burden, and may correlate with shorter life expectancy in men compared to women.[25]

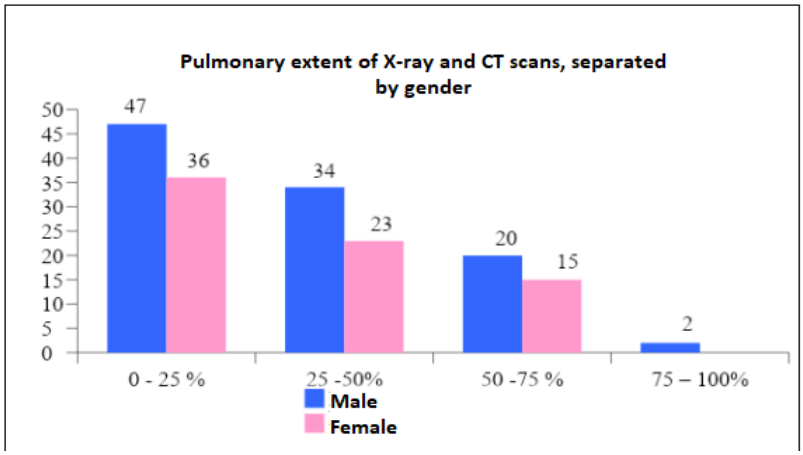
Table 1. Characterization of patients according to sociodemographic data, according to individual variables and pulmonary extension. (*) no data available

Variables	Pulmonary Extension (n/%)				
	0 - 25 %	25 -50%	50 -75 %	75 – 100%	Geral
Gender	**83 (n° / %)**	**57 (n° / %)**	**35 (n° / %)**	**2 (n° / %)**	**177 (n° / %)**
Masculino	47 (56,63)	34 (59,65)	20 (57,14)	2 (100,00)	103 (58,19)
Feminino	36 (43,37)	23 (40,35)	15 (42,86)	-	74 (41,81)
Age					
13 a 33	10 (12,05)	9 (15,79)	6 (17,14)	-	25 (14,12)
33 a 53	44 (53,01)	32 (56,14)	16 (45,71)	-	92 (51,98)
53 a 73	20 (24,10)	13 (22,81)	8 (22,86)	2 (100,00)	43 (24,29)
73 a 93	8 (9,64)	3 (5,26)	5 (14,29)	-	16 (9,04)
X-ray (+) Covid					
Sim	25 (30,12)	55 (96,49)	35 (100,00)	2 (100,00)	117 (66,10)
No	58 (69,88)	2 (3,51	-	-	60 (33,90)
Did an X-ray					
Yes	83 (100,00)	57 (100,00)	35 (100,00)	2 (100,00)	117 (66,10)
Não	-	-	-	-	-
PCR (+)					
Yes	69 (83,13)	54 (94,74)	33 (94,29)	1 (50,00)	157 (88,70)
No	4 (4,82)	2 (3,51)	-	-	6 (3,39)
Unsolicited	10 (12,05)	1 (1,75)	2 (5,71)	1 (50,00)	14 (7,91)

Tests					
PCR (+)	68 (81,93)	54 (94,74)	33 (94,29)	1 (50,00)	156 (88,14)
PCR (-)	4 (4,82)	2 (3,51)	-	-	6 (3,39)
Unsolicited	11 (13,25)	1 (1,75)	2 (5,71)	1 (50,00)	15 (8,47)
Intubation					
Yes	2 (2,41)	6 (10,53)	21 (60,00)	1 (50,00)	30 (16,95)
No	80 (96,39)	51 (89,47)	14 (40,00)	1 (50,00)	146 (82,49)
No data	1 (1,20)	-	-	-	1 (0,56)
Azithromycin					
Yes	17 (20,48)	23 (40,35)	11 (31,43)	-	51 (28,81)
No	10 (12,05)	6 (10,53)	3 (8,57)	-	19 (10,73)
No data	56 (67,47)	28 (49,12)	21 (60,00)	2 (100,00)	107 (60,45)
Chloroquine					
Sim	43 (51,81)	39 (68,42)	26 (74,29)	1 (50,00)	109 (61,58)
No	14 (16,87)	8 (14,04)	5 (14,29)	-	27 (15,25)
No data	26 (31,33)	10 (17,54)	4 (11,43)	1 (50,00)	41 (23,16)
Deaths					
Yes	1 (1,20)	3 (5,26)	7 (20,00)	1 (50,00)	12 (6,78)
No	80 (96,39)	54 (94,74)	28 (80,00)	1 (50,00)	163 (92,09)

Source: Research Data.

Graph 1. Characterization of patients according to sex, according to individual variables and pulmonary extension. (*) no data available



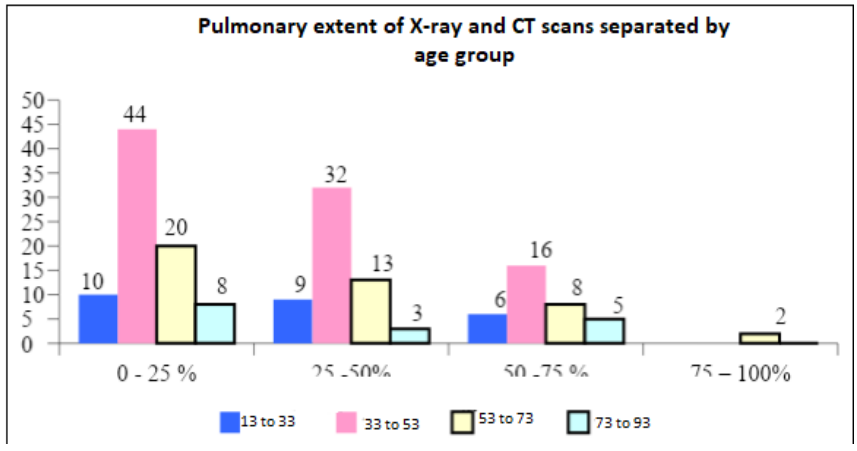
Source: Research Data.

The findings in relation to Age Range showed that most patients were between 33 and 53 years old, shown in Graph 2.

It is possible to state that the probability of falling ill from this pandemic was lower in Santa Catarina than in Brazil as a whole, in the analyzed period, indicating that the disease containment control was more marked in the territory of Santa Catarina. The risk of incidence is lower for children and adolescents but increases rapidly for adults. For adults over age 40, the risk is greater than 0.9 when they have full exposure to the virus. [21]

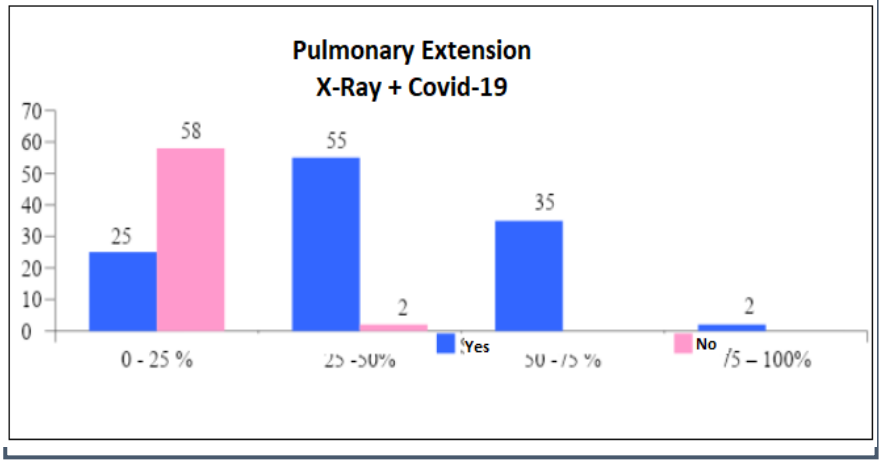
Nunes et al. [26] demonstrated the magnitude of the occurrence of multiple morbidities related to the risk of developing cli-

Graph 2. Characterization of patients according to age group, according to individual variables and pulmonary extension. (*) no data available



Source: Research Data.

Graph 3. Characterization of patients according to X-ray + COVID-19, according to individual variables and lung extension. (*) no data available



Source: Research Data.

nically severe forms of COVID-19 among the Brazilian population in the aging process. It is estimated that at least 34 million individuals aged ≥ 50 years attended with some type of assessed morbidities, highlighting the considerable number of individuals at risk of severe COVID-19, thus representing a greater number of the population of South American countries, except Colombia and Argentina.

Based on the data in Graph 3, it is evident that a large number of patients underwent X-rays to verify whether the lung extension was related to COVID-19.

Para avaliar as noções monetárias dos pacientes em relação ao custo dos exames, foi questionado as variáveis sociodemográficos sobre quais métodos diagnósticos foram solicitados, assinalando o RX e a TC.

To assess the monetary notions of patients in relation to the cost of exams, sociodemographic variables were asked about which diagnostic methods were requested, indicating X-ray and CT.

According to Bomfim [27], chest radiography is the imaging test of choice in the initial approach to CAP, due to its excellent cost-effectiveness ratio, low radiation doses and wide availability. Chest X-rays, in addition to being essential for the diagnosis, help in assessing severity, identifying multilobar involvement and may suggest alternative etiologies. It can also indicate associated conditions, such as pleural effusion, in addition to monitoring the response to treatment. CT should be requested if the professional has any doubts about the infiltrate on plain radiology, in order to detect complications and differentiate from neoplasia.

Brazil does not have an explicit threshold of the incremental cost-effectiveness ratio for the incorporation of technologies, and therefore, it was decided to use the availability of using the WHO proposal for countries that do not have it. This body suggests two classifications of limits for the incorporation of a technology. In the first, outlay for technology below a country's per capita GDP proves to be highly cost-effective. In the second, the disbursement of less than three times the value of GDP per capita is shown as an effective cost. [28]

The findings observed through Computed Tomography were grouped into six distinct categories. Ground Glass was the most frequent finding (56%), followed by Septal Thickening (19%) and Consolidations (18%). Variations of findings that could not be classified into the categories shown in the chart below. They were grouped in the category others (1%) that presented a low frequency of occurrence (Graph 4).

Implementations of the chosen methods were carried out to compare and evaluate the diagnosis of the two techniques in relation to the segmentation carried out by the specialists. The properties of the segmentations to be compared are area and perimeter and, in addition to these two characteristics,

information on abnormalities suggestive of diseases in real time and with a percentage of sensitivity in the diagnosis of CAP was used (Figures 8, 9 and 10).

In the agreement analysis (positive or negative), all those who underwent the test were diagnosed with PCR(+), with a predominance of 25-50% lung extension (Graph 5).

It was found in the research carried out by Xie et al. 29 with 167 patients, 5 of them did not have a diagnosis of COVID-19 on RT-PCR, although the patients had viral pneumonia confirmed by chest CT. However, after repeat testing, patients received a positive diagnosis of COVID-19 and were isolated for treatment. Hao et al.[30] reported in their research the case of a patient with suspected COVID-19 who, after undergoing two RT-PCR tests, the result was negative and even with the presence of a slight ground-glass opacity in the apical segment of the right upper lobe observed on chest CT, the patient was discharged. However, due to recurrent symptoms of fever, dry cough and fatigue, the patient returned to the hospital on the same day of discharge and repeated the test, with a positive result for the disease.

Graph 6 demonstrates the clinical outcome of the patients, where it was evidenced that the majority were discharged from the hospital, however, even so, there were 12 deaths.

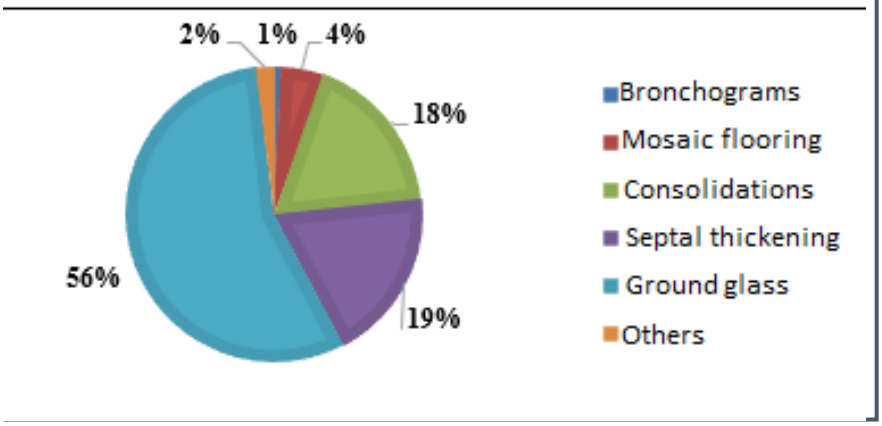
In Brazil, until April 16, 2020, equivalent to the ninth week of the pandemic, 1,924 deaths from COVID-19 were recorded. Of these, 72% occurred in people aged 60 years or older. [31] In China, more than 80% of deaths among adult patients occurred in individuals older than 65.6 years. It was found that elderly patients and those with comorbidities had the highest risk of severe illness and death. [32]

According to what was observed in Figures 8, 9 and 10 with the two technologies, it is observed that the Computed Tomography exam offers similar sensitivity to that of a lower cost exam, in this case, the X-ray. Both allow image formation, except that CT is a more sophisticated method and requires greater cost-effectiveness (Table 2).

The minimization cost analysis (ACM) is justified, represented by the difference in costs between the alternatives Computed Tomography and X-ray, therefore, R$ 7,605.00 – R 24,000.00 = - R$ 16,395.00. Therefore, when opting for X-ray to screen CAP in this sample of 177 reports, the cost was lower by 17,000.00.

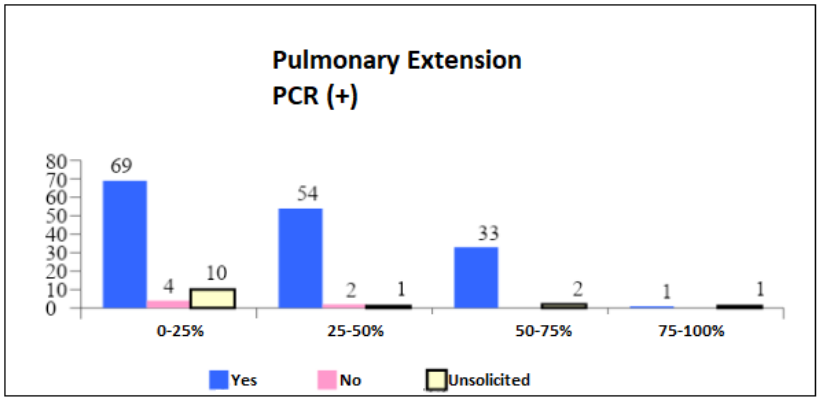
On the one hand, there is the subjectivity of the preference that the patient or society offers in the face of two mutually exclusive alternatives. On the other hand, there is the assertiveness and reproducibility of science, assessing that the cost of a new technology needs to be regulated. In the cost-effectiveness assessment, costs are checked against clinical outcomes in order to understand the impact of different options, identifying them with better treatment outcomes, in general, in exchange for a lower cost. The cost-effectiveness ratio, one of the steps to generate whether a program or treatment should be practiced

Graph 4. Findings observed through Computed Tomography, according to six different categories.



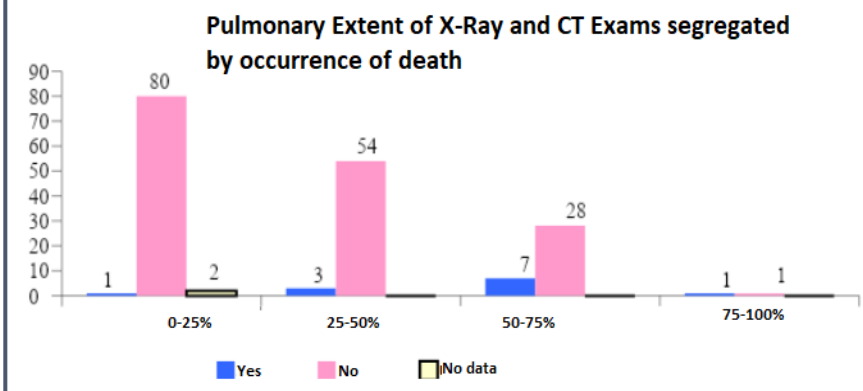
Source: Research data.

Graph 5. Characterization of patients according to CRP(+), according to individual variables and lung size. (*) no data available



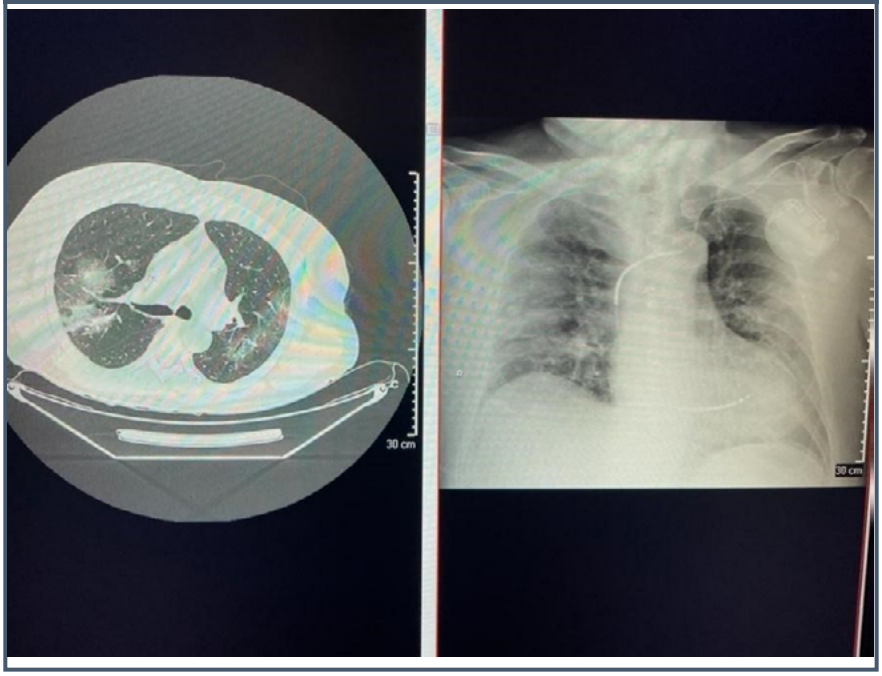
Source: Research data.

Graph 6. Characterization of patients according to CRP(+), according to individual variables and lung size. (*) no data available



Source: Research data.

Figure 8. A - Axial Computed Tomography image showing foci of consolidation, interlobular and intralobular septal thickening associated with ground-glass opacities, typical findings of COVID-19 viral pneumonia, with extension between 25% and 50% of the pulmonary parenchyma; B - AP Chest X-ray of the same patient, noting bilateral and peripheral alveolar pulmonary opacities, predominantly in the lower third of both hemithoraxes, in correspondence with CT scan.



Source: Research data.

or not, is defined as the difference between the cost of two interventions divided by the difference between their effects in terms of health (effectiveness). [33]

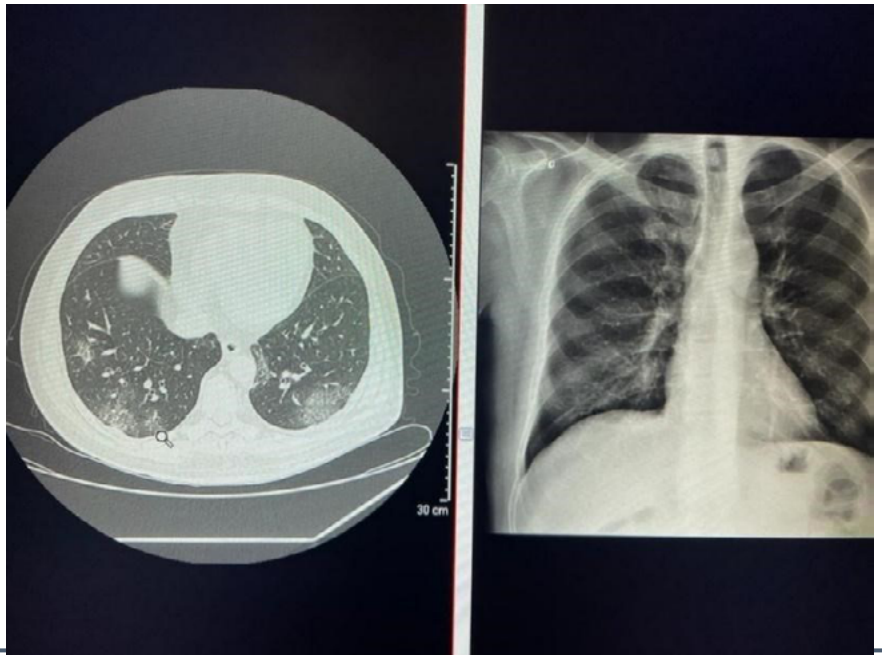
Cost estimates are defined based on billing values corresponding to the expectation adopted by the Health Institution. It is important for the cost-effectiveness analysis from the perspective of the health system, allowing the incorporation of the range of institutional and regional variations in the country. On the other hand, as much as micro-costing allows for more details of expenses and the individual measurement of items consumed by the patient and the promoting institution. [34]

Cost-of-illness study based on primary data collected from a sample of 59 patients with bacterial pneumonia, considering direct medical and non-medical costs and using three costing methods: microcosting based on review of medical records, microcosting based on therapeutic guidelines and gross costing based on the reimbursement rates of the Unified Health System. Cost estimates in the different methods were compared using the Friedman test, where cost estimates for cases of hospitalization due to severe pneumonia totaled R$ 780.70 (review of medical records), BRL 641.90 (therapeutic guidelines) and BRL 594.80 (SUS reimbursement fees). Brazilian SUS costs estimated using different costing methods differ significantly, with gross costing generating lower cost estimates. [35]

When comparing options with a view to choosing the most cost-effective one, an important concept that must be taken into account is the opportunity cost. The act of option means sacrificing to an alternative. In economics, the concept of cost refers to the value of benefits not obtained by making a decision instead of another. [36]

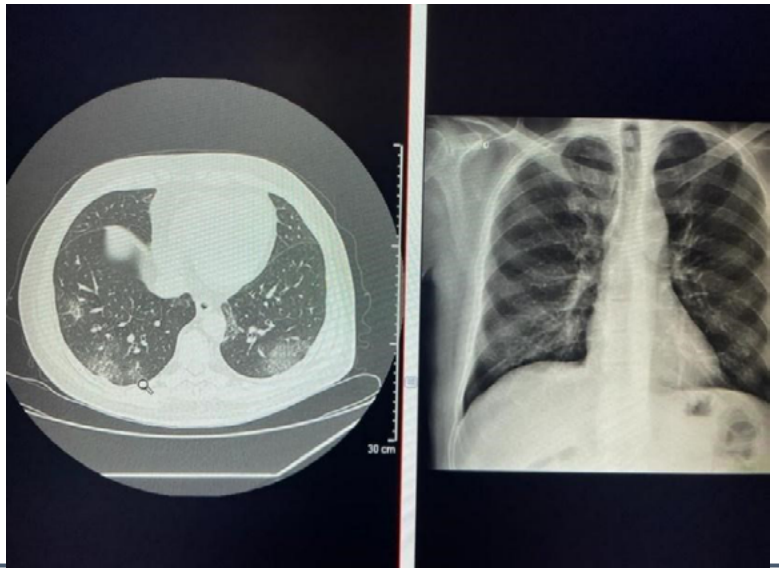
In this way, reducing the opportunity cost of other interventions, which could be replaced by innovation, due to budget constraints. In view of this, the estimate of the occasional cost has not yet been an estimated criterion in favorable recommendations, which is essential for health economics. [37]

Figure 9. A - Axial Computed Tomography image showing ground-glass opacities, typical findings of COVID-19 viral pneumonia, with an extension of less than 25% of the lung parenchyma; B - PA Chest X-ray of the same patient, noting bilateral and peripheral alveolar pulmonary opacities, predominantly in the lower lobes, in correspondence of CT scan.



Source: Research data.

Figure 10. A - Axial Computed Tomography image showing foci of consolidation, interlobular and intralobular septal thickening associated with ground-glass opacities, typical findings of COVID-19 viral pneumonia, with extension greater than 50% of the lung parenchyma; B - AP Chest X-ray of the same patient, noting bilateral and diffuse pulmonary alveolar opacities, corresponding to computed tomography.



Source: Research data.

Table 2. Distribution of total costs considering 177 exams and effectiveness of performance, visualization/interpretation of CT scans, comparing to the X-ray exam.

Alternative	Cost per exam	Amount	35 (n° / %)	Total cost
CT scan	400,00	60	20 (57,14)	24.000,00
X-Ray	65,00	117	15 (42,86)	7.605,00

Source: Research data.

CONCLUSION

This study found two areas of important questioning, health and cost/effectiveness, with the aim of analyzing the cost/effectiveness of imaging exams as a parameter of efficiency in health services, with financial comparisons and diagnoses between Radiography and Computed Tomography.

The intention of the research was to initially evaluate only patients affected by Community Acquired Pneumonia. Meanwhile, due to what the world is in because of COVID-19.

One of the biggest challenges in approaching pneumonia today is the assimilation of the etiological agent, since, during collection, contamination of the sample with material from the upper respiratory tract may occur, which may be colonized by pathogenic microorganisms, however not causing infections.

In several published studies, there is no identification of the etiology of pneumonia cases, despite the various diagnostic resources such as serology, antigen research and detection of genetic material by the polymerase chain reaction method, in this case, PCR. In most cases, it is not possible to distinguish COVID-19 from CAP based on signs and symptoms alone..

In a survey carried out by Levi et al. (2020), it was observed that patients with bacterial pneumonia are more likely to develop symptoms quickly, with purulent sputum and pleuritic pain. Secondary pneumonia usually happens after the initial phase of the viral respiratory infection, or it can also happen during the recovery phase, whose etiological agent can be identified through bacterial cultures of bronchoalveolar lavage and/or bronchial brushing in patients with COVID-19.

For an effective diagnosis, the doctor suggests exams and diagnostic tests, such as laboratory and imaging tests. Generally, chest X-ray is indicated to evaluate the patient in outpatient treatment. However, due to the pandemic, Computerized Tomography has been combined with the diagnostic efficiency of pneumonia.

The result of the analysis shows that the implementation of the chosen methods, both in the comparison and evaluation of the diagnoses of the two techniques (X-ray and CT) leads to a conclusive result. And it was thus perceived that the properties of the segmentations that were compared, information on abnormalities suggestive of diseases in real time and with a percentage of sensitivity in the diagnosis of CAP were used, that is, in the face of so many questions covered in the research, it is clear that when comparing the two imaging examination techniques, the X-ray system is as effective as the Computed Tomography. What happens is that without a doubt, great technological advances have taken place, when it comes to Quality Cost-Effectiveness Analysis (CEA - Análise de Custo-Efetividade).

As it requires more data and obtains better results, it is possible that CEA obtains questionable results, hence the need to be careful with the methodology, which is extremely important for carrying out various sensitivity analyses. However, it is recommended that ACE have a significant impact on efficiency and budget changes over time, recognizing patient equity characteristics in terms of opportunity cost.

Furthermore, it is feasible to carry out new studies comparing costing methodologies to corroborate our findings, since these results can support other research on economic evaluation of intervention for prevention and control of CAP. However, after analyzing the data presented here, the place and importance of chest radiography in the diagnosis of CAP became clear.

REFERENCES

1. Brasil. Ministério da Saúde (MS). Diretrizes metodológicas: estudos de avaliação econômica de tecnologias em saúde Brasília: MS; 2009. Disponível em: http://bvsms.saude.gov.br/bvs/publicacoes/avaliacao_economica_tecnologias_saude_2009.pdf. Acesso em 29 de dezembro de 2021.

2. Vassalo, Claúdia. "Por que os preços cobrados pelos hospitais brasileiros são tão altos." Revista Exame 19 (1997): 84-96.

3. Eldenburg, Leslie. "The use of information in total cost management." Accounting Review (1994): 96-121.

4. Baker, Laurence C. "Managed care and technology adoption in health care: evidence from magnetic resonance imaging." Journal of health economics 20.3 (2001): 395-421.

5. Bonacim, Carlos Alberto Grespan, and Adriana Maria Procópio de Araujo. "Gestão de custos aplicada a hospitais universitários públicos:

a experiência do Hospital das Clínicas da Faculdade de Medicina de Ribeirão Preto da USP." Revista de Administração Pública 44 (2010): 903-931.

6. Camelo, Silvia Helena Henriques, et al. "Auditoria de enfermagem e a qualidade da assistência à saúde: uma revisão da literatura." Revista eletrônica de Enfermagem 11.4 (2009): 1018-25.

7. Lopes, Lauren Auer, Ana Maria Dyniewicz, and Luísa Canestraro Kalinowski. "Gerenciamento de materiais e custos hospitalares em UTI neonatal." Cogitare Enfermagem 15.2 (2010).

8. Aranha, Guiomar Terezinha Carvalho, and Reinaldo Wilson Vieira. Estudo de um dos indicadores do custo da qualidade: o desperdício. Diss. Faculdade de Engenharia Mecânica, Universidade Estadual de Campinas., 2004.

9. Amorim, Maria Cristina Sanches, and Eduardo Bueno da Fonseca Perillo. "Para entender a saúde no Brasil 2." Para entender a saúde no Brasil 2. 2008. 214-214.

10. CISAMUSEP. Tabela SUS, procedimentos e exames SUS, set.2019 sítio. Disponível em:<https://www.cisamusep.org.br/uploads/credenciamento/86_Tabela_SUS_referencia-SETEMBRO_2019.pdf > Acesso em: 15 mar 2020.

11. Brasil, Atenção Hospitalar, Domiciliar e de Urgência. Coordenação-Geral de Urgência. Força Nacional do Sistema Único de Saúde. Protocolo de manejo clínico para o novo coronavírus (2019-nCoV) [Internet]. Brasília (DF); 2020, visitado em 5 Ago 2020. Disponível em: http://189.28.128.100/dab/docs/portaldab/documentos/20200330_ ProtocoloManejo_ver06_Final.pdf

12. Chate, Rodrigo Caruso, et al. "Apresentação tomográfica da infecção pulmonar na COVID-19: experiência brasileira inicial." Jornal Brasileiro de Pneumologia 46 (2020).

13. upurdija, Vojislav, et al. "Pneumonia adquirida na comunidade: economia de cuidados médicos, em relação à gravidade clínica." Jornal Brasileiro de Pneumologia 41 (2015): 48-57.

14. Polverino, E. "Community-acquired pneumonia." Minerva anestesiologica 77.2 (2011): 196-211.

15. Dalmora, Camila Hubner, et al. "Definindo pneumonia associada à ventilação mecânica: um conceito em (des) construção." Revista brasileira de terapia intensiva 25 (2013): 81-86.

16. Sousa, Paulo, and Walter Mendes. Segurança do paciente: criando organizações de saúde seguras. Editora Fiocruz, 2019.

17. http://arquivos.camacari.ba.gov.br/compras/Tabela%20SUS%20 Nacional.pdf

18. Savedoff, William D. "Kenneth Arrow and the birth of health economics." Bulletin of the World Health Organization 82 (2004): 139-140.

19. Prado, Clementina Corah Lucas. "A adoção do limite custo-efetividade na incorporação de tecnologias no SUS–o que se pode esperar." Revista Eletrônica Gestão e Saúde 4 (2015): 3127-3149.

20. IBGE. Instituto Brasileiro de Geografia e Estatística. Estatísticas de gênero – Indicadores sociais das mulheres no Basil. Disponível em: https://www.ibge.gov.br/estatisticas/multidominio/genero/20163-estatisticas-de-genero-indicadores-sociais-das-mulheres-no-brasil.html. Acesso em: 17 de janeiro de 2022.

21. Li, Lin, et al. "Using artificial intelligence to detect COVID-19 and community-acquired pneumonia based on pulmonary CT: evaluation of the diagnostic accuracy." Radiology 296.2 (2020): E65-E71.

22. Zhou, Fei, et al. "Clinical course and risk factors for mortality of adult inpatients with COVID-19 in Wuhan, China: a retrospective cohort study." The lancet 395.10229 (2020): 1054-1062.

23. de Moura, Pedro Henrique, et al. "Perfil epidemiológico da COVID-19 em Santa Catarina." Revista Interdisciplinar de Estudos em Saúde 9.1 (2020).

24. Scully, Eileen P., et al. "Considering how biological sex impacts immune responses and COVID-19 outcomes." Nature Reviews Immunology 20.7 (2020): 442-447.

25. Jin, Jian-Min, et al. "Gender differences in patients with COVID-19: focus on severity and mortality." Frontiers in public health (2020): 152.

26. Nunes, Bruno Pereira, et al. "Multimorbidade e população em risco para COVID-19 grave no Estudo Longitudinal da Saúde dos Idosos Brasileiros." Cadernos de Saúde Pública 36 (2020): e00129620.

27. Bomfim. Ana Beatriz. Pneumonia adquirida na comunidade (PAC). Sanar Comunidade. 2020. Disponível em: https://www.sanarmed.com/pneumonia-adquirida-na-comunidade-pac-colunistas. Acesso em: 29 de dezembro de 2021.

28. Marseille, Elliot, et al. "Thresholds for the cost–effectiveness of interventions: alternative approaches." Bulletin of the World Health Organization 93 (2014): 118-124.

29. Xie, X., et al. "Chest CT for typical coronavirus disease 2019 (COVID-19) pneumonia: relationship to negative RT-PCR testing. Radiology 296: E41–E45." (2020).

30. Hao, Qinjian, Hongmei Wu, and Qiang Wang. "Difficulties in false negative diagnosis of coronavirus disease 2019: a case report." (2020).

31. Brasil, Atenção Hospitalar, Domiciliar e de Urgência. Coordenação-Geral de Urgência. Força Nacional do Sistema Único de Saúde. Protocolo de manejo clínico para o novo coronavírus (2019-nCoV) [Internet]. Brasília (DF); 2020, visitado em 5 Ago 2020. Disponível em: http://189.28.128.100/dab/docs/portaldab/documentos/20200330_ ProtocoloManejo_ver06_Final.pdf

32. Shahid, Zainab, et al. "COVID-19 and older adults: what we know." Journal of the American Geriatrics Society 68.5 (2020): 926-929.

33. Brasil, Ministério da Saúde (MS). Avaliação econômica em saúde: desafios para a gestão no Sistema Único de Saúde Brasília: MS; 2008. Disponível em: http://portal.saude.gov.br/portal/arquivos/pdf/livro_aval_econom_saude.pdf» Acesso em 29 de dezembro de 2021.

34. BMdSS, Ciência. Diretrizes metodológicas: Diretriz de Avaliação Ecônomica. In: Departamento TelE, Tecnologia DcE, editors. 2a ed.: Brasília: Ministérios da Saúde, 2014.

35 Nunes, Altacílio Aparecido, et al. "Análise de Custo-Efetividade do uso do Sistema de Comunicação e Arquivamento de Imagens (PACS) em mamografias digitais." Value in Health Regional Issues 11 (2016): 49-56.

36. Prado, Clementina Corah Lucas. "A adoção do limite custo-efetividade na incorporação de tecnologias no SUS–o que se pode esperar." Revista Eletrônica Gestão e Saúde 4 (2015): 3127-3149.

37. Brasil. Ministério da Saúde. Secretária de Ciência, Tecnologia e Insumos Estratégicos. Entendendo a incorporação de tecnologias em saúde no SUS: como se envolver. Brasília: Ministério da Saúde, 2015.