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Quality and technical efficiency in hospital care: a study using the Donabedian Model and Data Envelopment Analysis

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Abstract

Objective: To analyze the influence of quality dimensions at the structural, process, and outcome levels on the technical efficiency of general hospitals in São Paulo.
Method: For the quality analysis, we considered the triad of quality proposed by Donabedian (1966), which consists of structure, process, and outcome. The technical efficiency of the hospital units was obtained using Data Envelopment Analysis (DEA), and public and private general hospitals were investigated in the period from 2019. Thus, after listing the efficiency scores, robustness tests were performed and robust linear regression was applied to test the research hypotheses.
Results: The trade-off between quality and efficiency depends on the dimension of quality. Structure has a statistically significant but inversely proportional influence on efficiency. When analyzing quality at the process level, it was found that hospital commissions and accreditation can positively or negatively influence technical efficiency results. In the analysis of quality at the outcome level, inefficiency and high mortality rates are related, i.e., efficient hospitals tend to have a lower mortality rate.
Contributions: A model for analyzing quality from multiple dimensions was presented, which allows hospital managers to have a systemic view of the factors that contribute to quality of care. When analyzed with technical efficiency, this perception can contribute to decision-making at the structural, process, and outcome levels, reducing costs without sacrificing quality.

Keywords: Quality. Efficiency. Hospital. Donabedian. Quality triad.

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Introduction

In hospital care, it is expected that quality services will be offered to the same extent as efficiency gains and cost reductions occur (Mezomo, 2001; Missunaga et al. 2024). In this sense, recent studies indicate that the relationship between quality and cost is not linear: hospitals face financial constraints that limit investments and, at the same time, regulatory pressures that link their sustainability to higher standards of care (Onder et al., 2022). As a result, analyzing the relationship between efficiency and quality becomes indispensable for public policy makers, but the literature shows that this link remains controversial.

Some studies indicate that it is possible to improve efficiency without sacrificing quality (Chang et al., 2011; Ferreira et al., 2013; Obure et al., 2016), suggesting simultaneous gains. Chang et al. (2011) investigated 31 hospitals in Taiwan from 1998 to 2004 and found that the implementation of a quality-focused program resulted in simultaneous improvements in productive efficiency and quality of care, demonstrating that it is possible to improve hospital performance without compromising health outcomes. Some convergent results were observed by Ferreira et al. (2013) and Obure et al. (2016), who identified that efficiency can be increased concomitantly with the preservation of quality, reinforcing the absence of a trade-off.

Other studies, however, highlight the existence of a trade-off, in which improving quality through greater availability of human and material resources implies increased costs and reduced efficiency (Garavaglia et al. 2011; Yang & Zeng, 2014; Lin, Chen & Peng, 2017; Dulal, 2018; Salas-Ortiz et al., 2019). In this context, Lin et al. (2017) directly identified a trade-off between quality of care and hospital efficiency. Similarly, Yang and Zeng (2014) found a negative relationship in both public and private hospitals, highlighting that this trade-off is more common in small and medium-sized institutions. Corroborating this evidence, Salas-Ortiz et al. (2019), when considering variables such as geographic location, scale, structure, and forms of financing, also concluded that quality has a negative correlation with efficiency.

Studies by Garavaglia et al. (2011) and Dulal (2018) evaluated quality at the structural level through nursing staff hours, finding that increasing the workforce, although intended to improve care, can negatively impact efficiency. There are also studies that point to varied results, showing that the association depends on the indicators used or the context analyzed, as in the case of Lindlbauer et al. (2016), who observed different effects depending on the type of certification considered.

In the Brazilian scenario, Missunaga et al. (2024) indicate that there are no statistically significant differences in efficiency between public, private, and philanthropic hospitals, nor is there a direct relationship between quality and efficiency when viewed from the perspective of accreditation. However, when analyzing the nature of ownership, quality, and efficiency simultaneously, they observed that most accredited hospitals are public and have the highest efficiency scores. In contrast, private and philanthropic hospitals, in addition to representing a minority among those accredited, recorded the lowest efficiency scores, evidencing a negative relationship between these variables.

The results show that the relationship between quality and efficiency is not linear but depends on the context and the management of resources and processes, which justifies the use of Donabedian's (1966) model as a theoretical basis. This model classifies quality into three dimensions: structure (material, human, and organizational resources), process (care and professional practices), and outcome (effects and patient satisfaction). Thus, the application of the Donabedian model provides a systemic view of the services offered and highlights factors that influence poor quality (Donabedian, 2003).

Therefore, the combination of the three aspects of the model offers a complete analysis of quality, allowing the identification of causes of failures and the proposal of corrective actions to improve health services. For Donabedian (2003), efficiency is also an attribute of quality, achieved by reducing costs without compromising health status or by increasing results with the same resources. Thus, evaluating hospital performance is essential for providers to maintain efficiency without compromising quality, establishing ideal care parameters and ensuring safe care (Donabedian et al., 1982).

The literature review conducted by Yang et al. (2025) shows that Donabedian's model remains a robust tool for assessing the quality of healthcare, including outpatient settings. The authors demonstrate that structural, procedural, and outcome indicators offer a comprehensive view of quality, with direct implications for management. It is a widely established model (Yang et al., 2025), which allows not only the assessment of healthcare quality but also an understanding of how each dimension may relate to hospital technical efficiency.

In this regard, Tran et al. (2019) add that measuring quality based on the dimensions proposed by Donabedian allows for more accurate identification of the determinants of quality. It is worth remembering, in the meantime, that in the hospital context, performance is not limited to efficiency, but also involves the social role, in which quality is expressed in multiple dimensions. Thus, an efficient hospital is one that maximizes its resources

to improve the health status of patients and eliminates waste to achieve sustainability (Ferreira et al., 2020). Similarly, Moayed et al. (2022) found that structural, procedural, and outcome factors determine the perception of quality in the care of patients with COVID-19 when applying Donabedian's model in a health crisis context. These findings are consistent with the present investigation, as they show that quality is not an isolated attribute but results from the interaction between resources, organizational processes, and clinical effects.

Despite advances in research, there remains a gap in the systematic incorporation of Donabedian's three dimensions of quality and the analysis of this relationship with hospital technical efficiency, especially in the Brazilian context. In view of this, the present study aims to answer the following question: What is the influence of the dimensions of quality at the structural, process, and outcome levels on hospital technical efficiency? This question aligns with the need to offer scientific and practical support to managers and public policy makers, reinforcing the importance of integrating quality and efficiency in hospital performance analyses. Given these considerations, this study aims to analyze the influence of the dimensions of quality at the structural, process, and outcome levels on the technical efficiency of general hospitals in São Paulo.

In addition to its theoretical contribution, this study offers practical implications. By proposing a multidimensional analysis of quality, it provides managers with a systemic view of the factors that affect hospital performance. At the structural level, it shows that simply expanding human, material, or financial resources may not translate into efficiency gains without strategic planning. At the process level, it shows that protocols, committees, and accreditation can positively or negatively influence efficiency, depending on their effective implementation. At the outcome level, it contributes by suggesting effectiveness metrics, such as the inverse mortality rate, which can be complemented by other indicators of clinical performance and patient satisfaction.

The results of this research indicate that the fact that few hospitals achieve optimal levels of efficiency demonstrates that merely expanding resources does not guarantee superior performance. It is therefore essential to adopt integrated management capable of promoting the rational use of inputs, ensuring the effectiveness of institutional processes, and achieving better clinical outcomes. In this sense, this study showed that quality and efficiency go hand in hand and that understanding this relationship is fundamental to guiding hospital management strategies.

2 Theoretical Framework

2.1 Dimensions of health quality: Donabedian model

Avedis Donabedian, a physician who graduated from the American University of Beirut and holds a master's degree in public health from Harvard University, is widely recognized for his conceptual contributions to improving health care quality. His model has become an international reference for strategy formulation and quality monitoring (Aguilar & Ander-Egg, 1994; Ibn El Haj et al., 2013). In 1966, he proposed the triad of structure, process, and outcome as the basis for quality analysis. Although these elements are not direct attributes, they allow us to infer the presence or absence of quality (Donabedian, 1966).

The structural dimension of quality is related to environmental conditions and the qualifications of the professionals involved in care. From a human perspective, it involves experience, certifications, and training; from an organizational perspective, it includes infrastructure, facilities, and equipment (Ibn El Haj et al., 2013). Thus, assessing structural conditions allows for verification of the availability of material, human, and institutional resources (Donabedian, 2003). For the author, the structure influences the behavior of the actors in the care process and, consequently, interferes with the quality of care. A well-organized structure increases the likelihood of positive results, especially when accompanied by mechanisms for supervision, performance monitoring, and integration with teaching and research activities (Donabedian, 1966).

The process dimension focuses on care practices. It evaluates the care provided based on technical and scientific standards and procedures, encompassing diagnosis, treatment, rehabilitation, prevention, and educational actions directed at patients and family members (Donabedian, 2003; D'Innocenzo et al., 2006). In this dimension, both the performance of professionals and the relationship established between them and patients are considered, including technical, interpersonal, and ethical aspects (Reis et al., 1990; Silva & Formigli, 1994; Pertence & Melleiro, 2010; Voyce et al., 2015). Clinical protocols, hospital committee guidelines, and accreditation play a crucial role, as they standardize practices, reduce errors, and improve the coordination of care. Empirical evidence confirms this relationship: Ferreira et al. (2021), when evaluating the Family Health Strategy, demonstrated that links with users, effective home visits, institutional support, and continuous monitoring directly influence outcomes. Thus, procedural quality improves the patient experience and is a determining factor in hospital performance.

The outcome dimension reflects people's health status and satisfaction after receiving care. It encompasses clinical, physiological, and social indicators, as well as psychological and quality of life aspects (Donabedian,

2003). In this sense, results can be evaluated by parameters such as longevity, mortality rates, and treatment adherence, but also by the appropriation of the knowledge transmitted and the satisfaction of patients and family members (Reis et al., 1990; Silva & Formigli, 1994; D'Innocenzo, et al., 2006; Pertence & Melleiro, 2010). This dimension synthesizes the effects of structure and process, functioning as a key indicator of hospital performance. Onder et al. (2022) deepen this analysis by highlighting a distinction between clinical quality, linked to technical practices and evidence-based protocols, and experiential quality, associated with patient perception. Both directly influence outcomes: while the clinical dimension reduces failures and complications, the experiential dimension strengthens adherence to treatment and trust in care.

Recent research confirms the relevance and applicability of Donabedian's model for quality. Mansoor et al. (2025), when analyzing care for women with gestational diabetes in Pakistan, identified structural failures, procedural gaps, and negative impacts on outcomes, highlighting that integration between structure, process, and outcome is essential to ensure quality. Similarly, Moayed et al. (2022) showed that during the COVID-19 pandemic, organizational readiness, continuous training, effective leadership, and inter professional communication were decisive for the quality of care. Goenka et al. (2024), in a study conducted in India, demonstrated that structural interventions and procedural improvements generated significant advances in care outcomes, such as shorter length of stay, greater agility in analgesia, and a reduction in patients without care, thus confirming the triad as a guide for continuous improvement strategies and hospital efficiency.

Health quality assessment, therefore, was consolidated in Donabedian (1966) as a conceptual framework. Subsequent studies confirmed its relevance, showing that the integration of the three dimensions makes it possible to identify failures, propose corrective actions, and understand the relationship between quality and efficiency (Donabedian, 2003; Mezomo, 2001; Yang et al., 2025). Current literature also recognizes quality as a strategic tool for regulating and planning health systems, associated with financing criteria and standards of care (Kessler & Heidecke, 2017). Thus, quality should be understood as a multidimensional, technical, regulatory, and strategic construct directly linked to hospital performance, efficiency, and service sustainability (Onder et al., 2022).

In addition, Donabedian (2003) defined seven pillars that guide quality assessment: efficacy, effectiveness, efficiency, optimization, acceptability, legitimacy, and equity. For this author, efficacy corresponds to the ability to achieve the best possible health condition; effectiveness refers to the degree to which health goals are achieved; and efficiency refers to achieving the best results at the lowest cost. Optimization, in turn, considers the cost-benefit ratio, ensuring that gains exceed expenses. Acceptability involves compliance with the expectations of patients and family members; legitimacy refers to the adequacy of social preferences; and equity refers to the fair distribution of care and its effects on health improvement (Donabedian, 2003).

Finally, Portela (2000) observes that the health assessment process generates fundamental information to support decisions about service provision and the management of available resources. By relating structure, process, and outcome, this author emphasizes that quality control, when well conducted, strengthens management practices and promotes a continuous cycle of improvement.

2.2 Theoretical hypotheses of the research

Monitoring efficiency in hospitals has proven relevant due to the high costs of hospital care, coupled with limited resources, thus generating trade-offs. Faced with this scenario of scarce resources, hospitals need to monitor the results of health policies while structuring actions and identifying their priorities (Wolff, 2005). In this regard, the discussion around efficiency is fundamental, since the optimal use and combination of resources are essential for achieving hospital performance (Silva et al., 2016).

In the organizational environment, efficiency is a broad concept and can have different meanings depending on the area of application. Technical efficiency, addressed in this study, relates to maximizing productivity given the inputs and technologies employed, that is, it concerns the ability to use resources as efficiently as possible (Farrell, 1957; Mariano, 2008; Hollingsworth et al., 1999).

In hospital management, there is a constant concern due to the scarcity of resources in the face of demands and, on the other hand, there is an expectation to achieve efficiency in the provision of services without sacrificing quality (Ferreira et al., 2013; Obure et al., 2016). When it comes to the relationship between quality and technical efficiency, according to Dulal (2018) and Nayar et al. (2013), multiple dimensions of quality need to be evaluated in the theoretical model, as each of these dimensions can be associated in different ways with technical efficiency.

Based on a systematic review, studies were identified that used Donabedian's (1966) model for quality and

analyzed the relationship with efficiency. Table 1 lists the studies that explicitly used Donabedian's model for quality.

Table 1

Treatment of the quality variable according to the Donabedian model

Dimensions for quality	Author/Year
Structure	Garavaglia et al. (2011); Gok and Sezen (2013); Navarro-Espigares and Torres (2014); Obure et al. (2016); Dulal (2018)
Process	Navarro-Espigares and Torres (2014); Obure et al. (2016)
Result	Chang et al. (2011); Garavaglia et al. (2011); Gok and Sezen (2013); Navarro-Espigares and Torres (2014); Dulal (2018)

Note: Prepared by the authors based on related studies.

In order to analyze the influence of quality dimensions on technical efficiency, three research hypotheses were formulated, based on the triad proposed by Donabedian (1966). Studies investigating the relationship between these dimensions and efficiency were also considered in formulating the hypothesis, as well as research addressing the variables used in this study that comprise this Donabedian dynamic (structure-process-outcome).

For Donabedian (1966), structure can influence the care process and, consequently, the quality of care. It has stable characteristics and includes data on material and human resources, as well as those related to organizational structure (Donabedian, 1966). In this regard, Pertence and Melleiro (2010) note that assessing the hospital's operational capacity is essential to identify the potential of the structure and, thus, evaluate, in addition to the physical aspect, whether there are adequate human resources for the provision of health services.

Costa et al. (2020), when investigating the attributes related to patient satisfaction with safety and quality of care, found that the workforce has a direct relationship with care when performed in a timely manner. In turn, Bittencourt and Hotale (2009) stated that delays in diagnosis and treatment of patients can lead to increased mortality rates. It is clear that managers expect that an increase in the number of professionals will improve the quality of care (Garavaglia et al., 2011; Dulal, 2018).

Material resources can support good results in patient care and are part of the structure. The Taiwanese government, for example, in an attempt to strengthen the quality of care, implemented a national system of quality indicators to evaluate hospitals, which were classified by Chiu et al. (2007) according to Donabedian's dimensions of quality. In this scenario, both human and material resources were listed, such as the number of beds with ventilators.

In Brazil, Barcelos et al. (2022) identified and categorized the establishments managed by Social Health Organizations in Brazil and observed that there is a significant difference in the amount of life support equipment per bed between hospitals. In this study, information on all life support equipment available in the database was considered.

Structure is a concern in the hospital context because it is associated with the efficient use of available resources and quality through timely care and treatment. The relationship between structural quality and technical efficiency has been little explored in the literature based on Donabedian's model (Garavaglia et al., 2011; Gok & Sezen, 2013; Obure et al., 2016; Dulal, 2018). Dulal (2018), when investigating nursing homes, identified that greater availability of nursing staff, measured by working hours, was associated with inefficiency, suggesting that simply expanding the number of professionals does not guarantee performance gains, and that it is more effective to invest in improvements in the care process. Similarly, Obure et al. (2016), when analyzing health facilities in Kenya and Swaziland, observed that deficiencies in infrastructure, equipment, and management practices resulted in poor performance in both quality and efficiency, highlighting the need for strategic policies that go beyond specific technical adjustments.

In Turkey, Gok and Sezen (2013) examined hospitals of different sizes and found that, in small institutions, efficiency was associated with lower structural quality; however, in large hospitals, it was possible to increase efficiency without compromising quality. In turn, Garavaglia et al. (2011), when analyzing Italian nursing homes, found that excessive overtime by nursing staff reduced efficiency, reinforcing the need for management strategies aimed at containing labor costs.

Studies indicate that expanding structural resources without strategic planning tends to compromise efficiency. In this sense, Jorge et al. (2013) point out that increasing technology in terms of equipment can expand treatment possibilities and influence the cost of hospital care, and when these resources are not managed, efficiency is reduced. Moayed et al. (2022), in turn, showed that perceived quality depends not only on the quantity of resources, but also on organizational readiness and continuous training. This evidence reinforces the importance of balanced management that seeks to align structural quality with the sustainability of services, avoiding waste and maximizing health outcomes.

In this study, structure was defined as (i) the workforce characterized by "hospital hours" and (ii) material resources demonstrated by the variable "number of life support devices per bed." Based on the theoretical

discussion, the following research hypotheses are formulated:

H1a: The workforce (quality at the structural level) negatively influences hospital technical efficiency;

H1b: Physical resources (quality at the structural level) negatively influence hospital technical efficiency.

The process is related to patient care and the technical-scientific standards practiced, in addition to the commitment of professionals and ethical behavior (Donabedian, 2003; Reis et al., 1990; Silva & Formigli, 1994; D'innocenzo et al., 2006; Pertence & Melleiro, 2010). In this regard, Navarro-Espigares and Torres (2014) analyzed Andalusian hospitals between 1997 and 2004 and found that there was no trade-off between technical-scientific quality and technical efficiency. Complementarily, Obure et al. (2016) considered variables such as confidentiality, privacy, protocols, guidelines, and communication with patients, finding that most establishments simultaneously presented low technical efficiency and reduced quality, highlighting the importance of strengthening care and management practices to improve performance.

In this study, hospital committees on deaths and biopsies, medical ethics, and infection control, in addition to accreditation, were selected as process-level quality variables. The implementation of committees and certification can lead the hospital into a process of continuous improvement. The scores of Martins et al. (2012) corroborate this statement by mentioning that public hospitals in the state of São Paulo have implemented hospital committees with the purpose of offering quality and safe services to patients, thus contributing to the improvement of health processes and services offered. The medical ethics committee performs investigative, educational, and supervisory functions regarding the ethical performance of medicine. According to the legislation, the medical ethics committee must have autonomy to carry out its administrative and directive activities in the institution in which it operates (CFM Resolution No. 2,152/2016).

According to Azevedo (1991), the death review committee can analyze occurrences and complications that influence the outcome of the appropriate care process. The physician responsible for the death commission, when evaluating the conduct of the professional who provided care to the patient, is limited to issuing a report on the facts analyzed, since cases of medical malpractice must be handled by the medical ethics committee (Resolution No. 2,171/2017). Regarding the importance of hospital infection control committees, Alvim et al. (2021) point out that Healthcare-Associated Infections (HAIs) have a significant influence on mortality and hospital costs. Therefore, healthcare professionals who are members of the Hospital Infection Control Committee must ensure the guarantee and compliance of the actions developed by the infection control program with a view to patient safety.

Hospital accreditation has been widely reported in the literature as a factor of quality (Missunaga et al., 2024). For Alonso et al. (2014), accreditation is a management tool that, based on standards, systematically identifies areas for improvement with the integration of hospital sectors and staff. As it is a multifaceted evaluation process, Sommersguter-Reichmann (2021) and Camillo et al. (2016) suggest that accreditation can be evaluated from a structural and process perspective. In a first analysis, accreditation was treated in this study as a process variable due to the protocols, guidelines, and standards established for patient care.

When applying Data Envelopment Analysis in veterans' hospitals in Taiwan, Lin et al. (2019) identified that the "New Hospital Accreditation," introduced in 2007 and revised in 2011, generated immediate efficiency gains, although these effects proved to be temporary, especially in Surgery and Specialty departments. Accreditation can influence both care quality and hospital efficiency.

Missunaga et al. (2024), when analyzing the relationship between efficiency, quality, and ownership in the state of São Paulo, used accreditation as a factor to measure quality. The authors did not find a significant relationship; however, Missunaga et al. (2024) point out that as quality increases, there is an increase in the median efficiency scores for accredited hospitals.

For Moayed et al. (2022), procedural elements such as effective leadership, inter professional communication, and safe care are determinants of quality. This suggests that well-implemented institutional processes, such as committees and accreditation, can generate efficiency gains. However, ambiguous effects can be observed when such practices are only formal, which justifies the need to test them empirically in the Brazilian context. Based on these findings and the need to broaden the discussion in light of the few approaches in the literature, the following research hypotheses were developed:

H2a: The medical ethics committee (process-level quality) positively influences hospital technical efficiency;

H2b: The death and biopsy analysis committee (process-level quality) positively influences hospital technical efficiency;

H2c: The hospital infection control committee (process-

level quality) positively influences hospital technical efficiency;

H2d: Accreditation (process-level quality) positively influences hospital technical efficiency.

Outcome-level quality reflects the patient's final health status after the care process (Donabedian, 2003; Reis et al., 1990; Pertence & Melleiro, 2010). The association between outcome-level quality and efficiency has been explored in different contexts (Chang et al., 2011; Navarro-Espigares & Torres, 2014). As an illustration, Chang et al. (2011) demonstrated that Taiwan's Quality Indicator Project reduced the mortality rate, showing that it is possible to improve efficiency without compromising quality. Navarro-Espigares and Torres (2014) confirmed, based on patient perceptions, that there is no trade-off between quality and efficiency, reinforcing that continuous improvement practices in health outcomes contribute to hospital performance.

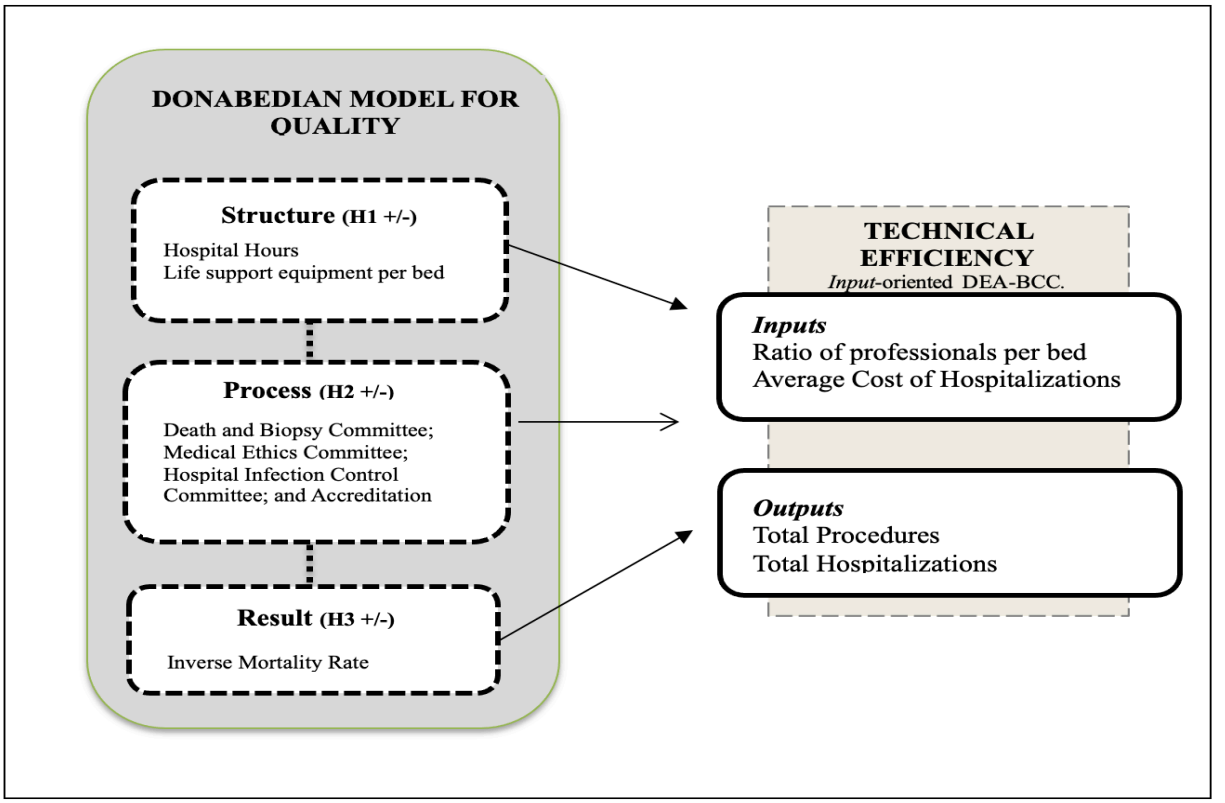
The mortality rate has been widely used as an indicator of the quality of care outcomes and as a variable to assess its relationship with technical efficiency (Santos, 2021; Gonçalves et al., 2007; Chang et al., 2011). In addition, recent studies reinforce that clinical outcomes are determinants of hospital efficiency, such as those by Onder et al. (2022), which show that both clinical quality and health outcomes are significantly associated with financial viability and efficiency, indicating that the reduction of adverse events, such as mortality, contributes to better efficiency rates. Thus, based on the theoretical approach proposed by Donabedian (1966; 2003), the following research hypothesis was developed:

H3: The inverse mortality rate (quality at the outcome level) positively influences hospital technical efficiency.

Finally, a secondary analysis was proposed in which the variable "hospital hours" was excluded and the relationship between accreditation and efficiency as a workforce was tested. The literature mentions that hospitals that undergo external evaluation and receive certification show improvements in the quality of structure and process dimensions due to previously defined standards (Vargas et al., 2007; Camillo et al., 2016; Sommersguter-Reichmann, 2021; Missunaga et al., 2024).

Figure 1 shows the theoretical model constructed from the research hypotheses.

Figure 1 - Theoretical Model



Source: Prepared by the authors (2025).

Thus, the hypotheses formulated seek to test the influence of the dimensions of structural quality, process quality, and outcome quality on hospital technical efficiency, allowing us to verify whether these relationships are complementary or reveal possible trade-offs. The proposed analysis allows us to advance our understanding of the interaction between quality and efficiency, a topic still marked by controversial results in the literature.

4 Methodological Approach

Due to the Covid-19 pandemic, 2019 was defined as the reference period for the research. According to data from the National Register of Health Establishments (Cadastro Nacional de Estabelecimentos de Saúde - CNES), the state of São Paulo had 739 registered general hospitals in that year, including public, private, and philanthropic institutions. Therefore, specialized and teaching hospitals were not considered in the construction of the sample. Subsequently, hospitals that did not provide information on the variables necessary for the research in the reduced Hospital Admission Authorization (HAI) files were excluded. After this process, 374 hospitals remained in the final sample for the study.

The treatment and analysis of the research data were performed based on the selection of input and output variables, the definition of the modeling, and the orientation for the model. The technical efficiency scores of the hospitals were obtained using DEA. Subsequently, robustness tests were performed, and robust linear regression was applied to analyze the influence of quality dimensions on the technical efficiency of general hospitals in São Paulo.

The technical efficiency addressed in this study refers to the organization's ability to maximize production levels given the available inputs and technologies (Farrell, 1957; Mariano, 2008). Thus, a hospital will be considered technically efficient when it operates at its maximum production frontier (Hollingsworth et al., 1999), achieving an efficiency score of 1.0.

Initially, the number of variables selected for the DEA model was evaluated. When operationalized with many variables, a model can contribute to many DMUs achieving efficiency (Souza et al., 2016). In the same vein, Fitzsimmons and Fitzsimmons (2005) point out that the total number of DMUs should be at least twice the total number of inputs and outputs. The literature also recommends that a correlation analysis be performed after the selection of variables (Senra et al., 2007; Lins et al., 2007).

Based on related studies, it was possible to identify that the most commonly used input variables are: the number of doctors and nurses and the number of beds. The outputs considered repeatedly in the literature were: the inverse mortality rate, the total number of hospitalizations, surgeries, and discharges, in addition to the total number of outpatient procedures.

Following the methodological recommendations, two inputs were selected: the total number of professionals per bed and the average cost of hospitalizations. For the variable total number of professionals per bed, the average number of hospital professionals per bed was calculated. This category included all professionals, i.e., those who provide direct patient care, support services, and administrative sectors. For outputs, the total number of procedures and the total number of hospitalizations were considered. The total number of procedures refers to the sum of health promotion and prevention actions, diagnostic procedures, clinical procedures, and surgical procedures.

The technical efficiency measures of DEA modeling can be input- or output-oriented. This study was input-oriented, since hospitals have a greater influence on inputs, allowing for the management and control of costs with a view to maintaining quality (Lobo et al., 2009). As for modeling, the DEA-BCC linear programming model was selected, since the use of variable returns to scale allows DMUs to be compared with units on a similar scale. In addition, it is recommended for organizations when it is not possible to ensure that all units operate at an optimal scale, since hospitals tend to operate at an inefficient scale (Lindlbauer et al., 2016).

Data collection for the selection of variables for the Donabedian (1966) model was carried out on the official websites of the Department of Informatics of the Unified Health System (DataSus) and the National Register of Health Establishments (CNES). To infer quality at the structural level, hospital hours (workforce) and the number of life support devices per bed (material resources) were listed. Regarding process-level quality, the variables of medical ethics committee, death and biopsy analysis committee, hospital infection control committee, and accreditation were selected and measured based on the existence or absence of these committees and certification. Finally, regarding the outcome, the inverse mortality rate was used to test the relationship between outcome-level quality and hospital technical efficiency.

A preliminary analysis of the availability of the variables considered for the study was performed. However, it was found that the hospital accreditation variable presented a higher level of variation in its distribution among the states. Among the states with the highest relative number of accredited hospitals, São Paulo stood out significantly,

concentrating the largest share of institutions with this characteristic, which justified its choice for this study. Once the variables for Donabedian's (1966) quality triad and for the analysis of the technical efficiency of hospitals had been defined, the non-parametric Data Envelopment Analysis (DEA) model was applied to obtain the technical efficiency scores. In a second step, the variables were subjected to robust regression statistical tests to investigate the relationship between quality and technical efficiency.

For data processing, MaxDEA 8 software was used to establish technical efficiency scores, and STATA 13 software was used to perform robustness tests and regression analysis.

4 Results

Table 2 shows the main results for efficient and inefficient hospitals in relation to the mean, standard deviation, minimum, and maximum based on hospital hours (Hrhosp), number of life support devices per bed (Supvidaleito), and inverse mortality rate (Txinvmort).

Table 2 - Descriptive statistics of efficient and inefficient hospitals

Efficient Hospitals

Variable	Obs.	Mean	Std. Dev.	Min	Max
Hrhosp	16	380236.8	644021.7	5211	2372349
Supvidaleito		1.49	1.359553	0.11	3.48
Txinvmort		96.59	1.812853	93.31	99.1

Inefficient Hospitals

Mean	Std. Dev.	Min	Max	Mín.	Máx.
Effic	358	0.59	.1861075	0.07	0.99
Hrhosp		120585.4	157231.7	300	1180454
Supvidaleito		1.30	1.071675	0.14	9.72
Txinvmort		94.47	4.219638	35.37	99.76

Source: Prepared by the authors (2025).

The observed variables of quality at the structural level indicated that the workforce (Hrhosp) and material resources (Supvidaleito) consumed by efficient hospitals were higher than the average for inefficient hospitals. When analyzing the outcome component (Txinvmort), it can be observed that the average non-mortality rate (96.59) also exceeds that of inefficient hospitals (94.47). The findings suggest that hospital technical efficiency may be associated with inverse mortality rate outcomes. Based on the DEA results, Table 3 shows the percentage of efficient hospitals among accredited and non-accredited hospitals.

Table 3 - Accreditation between efficient and inefficient

Accreditation	Obs.	No. of efficient hospitals	% of efficient hospitals in the group
Accredited	32	3	9.38%
Not accredited	342	13	3.80%
Grand Total	374	16	4.28%

	Efficient Hospitals Total: 16		Inefficient Hospitals Total: 358	
Commissions	Number of hospitals with commissions	Percentage of hospitals with committees	Number of hospitals with committees	Percentage of hospitals with committees
Biopsy and Death analysis	11	69%	219	61%
Infection Control	11	69%	337	94%
Medical Ethics	16	100%	288	80%

Source: Prepared by the authors (2025).

It can be noted that 9.38% of accredited hospitals were considered efficient by the model, while 3.80% of non-accredited hospitals achieved a score of 1. This result is similar to the findings of Missunaga et al. (2024), who found that there are more efficient accredited hospitals than non-accredited ones when analyzing the proportional aspect. Regarding the other process variables, it was possible to identify the percentage of hospital units with committees in place in the group of efficient and inefficient hospitals.

The results indicated that 69% of efficient hospitals have biopsy and death analysis committees, while inefficient hospitals have a lower percentage (61%). The same occurred in relation to the medical ethics committee, i.e., all hospitals with a score of 1 have this committee, unlike inefficient hospitals (80%). In relation to the infection control committee, the opposite occurred, i.e., the percentage of committees in inefficient hospitals (94%) is higher than in efficient hospitals (69%).

The results of the robust linear regression that explain some of the findings of the descriptive statistical analysis and confirm or reject the research hypotheses are presented in Table 4.

Table 4 - Robust Regression Matrix

				Number of obs =	364
				F (7, 356) =	18
				Prob > F =	0.000
Efficiency	Coef.	Std. Err.	T	P>t	[95% Interval] Conf.
Supvidaleito	-0.06	.0132222	-4.39	0.000	-.0839935 -.0319867
Hrhosp	-2.95e-07	1.02e-07	-2.89	0.004	-4.96e-07 -9.45e-08
Sobbi	.0469345	.0208621	2.25	0.025	.005906 .087963
Seticamed	-.1078731	.025308	-4.26	0.000	-.157645 -.0581011
Scinf	-.0594912	.03953	-1.50	0.133	-.137233 .0182505
Sacred	.1142759	.0386832	2.95	0.003	.0381996 .1903522
Txinvmort	.0089867	.002244	4.00	0.000	.0045736 .0133997
_cons	0.0389559	0.2183639	-0.18	0.859	-0.4684 0.39049

Note: Hrhosp (hospital hours); Supvidaleito (number of life support devices per bed); Sacred (Accreditation); Seticamed (medical ethics committee); Sobbi (biopsy and death analysis committee); Scinf (infection control committee); Txinvmort (inverse mortality rate).
Source: Prepared by the authors (2025).

Hypothesis H1a predicts that the workforce (quality at the structural level) negatively influences hospital technical efficiency. According to the results of the regression, the hypothesis was supported, as the data showed that the workforce negatively influences technical efficiency at a 5% significance level.

Hypothesis H1b establishes that physical resources (quality at the structural level) negatively influence hospital technical efficiency. The hypothesis was supported, showing that physical resources have a significant influence on technical efficiency at a 5% significance level. The descriptive statistics results highlighted that efficient hospitals consume more resources in terms of hospital hours and have a higher number of life support equipment per bed when compared to inefficient hospitals.

Process-level quality was tested based on four variables, three related to hospital committees and a fourth variable related to hospital accreditation. Hypothesis H2a tested whether the biopsy and death analysis committee positively influences hospital technical efficiency. According to the regression results, the hypothesis was supported at a 5% significance level.

Hypothesis H2b was also supported, showing that there is a statistically significant relationship between the medical ethics committee and hospital technical efficiency; however, a negative relationship was found. Hypothesis 2c, which predicted a positive influence of the hospital infection control committee on hospital technical efficiency, was rejected ($p = 0.133$). When testing the influence of accreditation (H2d) on technical efficiency, the results showed that there is a statistically significant relationship, indicating that the practices imposed by the certification model can lead to an improvement in the level of efficiency.

Furthermore, hypothesis 3, which predicted a positive relationship between the inverse mortality rate (quality at the outcome level) and hospital technical efficiency, was also supported. Therefore, the results indicate that the higher the non-mortality rate, the greater the technical efficiency. Table 5 below presents a secondary analysis with the purpose of testing hospital accreditation as a workforce.

Table 5 - Robust Regression Matrix – Secondary Analysis

					Number of obs =	372
					F (6, 365) =	17.44
					Prob > F =	0.000
Efficiency	**Coef.**	**Std. Err.**	**t**	**P>t**	**[95% Interval]**	**Conf.**
Sacred	.116681	.0375455	3.11	0.002	.0428484	.1905137
Supvidaleito	-.0683905	.0122508	-5.58	0.000	-.0924815	-.0442995
Sobbi	.0404755	.0211235	1.92	0.056	-.0010634	.0820145
Seticamed	-.1206592	.0254194	-4.75	0.000	-.1706461	-.0706724
Scinf	-.067606	.0406127	-1.66	0.097	-.1474702	.0122582
Txinvmort	.0095818	.0023043	4.16	0.000	.0050504	.0141132
_cons	-.0848367	.2244754	-0.38	0.706	-.5262641	.3565908
_cons	0.0389559	0.2183639	-0.18	0.859	-0.4684	0.39049

Note: Hrhosp (hospital hours); Supvidaleito (number of life support devices per bed); Sacred (Accreditation); Seticamed (medical ethics committee); Sobbi (biopsy and death analysis committee); Scinf (infection control committee); Txinvmort (inverse mortality rate).
Source: Prepared by the authors (2025).

With the replacement of the variable "hospital hours" by "accreditation" in the workforce, it was observed that accreditation positively influences efficiency; however, the hypothesis that the biopsy and death analysis committee has a significant relationship with technical efficiency was rejected. Although it is not the parameter established by this study, it should be noted that the hypothesis was supported at a significance level of 10%.

5 Discussion of results

Regarding the technical efficiency results, it was observed that few hospitals achieved an efficiency score of 1. The results corroborate the findings of Missunaga et al. (2024), who, when analyzing the efficiency of hospitals in São Paulo, identified few efficient units. The literature shows that the waste of resources and activities below a desirable level of efficiency indicates that health service offerings are below their relative potential capacity (Jorge et al., 2013). The findings of this study suggest that inefficient hospitals should manage their resources .

Regarding the analysis of the relationship between quality and technical efficiency, three research hypotheses were tested. Hypotheses H1a and H1b were considered statistically significant, however, they presented an inverse relationship with technical efficiency. Garavaglia et al. (2011) mention that high personnel costs can reduce efficiency, and the results of this study corroborate the findings of Dulal (2018), identifying that there may be a trade-off between structural quality and efficiency. According to the author, among the factors that cause this trade-off is the expectation that the expansion of human, material, or financial resources can generate improvements in service and, consequently, in quality.

Complementarily, Obure et al. (2016) and Gok and Sezen (2013) emphasize that the availability of structure alone does not guarantee superior performance, and that alignment between investments, planning, and integrated management is indispensable. These theoretical contributions reinforce that gains in structural quality only translate into efficiency when resources are managed in a rational and strategically oriented manner, supporting the interpretation of the results obtained in this research.

One of the assumptions of quality is the proper use of resources; therefore, actions in the health sector need to be developed based on a cost-benefit and cost-effectiveness perspective (Donabedian et al., 1982). Optimization, one of the attributes of quality proposed by Donabedian (2003), explains this relationship between the balance of costs and benefits generated in terms of health improvement. For Donabedian (2003), as more resources are applied, improvements in health tend to decrease, that is, there is an optimal level in the cost-benefit ratio at which

no additional health improvements can be achieved by making more resources available. The author states that quality is related to the care and diagnostic capabilities of the medical staff and healthcare team when performed assertively and optimally, but not necessarily linked to the availability of additional resources.

Process-level quality was tested based on the existence or absence of biopsy and death review committees, hospital infection control and medical ethics committees, and hospital accreditation. The hypothesis that addressed the relationship between the infection control committee and technical efficiency was not statistically significant. The results of the descriptive analysis indicated that only 23 hospitals in the sample did not have such a committee. In the meantime, it is important to note that the mandatory nature of this committee in hospitals in the country was established by regulation; however, the database showed that not all units had a committee in place in 2019. This is a fact that raises concern and requires further investigation.

Even in those hospitals that comply with the requirement, the literature points out some of the challenges faced by these units, such as the shortage of professionals to compose these committees, the overload of duties of some of its members, and the need to develop strategies to evaluate the effectiveness of Hospital Infection Control Programs and their influence on the quality of health services (Cavalcante et al., 2019; Giroti et al., 2018).

Hypothesis H2a, which addressed the relationship between the biopsy and death analysis committee and hospital technical efficiency, was supported at a significance level of 5%. The results of this research suggest that the actions of this committee can influence future actions for patient care and promote a process of continuous improvement, since this committee analyzes occurrences and complications arising from hospital care.

Hypothesis H2b was also supported, demonstrating that there is a statistically significant relationship between the medical ethics committee and hospital technical efficiency; however, it is an inverse relationship. Medical ethics committees have autonomy in the institutions where they operate, and their responsibilities involve the supervision of medical activity, the establishment of preliminary internal procedures, and health awareness and guidance actions. Many of these deliberations regarding care and forms of medical treatment may be associated with the management of hospital resources (Bampi & Grande, 2020).

The results showed that the death and biopsy committee positively influences efficiency, confirming Azevedo (1991) and Martins et al. (2012), who highlight its investigative and preventive role. The medical ethics committee, on the other hand, showed a negative relationship, in line with Bampi and Grande (2020) and Moayed et al. (2022), suggesting that, although essential, its deliberations can generate additional costs when not fully integrated into management.

The findings of this research indicated that part of the deliberations influence technical efficiency, since recommendations can occur in the context of patient treatment and professional activity. When evaluating this perspective, it is possible that there may be a reduction in hospital efficiency due to the use of resources. In this regard, Jorge et al. (2013) state that advances in medical knowledge have expanded treatment possibilities, in addition to the process of innovation in equipment and processes that can lead to more expensive medical care. Thus, the result suggests that, although fundamental to the quality of care, ethics committees can generate additional pressures that reduce efficiency in the short term when they are not fully aligned with institutional strategy. Regarding the other process variables, the lack of effect of the infection control committee reflects the challenges pointed out by Cavalcante et al. (2019) and Giroti et al. (2018), linked to the shortage of professionals and limitations in effectiveness.

On the other hand, accreditation had a positive impact, contrasting with Missunaga et al. (2024) but converging with Lin et al. (2019), reinforcing that its effects depend on the context and the effective implementation of practices. Lindlbauer et al. (2016) identified a variation in results when comparing hospital efficiency with different certifications. The findings indicated that efficiency is negatively related to ISO 9001 certification and positively related to that country's own certification. This contrast shows that the effects of accreditation are conditioned by the context and the degree of implementation of practices, reinforcing that certification, when effectively incorporated into institutional routine, can contribute to hospital technical efficiency.

Based on the sample in this study, few hospitals have accreditation certification, and according to data from ONA (2022), this reflects the situation in Brazil. Nayar et al. (2013) found the opposite in the United States, identifying that 84.64% of the hospitals analyzed were accredited. However, when evaluating efficiency and quality, they found that there was no significant relationship between accreditation and technical efficiency scores. The authors suggest that accreditation alone is not a determining factor of quality, such that it can influence efficiency. Lin et al. (2019), in turn, reported that the impact of accreditation was positively significant in relation to efficiency in the first year of certification; however, a decline in this influence was observed

in subsequent years. This research did not allow for expansion to time series analysis due to data restrictions.

Even with this limitation regarding accreditation, the findings of this study show that certification influences the results achieved, positively impacting efficiency, possibly due to well-defined guidelines and criteria, in addition to encouraging training for professionals in order to achieve a process of continuous improvement. Regarding education, Hsu (2013) considered that such actions lead to gains in efficiency due to training in the proper use of resources. In addition to the influence on efficiency, it was found that accredited hospitals have a higher average inverse mortality rate when compared to non-accredited hospitals. However, this analysis requires further investigation, as it is important to assess the interrelationships between the dimensions of quality.

Accreditation can be treated as a variable that comprises the process or structure dimension (Sommersguter-Reichmann, 2021). Accreditation consists of a process of restructuring and reorganizing internal and care practices, integrating the hospital and personnel sectors (Alonso et al., 2014).

In view of this, this study proposed a secondary analysis with the purpose of evaluating the behavior of the model by excluding the variable "hospital hours" from the workforce and replacing it with "accreditation." The results of this second analysis indicated that accreditation remained statistically significant in relation to efficiency. The findings suggest that the process of continuing education and training resulting from accreditation can contribute to efficiency gains. Manzo et al. (2011), when analyzing the implications of the accreditation process on health professionals, observed that hospital accreditation impacts the habits and values of professionals, in addition to stimulating behavior that goes beyond mechanized care, fostering an environment of excellence and development.

The physical layout and equipment, for example, relate to the hospital's potential to provide care, but an increase in this capacity may not have a significant influence on the quality of care (Vargas et al., 2007). According to Vargas et al. (2007), in addition to scenarios such as this, the human factor, with its commitment, training, and technical-scientific, can significantly influence the quality of care and efficiency. Furthermore, in the secondary analysis, it was observed that the variables remained unchanged in terms of significance, except in relation to the biopsy analysis committee and deaths, where the relationship was not considered statistically significant.

When testing hypothesis 3, which predicted that the inverse mortality rate (quality at the outcome level) has a significant relationship with hospital technical efficiency, it was possible to verify that, at a significance level of 5%, the hypothesis was supported. The results corroborate the findings of Santos (2021) and Gonçalves et al. (2007), who found that inefficiency and high mortality rates are related. Chang et al. (2011) found that an improvement in quality indicated a reduction in the mortality rate and, when analyzing quality and efficiency, concluded that there is no trade-off in this relationship. The findings also dialogue with the study by Onder et al. (2022), who demonstrated that clinical outcomes, variables that measure results, such as the reduction of complications and readmissions, are significantly associated with increased hospital efficiency. In this sense, mortality, treated in this study as an outcome indicator, reinforces the understanding that gains in quality can go hand in hand with efficiency. The results of this research corroborate the findings of Santos (2021), Gonçalves et al. (2007), and Chang et al. (2011), suggesting that hospitals with efficient resource management practices tend to achieve better results in relation to the effect promoted by healthcare, this result being measured by the inverse mortality rate.

An efficient care process consists of allocating resources among the various patient groups according to the specificities of each treatment (Donabedian, 2003). This distributive efficiency can benefit patients who need longer treatments, since the reduction of resources would not imply a reduction in health improvement. The results of this research reinforce the need for integrated management between the administrators of these resources and the clinical staff, without ignoring the patient.

This result is supported by Moayed et al. (2022), who demonstrated that the quality perceived during the COVID-19 pandemic does not depend only on the existence of practices and protocols, but above all on how they are implemented and conducted, highlighting the centrality of leadership, inter professional communication, and safe care. Thus, the divergence in the effects observed in this study may be associated not only with the presence of formal structures, but also with the effectiveness of their daily management, reinforcing that quality in health requires more than the institutionalization of practices; it demands their real incorporation into hospital dynamics.

Finally, the results corroborate the findings of Donabedian (2003) in noting the need to allocate resources according to the care group and the specificities of each treatment process. These results are explained by the author, who states that quality cannot be dissociated from efficiency, that is, there is no possibility of improving health without considering the capacity for efficient resource allocation. Efficiency is not limited to cost reduction, but is related to increased levels of health improvement or the ability to maintain

these levels even in the face of diminishing resources.

5 Conclusion

Given the social function that hospitals perform in society, this study analyzed the influence of quality dimensions on the technical efficiency of general hospitals in São Paulo. The results of the Data Envelopment Analysis indicated that there is still much to be done in terms of improving hospital management. Waste or inefficiency in the application of resources implies a restriction in the provision of health services. The findings corroborate this statement by showing that only 4.28% of the hospitals in the sample are efficient and that, among the inefficient ones, gaps were found that indicate that resources are not being optimized.

There are implications when it comes to resource management, however, quality is also a factor to be considered. Given the controversial relationship between quality and efficiency, this research was able to analyze the relationship between quality and technical efficiency based on Donabedian's model for quality, that is, at the level of structure, process, and outcome. When quality is observed from various dimensions, it allows hospital managers to have a systemic and objective view, enabling specific strategic actions. Thus, the findings indicate that the trade-off will depend on the dimension of quality in which the analysis is being performed.

For future research, we suggest expanding the results of this study by incorporating variables such as hospital size, ownership, and complexity of care, in addition to considering other locations and different types of establishments. This expansion could bring practical and theoretical contributions by recognizing the complex structure and internal and external factors that influence the performance of hospital units.

Differences in size, type of management (public, private, philanthropic), degree of accreditation, and regional location create unequal contexts for efficiency production. This diversity may explain why some hospitals manage to align quality and efficiency, while others face persistent trade-offs. Thus, incorporating institutional heterogeneity in to subsequent investigations will allow for a better understanding of performance disparities and support the formulation of public policies that are more attuned to local realities.

Furthermore, it is recommended that the analysis of quality at the outcome level go beyond traditional clinical indicators, such as mortality rates, and also include variables related to user experience and satisfaction. Studies such as that by Ferreira et al. (2021) demonstrate that elements such as speed of care, therapeutic bond, and perception of consultation quality are relevant dimensions for assessing health outcomes. Thus, future investigations may integrate clinical and perceptual metrics into efficiency models, providing a more comprehensive understanding of the impact of quality on hospital performance. This approach has the potential to enrich comparative evaluation between institutions, support results-oriented management, and contribute to public policies that reconcile technical quality, efficiency, and the patient's perspective.

As for limitations, the results described here regarding the inverse mortality rate had limitations, as it was not adjusted for disease severity, since the research analysis considered the hospital's overall outcome. Another limitation of the study concerns the unavailability of accreditation information for previous years, making a more robust time series analysis unfeasible.

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