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Impact of Private Management of Public Hospitals on Health Outcomes:

Evidence from Hospital Israelita Albert Einstein during the COVID-19 Pandemic

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Impact of private management of public hospitals on health outcomes: Evidence from Hospital Israelita Albert Einstein during the COVID-19 pandemic*

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Abstract

In this paper, we study the impact of Hospital Israelita Albert Einstein (HIAE) management of public hospitals during the COVID-19 pandemic on mortality, using data from the Brazilian *Sistema Único de Saúde* (SUS). Using a sample of COVID-19 patients hospitalized in Sao Paulo's public hospitals, we find that when the municipality's bed occupancy rate is above 90 percent, being hospitalized in an HIAE-managed public hospital decreases the likelihood of mortality by 10 percentage points. This decrease in mortality may be attributed to better medical care or management of beds, facilitating longer hospitalizations for the most severe cases.

Keywords: COVID-19, Brazil, public hospitals, mortality

JEL codes: I11, I18.

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1 Introduction

The COVID-19 pandemic was an unprecedented global public health crisis that forced policymakers to develop innovative strategies to contain and mitigate the pandemic. In this context, the Hospital Israelita Albert Einstein (HIAE) in Brazil, among other private institutions, contributed to the containment of the pandemic by expanding the healthcare infrastructure in both the private and public sectors, formulating health protocols, establishing a COVID-19 testing infrastructure, and conducting research on related issues.

Specifically, during the COVID-19 pandemic, HIAE managed two public hospitals, namely, Hospital Municipal Vila Santa Catarina – Dr. Gilson de Cássia Marques de Carvalho and Hospital Municipal M'Boi Mirim – Dr. Moysés Deutsch, in addition to overseeing operations at two temporary field hospitals, Morumbi Temporary Hospital and Pacaembu Temporary Hospital.

In this paper, we study the impact of HIAE management of public hospitals during the COVID-19 pandemic. We aim to answer: What is the impact of HIAE-managed public hospitals on patient mortality during the pandemic? In addition, we study differences in resource utilization and medical practices between HIAE-managed public hospitals and other public hospitals that can help explain differences in mortality.

To do so, we exploit the public access to rich administrative data from the Sistema Único de Saúde (SUS), the Brazilian public health system. Specifically, we use data sourced from the Sistema de Vigilância Epidemiológica da Gripe – SIVEP-Gripe (São Paulo), which records all COVID-19-related hospitalizations for residents of the municipality of São Paulo. We restrict our sample to COVID-19 hospitalizations exclusively within the public healthcare sector from March 2020 to December 2021.

We use a linear regression model to estimate the impact of hospitalization in a public hospital managed by HIAE on mortality and several hospital resource-related variables: length of hospital stay, ICU admission, and mechanical ventilation use. Crucially, we control for potential confounding variables, such as demographic characteristics, place of residence, pre-existing risk factors, and presenting symptoms. Our key identifying assumption is that, once we account for these confounders, COVID-19 patients are as good as randomly assigned to a public hospital. This assumption is credible because of the comprehensive data available on symptoms and risk factors at the time of hospitalization.

We find that hospitalization in an HIAE-managed public hospital has no statistically significant effect on the likelihood of mortality among COVID-19 patients overall. However, during periods of high COVID-19 case surges in the municipality of São Paulo, hospitalization in an HIAE-managed public hospital significantly reduces the probability of death by 10 percentage points when the municipality's bed occupancy rate exceeds 90%. This result underscores the effectiveness of HIAE management strategies during periods of peak demand on the health system. Regarding differences in resource utilization or medical practices, we find that patients admitted to an HIAE-managed hospital have longer hospital stays, higher ICU admission rates, and greater use of mechanical ventilation.

Finally, we estimate the expected number of lives saved as a result of hospitalization in an HIAE-managed hospital. For each patient hospitalized in an HIAE-managed hospital, we calculate the change in mortality probability compared to being hospitalized in another public hospital.

We then aggregate these changes in mortality across our sample. Using several functional forms, we estimate that between 46 and 72 lives were saved, with our preferred specification being that 70 lives were saved.

The remainder of the paper is organized as follows. Section 2 describes the Brazilian health system and the COVID-19 pandemic in Brazil, specifically in São Paulo. Section 3 describes the data used in the paper. Then, section 4 presents our econometric model and identification strategy. Section 5 presents our main results. Section 6 computes expected lives saved using different functional forms. Finally, section 7 concludes.

Literature review

Over the last two decades, there has been a global trend of increased private sector involvement in providing public healthcare infrastructure and services, mainly through public-private partnerships (PPPs). This rise in private sector participation has been particularly significant, though not limited to, several European countries (Roehrich et al., 2014).

In the context of hospital PPPs, the primary focus has been on the management of infrastructure and facilities, often following a model similar to the one implemented in the UK (Barlow and Köberle-Gaiser, 2008; Barlow et al., 2013). Nevertheless, there are instances where clinical management is also integrated into these arrangements. Examples of this comprehensive approach can be observed in hospital PPPs, particularly in Portugal (Ferreira and Marques, 2015; Ferreira and Marques, 2021) and in Spain (Caballer-Tarazona and Vivas-Consuelo, 2016).

As the use of PPPs in healthcare has been on the rise, there has been an increase in research evaluating the performance of these institutions. In a recent paper, Basabih et al. (2022) reviewed the evidence regarding the impact of PPPs on hospital performance indicators. Concerning access to healthcare, they found positive results in Iran (Bastani et al., 2019) and among cancer patients in the US (Holden et al., 2015). Additionally, as an indicator of service quality, they found a better performance of PPP hospitals in terms of speed in diagnosis, therapy and referral rates, reduced waiting time for surgery and chemotherapy, and shorter lengths of stay (Bastani et al., 2019 for Iran; Do Thu et al., 2020 for Vietnam; Kaliks et al., 2013 for Brazil; Pedrini et al., 2019 for Italy).

On the other hand, Comendeiro-Maaløe et al. (2019) found mixed evidence on the performance of PPP hospitals. They analyzed the PPP model (known as *Alzira's model*) used in the last two decades in Valencia, Spain. In this case, compared to its all public-tenured peers, PPP hospitals showed a greater improvement in 2003-2015 in eleven indicators but displayed a lower improvement in nine.

In the context of Brazil, La Forgia and Harding (2009) compared the performance of twelve PPP hospitals and a group of twelve other public hospitals that shared similar characteristics (number of beds, types of services, total spending, spending per bed, or number of professionals per bed) and serve similar populations (illness complexity, age distribution, and gender composition). They found that PPP hospitals were more efficient than the directly managed hospitals in bed turnover rate (measured as the annual number of discharges per bed), bed substitution rate (the average number of days a bed remains unoccupied between patients), bed occupancy, and length-of-stay.

2 Background

2.1 Healthcare in Brazil

Healthcare in Brazil is funded through a combination of sources, with the primary contributors being the public *Sistema Único de Saúde* (SUS), private health insurance plans, and direct payments made by individuals and households. According to the OECD, in 2019, Brazil allocated 9.6 percent of its GDP towards healthcare, which translates to USD 1,514 per capita when accounting for differences in purchasing power. However, only 41 percent of healthcare spending was covered by public financing, primarily through SUS. Private health insurance accounted for 30 percent of the funding, while 25 percent came from out-of-pocket payments (OECD, 2021).

In 2019, Brazil had around 474,000 hospital beds available, translating to approximately 2.3 beds for every 1,000 people. This number is roughly half of the average found in OECD countries. Specifically, 38.2 percent of these beds belonged to public hospitals, 38.1 percent to private non-profit hospitals, and 23.6 percent to private for-profit hospitals. The significant presence of the private sector in healthcare infrastructure indicates that public hospitals do not solely provide patient services. Instead, municipalities or states often engage private hospitals to deliver services under the *Sistema Único de Saúde* (SUS). In total, 345,000 registered health facilities (outpatient and inpatient) serve both public and private patients (OECD, 2021).

Public hospitals in Brazil can be owned and operated by the federal government, state governments, and municipal authorities. These hospitals may be managed directly by the public sector or outsourced to non-profit private institutions known as "Social Organizations" (*Organizações Sociais de Saúde*, OSS), a form of public-private partnership. As of 2015, in the state of São Paulo, these OSS entities managed approximately 30 hospitals and 100 ambulatory facilities (Lewis et al., 2015). As highlighted by La Forgia and Harding (2009), the contract between the government and the OSS is distinct because it is performance-based. It covers: (1) specific service quantity goals for various types of care, (2) quality benchmarks, like reducing hospital-acquired infections, and (3) reporting obligations, including production, expenses, payroll, and patient satisfaction survey results.

2.2 The COVID-19 pandemic in Brazil

Brazil's pandemic response operated on two levels: national and regional. At the regional level, sanitary measures were determined with prior approval from the national government. At the national level, policies were enacted to support families, workers, and businesses. A pivotal national initiative was the "Auxílio Emergencial" program, providing monetary assistance to help families in need. Additional family support measures included food distribution and an extension of the "Programa Bolsa Familia" for low-income households. The national government also implemented policies to assist small businesses with payroll obligations and introduce flexible working hours. Meanwhile, at the regional level, local authorities imposed an array of sanitary measures to curb the virus's spread, encompassing mobility restrictions, lockdowns, quarantines, and mandates for face mask usage.

Sanitary measures in the State of São Paulo

In the following paragraphs, we will outline the most important pandemic-related legislation in the State of São Paulo. A public emergency was declared on March 20, 2020, suspending non-essential activities. The initial lockdown, which began on March 22, 2020, and was initially set to last until April 7, was implemented to protect public health. During this period, various non-essential activities were temporarily suspended, including visits to commercial centers, restaurants, bars, nightclubs, physical activity centers, and supermarkets, without imposing a stay-at-home mandate. This initial 15-day measure was repeatedly extended and modified throughout the pandemic in response to the evolving case and death rates.

On May 28, a four-phase structure for quarantine was introduced, with each phase gradually relaxing restrictions on activities, capacity limits, and operating hours. This framework underwent multiple revisions in response to changing circumstances. During the peak of the pandemic in early 2021, authorities declared a state of emergency, representing the most stringent phase, to mitigate the surge in COVID-19 cases and fatalities. Beginning on February 26, 2021, stay-at-home orders were enforced from 23:00 to 05:00, allowing transit solely for essential workers. These quarantine measures remained in effect until August 16, 2021, when the state commenced a phased approach towards gradually reopening various businesses and activities.

Regarding the use of face masks, their mandatory application commenced on April 29 in public transport and was subsequently extended to other "essential" facilities, including healthcare institutions, supermarkets, and restaurants, among others, on May 5. The compulsory use of face masks remained in effect throughout 2020 and 2021.

Regarding schooling measures, on March 30, 2020, São Paulo authorities suspended classes for the duration of the state of emergency. A few months later, on July 13, local authorities implemented a three-stage program, progressively returning students to classes. These stages determined the percentage of students allowed to attend classes (35, 70, and 100 percent), contingent on the prevailing phase of the pandemic in the region.

COVID-19 indicators in the Municipality of São Paulo

Below, we provide a set of indicators related to the impact of the pandemic on the Municipality of São Paulo, a region with approximately 12 million residents, accounting for approximately 27 percent of the total population of the State of São Paulo.

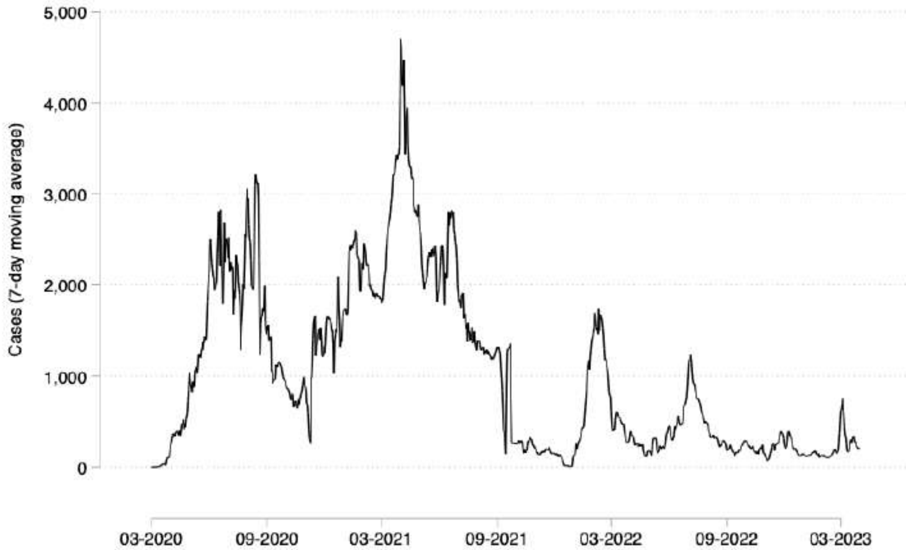

Figure 1: Daily new COVID-19 cases in the Municipality of São Paulo
Source: Secretaria de Estado da Saúde (e-SUS, SIVEP-Gripe, RedCap).

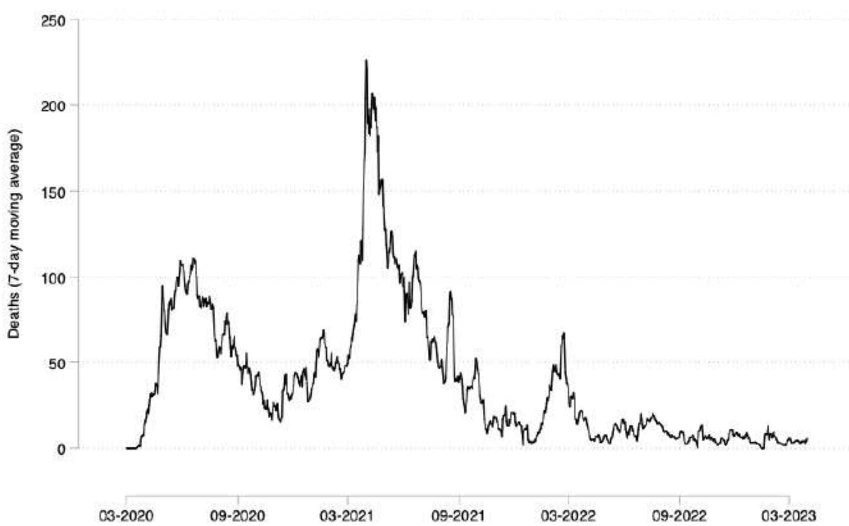

Figure 2: Daily new COVID-19 deaths in the Municipality of São Paulo
Source: Secretaria de Estado da Saúde (SIVEP-Gripe).

Figures 1 and 2 show the evolution of daily COVID-19 cases and deaths in the Municipality of São Paulo since the beginning of the pandemic. These two figures show a similar pattern, characterized by an initial peak around June 2020, followed by the highest peak in April 2021. An interesting event occurs around June 2022, when there is an increase in cases unaccompanied by a corresponding surge in deaths. This phenomenon could be attributed to the effectiveness of the vaccination protocol.

Figures 3 and 4 offer insights into the COVID-19 bed capacity within the Municipality of São Paulo.[1] Specifically, Figure 3 shows the daily stock of beds, encompassing both general wards and intensive care units (ICU), while Figure 4 shows the daily percentage of occupied ICU beds.

Figure 3 shows that the availability of beds designated for COVID-19 closely mirrors the daily count of newly confirmed cases. This suggests a certain level of adaptability within the healthcare system, allowing for the reallocation of beds in response to the pandemic's severity. This flexibility in bed allocation may also explain the high bed occupancy percentages observed during periods characterized by relatively low case numbers, as depicted in Figure 4.

[1] This information is available since May, 19, 2020.

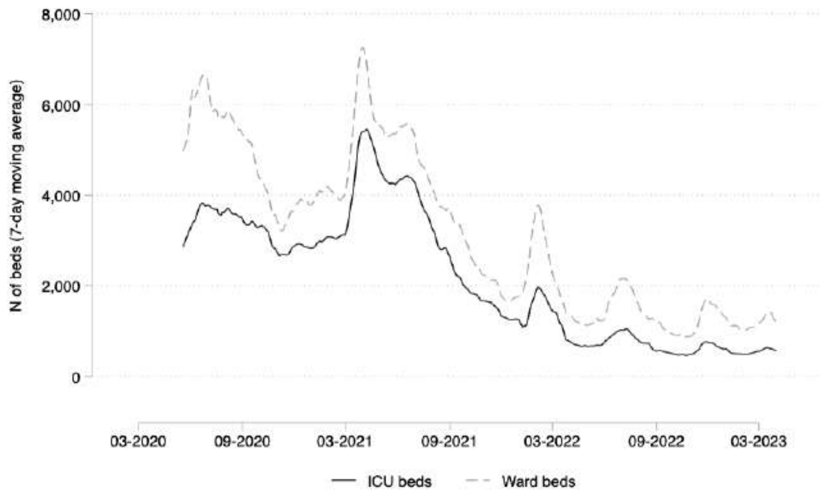

Figure 3: Beds destined for COVID-19 cases in the Municipality of São Paulo (general ward and ICU)
Source: Secretaria de Estado da Saúde (Censo Covid-19)

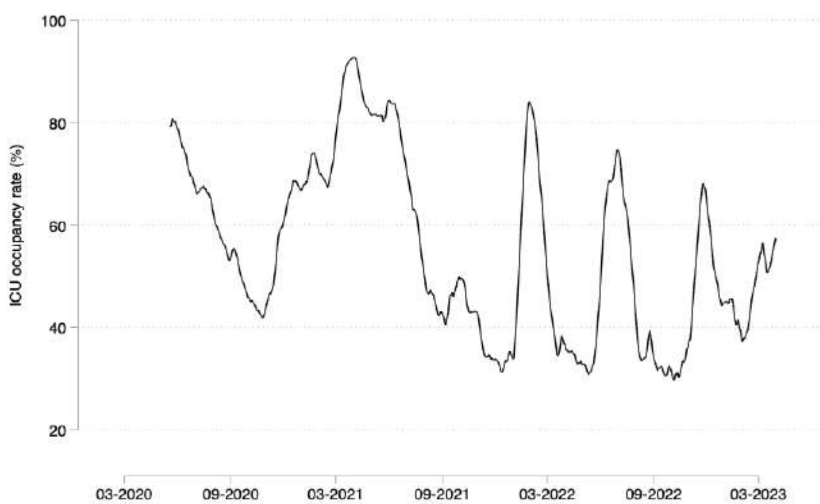

Figure 4: ICU occupancy rate for COVID-19 cases in the Municipality of São Paulo
Source: Secretaria de Estado da Saúde (Censo Covid-19)
Note: ICU occupancy rate is the ratio of COVID ICU hospitalizations (7-day moving average) over COVID ICU beds (7-day moving average).

Hospital Israelita Albert Einstein initiatives during the pandemic

Established in 1955 by the Brazilian Israeli community, the "Sociedade Beneficente Israelita Brasileira Albert Einstein" (HIAE) is a non-profit organization dedicated to providing healthcare services, education, training, innovation, and research. It operates a network of hospitals across the private and public sectors, covering all stages of healthcare production. (Sociedade Beneficente Israelita Brasileira Albert Einstein (2020))

During the pandemic, HIAE implemented several measures to prevent the virus from spreading. In the public sector, HIAE invested in the two public hospitals currently managed by HIAE: Hospital Municipal M'Boi Mirim and Hospital Municipal Vila Santa Catarina. Additionally, HIAE established an emergency care unit (*Unidade de Pronto Atendimento* – UPA), implemented two field hospitals—Morumbi Temporary Hospital and Pacaembu Temporary Hospital—and erected two screening tents at the emergency care units (UPAs).

To augment its capacity in the public sector, HIAE significantly increased the number of available beds from 423 to 1,146, encompassing the two recently established field hospitals (Blackman et al. (2020)). In addition, Einstein increased the number of available beds in the ICU, counting 180 at Hospital Municipal M'Boi Mirim and 59 beds at Hospital Municipal Vila Santa Catarina.

These developments suggest that HIAE played a role in accommodating a substantial portion of all COVID-19 hospitalizations, which can impact the health outcomes of the residents in the Municipality of São Paulo.

3 Data

Our analysis is based on data from the *Sistema de Vigilância Epidemiológica da Gripe* (SIVEP-Gripe) data. SIVEP-Gripe is a collaborative initiative led by the Ministry of Health, in partnership with the State and Municipal Health Departments, to monitor cases of severe acute respiratory syndrome (SARS) throughout Brazil. To monitor hospitalized patients of COVID-19, the Ministry of Health incorporated the testing of the SARS-CoV-2 virus into the SARS surveillance. Case reporting is mandatory, and records are stored in the SIVEP-Gripe computerized database.

We restrict our sample to confirmed COVID-19 cases involving residents of the municipality of São Paulo who were hospitalized in public hospitals between March 2020 and December 2021. This dataset includes information on date of admission, hospital IDs, ICU admission, length of hospital stay, use of mechanical ventilation, discharge status (dead or alive), patient characteristics (age, sex, race, education, place of residence), underlying risk factors (such as asthma, diabetes, cardiovascular, etc.), presenting symptoms (such as respiratory distress, fever, sore throat, etc.), and ancillary details (vaccination status and date of symptom onset). Particularly noteworthy is the inclusion of hospital IDs from the National Registry of Health Establishments (CNES). This allowed us to identify the two public hospitals managed by HIAE, namely the Hospital Municipal M'Boi Mirim and the Hospital Municipal Vila Santa Catarina, along with HIAE's Pacaembu Temporary Hospital.[2]

[2]The Morumbi Temporary Hospital, on the other hand, recorded no instances of COVID-19 hospitalizations, indicative of its primary role in providing outpatient services rather than inpatient care.

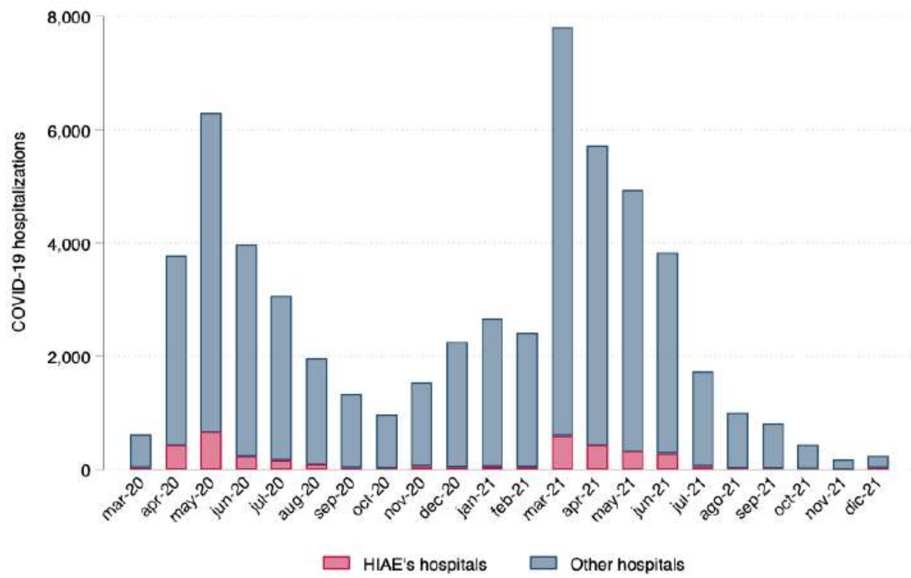

Figure 5: COVID-19 hospitalizations in HIAE's public hospitals and other public hospitals in São Paulo

Figure 5 shows COVID-19 admissions in HIAE public hospitals compared to other public hospitals. COVID-19 admissions in HIAE public hospitals account for approximately 7 percent of all public hospital admissions, with a larger share during the peak periods in May 2020 and March 2021. Figure 6 provides a comprehensive breakdown of hospitalizations in the HIAE-managed public hospitals. The figure illustrates that the Pacaembu Temporary Hospital was operational for three months at the onset of the pandemic (April to June 2020). Additionally, it is notable that M'Boi Mirim Hospital boasts a larger capacity compared to Vila Santa Catarina Hospital.

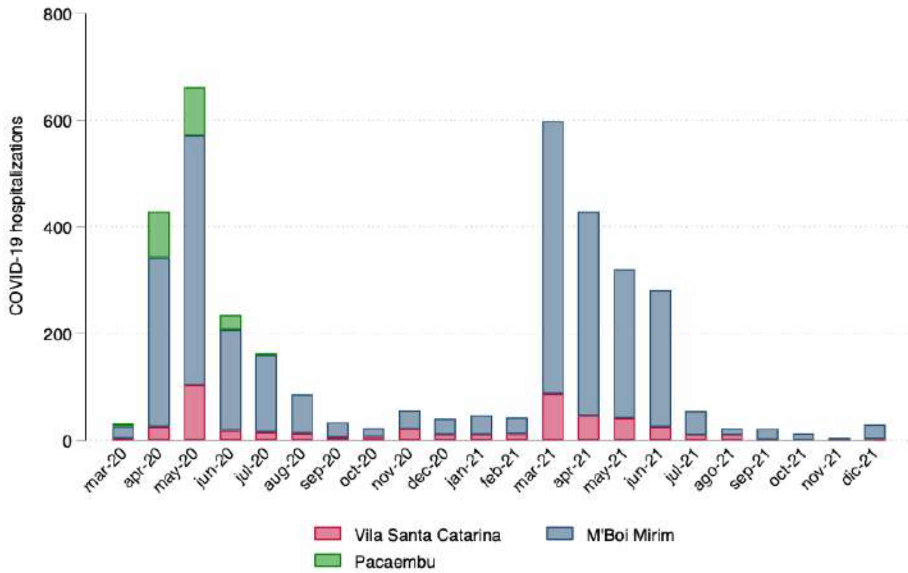

Figure 6: COVID-19 hospitalizations in HIAE's public hospitals in São Paulo

Tables 1 to 3 show summary statistics for our working sample comprising 46,728 observations.

Table 1 provides an overview of various factors, including treatment, clinical outcomes, and demographic variables. Specifically, this table shows that 6 percent of the sample was hospitalized in an HIAE-managed public hospital. In terms of clinical outcomes, the mortality rate is 33 percent, with an average hospital stay duration of 11.9 days (median of 8 days). Furthermore, there is a 40 percent probability of ICU admission and a 19 percent probability of requiring mechanical ventilation. Demographically, the sample has an average age of 58 years, 45 percent are female, 40 percent identify as white, 37 percent identify as mixed-race[3], 8 percent identify as black, and 14 percent do not report their race.

Table 2 shows summary statistics on risk factors. In this context, 62 percent of the sample presents some form of risk factors, with cardiovascular conditions being the most prevalent at 36 percent, followed by diabetes at 26 percent, and obesity at

[3]Identified as "*pardo*" in the data dictionary.

9 percent.

Table 3 shows summary statistics related to symptoms observed at the time of hospitalization. As anticipated, the most prevalent symptoms are associated with respiratory ailments, including dyspnea (79 percent), cough (74 percent), oxygen saturation below 95 percent (72 percent), respiratory distress (68 percent), and fever (52 percent).

To run a preliminary analysis of differences in outcomes and predetermined variables between COVID-19 hospitalizations at HIAE's public hospital (referred to as the treatment group) and other public hospitals (the control group), we calculated means for both groups and tested for differences in population means. The results are shown in Tables A.1 to A.4 in the Appendix.

Table A.1 shows the differences for mortality and variables related with hospital resources and practices. Interestingly, we observe a lower mortality rate in the treatment group compared to the control group (29 percent versus 33 percent). However, the treatment group was more likely to be admitted to the ICU, more likely to use mechanical ventilation, and had a longer length of stay. These findings suggest more favorable health outcomes in the treatment group but may also indicate greater availability of resources that facilitate access to ICU care or mechanical ventilators. Additionally, the longer length of hospital stay may reflect both increased resource utilization and the possibility that individuals with higher risk of mortality require shorter hospital stays, on average.

Regarding demographics, as shown in Table A.2 in the Appendix, the treatment group exhibits a slightly higher average age (57 versus 58 years old), with no discernible gender differences. Regarding racial composition, both groups display similar percentages of white individuals, but the treatment group includes more black and fewer mixed-race patients. Additionally, a higher proportion of patients in the treatment group did not report their race.

Examining risk factors, Table A.3 shows that the treatment group is more likely to present at least one risk factor (72.1 percent versus 61.5 percent). This discrepancy is primarily driven by the treatment group's higher prevalence of cardiovascular problems, obesity, and diabetes.

Concerning symptoms present at the time of hospitalization, Table A.4 shows that the control group exhibits a higher average number of symptoms. For instance, the control group is more likely to present with symptoms such as respiratory distress, sore throat, fatigue, and loss of smell or taste. In contrast, the treatment group is more likely to manifest symptoms like oxygen saturation below 95 percent, dyspnea, or fever.

We complement the SIVEP-Gripe data with aggregated information on ICU bed occupancy rates in the Municipality of São Paulo, sourced from the Secretaria de Estado da Saúde (Censo Covid-19) and available since May 19, 2020. This dataset reports daily figures for ICU COVID-19 patients and the number of available ICU COVID-19 beds as a 7-day moving average. We calculate the ICU bed occupancy rate by dividing the number of ICU COVID-19 patients by the available ICU COVID-19 beds. Table 1 shows that the average ICU bed occupancy is 73 percent. The ICU bed occupancy rate's evolution (shown in Figure 4) is characterized by two prominent peaks in May 2020 and March-April 2021. We will use this variable to analyze further the impact of hospitalization in an HIAE's public hospitals during low and high bed occupancy rates.

4 Empirical Strategy

Our estimating equation is

$$Y_{ijt} = \beta_0 + \beta_1 HIAE\,hospital_{jt} + \gamma' X_{it} + \mu_{w(t)} + \delta_c + \epsilon_{it} \tag{1}$$

where Y_{it} is the outcome variable (e.g., discharge condition) for COVID-19 patient i hospitalized in public hospital j in date t, $HIAE\,hospital_{jt}$ is a binary variable indicating whether the patient was hospitalized in HIAE's public hospital, and X_{it} are covariates related to demographics (such as race, age, and gender), risk factors, and symptoms at the time of hospitalization. Additionally, $\mu_{w(t)}$ is a week-month-year fixed effect, δ_c is a patient's district of residence fixed effect, and ϵ_{it}

includes unobservables affecting the outcome variable. In our estimating equation, β_1 captures the causal effect of interest.

We estimate equation (1) using OLS and compute clustered standard errors at the hospital level. Our main identifying assumption is that, after we control for confounding factors (fixed effects and covariates), patients are as good as randomly assigned to a public hospital. A direct comparison of average outcomes between HIAE's public hospitals and other public hospitals might yield a biased estimate of the effect of interest. This potential bias can arise, for example, if HIAE's public hospitals are located in districts with higher income levels than other public hospitals, confounding the effects of HIAE with socioeconomic differences. A similar concern exists if patients with more risk factors or severe symptoms are not evenly distributed between the two hospital types. The richness of our dataset enables us to control for a comprehensive array of variables, enhancing the credibility of our identifying assumption.

Extensive medical research has found a strong association between high strain on hospital capacity and increased mortality rates. For instance, Boden et al. (2016) studied an intervention at a large district general hospital in the United Kingdom that, which successfully reduced bed occupancy from 93.7 percent to 90.2 percent. This intervention resulted in a significant average decrease in all mortality indicators, ranging from 4.5 percent to 4.8 percent. Additionally, Bagshaw et al. (2018) investigated the relationship between strain (defined as occupancy at or above 95 percent) and outcomes in nine integrated ICUs in Alberta, Canada, from 2012 to 2014. They found that high occupancy was associated with increased severity of illness among admitted patients. They also document that the overall impact of strained capacity on ICU mortality includes direct and indirect effects. However, they also observed that high relative occupancy (at or above 90 percent and 95 percent) only had indirect effect on ICU mortality.

To examine whether the effect of being hospitalized in an HIAE hospital depends on the strain on the health care system, measured by the ICU bed occupancy rate in the municipality, we estimate the following equation:

$$Y_{ijt} = \beta_0 + \beta_1\, HIAE\, hospital_{jt} + \beta_2\, bed\, occ_t + \\ \beta_3\, HIAE\, hospital_{jt} \times (bed\, occ_t - \overline{bed\, occ}) + \gamma' X_{it} + \mu_{w(t)} + \delta_c + \epsilon_{it} \quad (2)$$

where $bed\, occ_t$ is the ICU bed occupancy rate in the municipality of São Paulo in date t (7-day moving average). In this equation, β_1 is the effect of being hospitalized in a HIAE's hospital on an average date (in terms of ICU bed occupancy) and β_3 measures how this effect changes when ICU bed occupancy is above average. It is worth noting that the ICU bed occupancy rate data is available from May 19, 2020, onwards, leading to a loss of 5 percent of observations when estimating the model with interactions.

Additionally, we estimate the following quadratic specification:

$$Y_{ijt} = \beta_0 + \beta_1\, HIAE\, hospital_{jt} + \beta_2\, bed\, occ_t + \beta_3 (bed\, occ_t - \overline{bed\, occ})^2 + \\ \beta_4\, HIAE\, hospital_{jt} \times (bed\, occ_t - \overline{bed\, occ}) \\ + \beta_5\, HIAE\, hospital_{jt} \times (bed\, occ_t - \overline{bed\, occ})^2 + \gamma' X_{it} + \mu_{w(t)} + \delta_c + \epsilon_{it}. \quad (3)$$

This functional form is more flexible than equation (2) but it is more complex to interpret. We will primarily use this specification as an alternative functional form to compute the expected number of lives saved.

Finally, to facilitate the interpretation of the interaction between being hospitalized in an HIAE hospital and bed occupancy, we also estimate the following equation:

$$
\begin{aligned}
Y_{ijt} = \beta_0 + \beta_1\, HIAE\, hospital_{jt} \times \mathbb{1}(bed\, occ_t \leq .70) + \\
\beta_2\, HIAE\, hospital_{jt} \times \mathbb{1}(.70 < bed\, occ_t \leq .85) + \\
\beta_3\, HIAE\, hospital_{jt} \times \mathbb{1}(.85 < bed\, occ_t \leq .90) + \\
\beta_4\, HIAE\, hospital_{jt} \times \mathbb{1}(bed\, occ_t > .90) + \beta_5\, \mathbb{1}(.70 < bed\, occ_t \leq .85) + \\
\beta_6\, \mathbb{1}(.85 < bed\, occ_t \leq .90) + \beta_7\, \mathbb{1}(bed\, occ_t > .90) + \gamma' X_{it} + \mu_{w(t)} + \delta_c + \epsilon_{it} \quad (4)
\end{aligned}
$$

where $\mathbb{1}(.)$ are indicator functions for different ranges of ICU bed occupation. In this specification, β_1 is the effect of being hospitalized in a HIAE's hospital when bed occupancy is less than 70 percent, β_2 is the same effect when bed occupancy is between 70 and 85 percent, β_3 when bed occupancy is between 85 and 90 percent, and β_4 when bed occupancy exceeds 90 percent. In our sample, 39 percent of observations have bed occupancy below 70 percent, 42 percent between 70 and 85 percent, 7 percent between 70 and 80 percent, and 12 percent above 90 percent. This last specification allows us to compare with other literature on the effect of high hospital occupancy on mortality (see, for example Wilde et al., 2021).

5 Results

5.1 Mortality

Tables 4 to 7 present the OLS estimates for mortality based on the models specified in equations (1) to (3), respectively.

Table 4, indicates a reduction in the probability of mortality for patients hospitalized in an HIAE hospital, although this effect is not statistically significant. It is of note that the point estimates show sensitivity to controls for district of residence and risk factors. This highlights the importance of accounting for these confounding factors in our analysis.

Table 5 shows the OLS estimates for the model that incorporates an interaction term with bed occupancy, as outlined in equation (2). The analysis reveals a small and statistically not significant effect for patients hospitalized in an HIAE hospital when ICU bed occupancy in the municipality is at the average level (73 percent). Nevertheless, the interaction term is negative and statistically significant, indicating that the effect hospitalization in an HIAE hospital on mortality varies with bed occupancy levels.

Table 6 presents analogous results for the quadratic model specified in equation (3). In this specification, the quadratic term is significant in all columns, suggesting that the mortality differences between HIAE-managed hospitals and other hospitals become more pronounced as bed occupancy levels in São Paulo increase. To gain a deeper understanding of the results on mortality and length of stay, Table 7 shows the OLS estimates for the model with interaction terms using dummies for different bed occupancy ranges, as defined in equation (4). Our findings indicate that mortality effects are generally non-significant or marginally significant (at the 10 percent level) for bed occupancy below 90 percent. However, when bed occupancy exceeds 90 percent (occurring in 12 percent of our sample), being hospitalized in an HIAE's public hospital exhibits a significantly negative effect on mortality once we control for all confounding factors. In brief, when bed occupancy in the municipality of São Paulo surpasses 90 percent, hospitalization in an HIAE public hospital reduces the probability of mortality by 10.3 percentage points (using the specification with all controls in column (6)). This effect is substantial, with a 31 percent decrease in mortality compared to the mean.

Our findings on mortality are of significant importance, particularly in the context of recent medical literature that studies the connection between bed occupancy and mortality, both in general (Lapichino et al. 2004; Boden et al. 2016; Bagshaw et al. 2018) and within the specific context of the COVID-19 pandemic. For instance, in a large cohort study involving 7,390 patients with COVID-19 in New York City, Castagna et al. (2022) found that the percentage of bed occupancy is associated with an increase in 30-day in-hospital mortality of patients (0.7 percent mortality increase for each 1 percent increase in bed occupancy). Furthermore, in a comprehensive national retrospective observational cohort study involving 89 English hospital trusts, Wilde et al. (2021) found that, after adjusting for patient-specific factors, mortality rates were higher for admissions that occurred during periods of high bed occupancy (exceeding 85 percent) when compared to the baseline occupancy range (45 to 85 percent).

It is noteworthy that Tables A.6 and A.7 in the Appendix present separate results for the first (2020) and the second (2021) wave of the Covid-19 pandemic. These tables suggest that the results on mortality are mainly driven by the second wave of the pandemic. This may indicate some form of adaptive learning by HIAE from one wave to another. However, it remains unclear whether the observed differences are due to changes in management strategies between the waves or whether the healthcare system faced its highest periods of stress during the second wave.

As an additional robustness check, Table A.8 in the Appendix shows that the results are similar if we exclude Hospital Vila Santa Catarina from the sample, which has a larger share of transplanted and cancer patients.

5.2 Resource utilization and medical practices

While the publicly available data does not allow us to identify the specific treatment received by each patient, it does provide information on the length of hospital stay, ICU admission, and use of mechanical ventilation for all patients. We tested for differences in these three variables to better understand the impact of treatment in Einstein-managed public hospitals.

Tables 8 and 9 present the OLS estimates for these variables, based on the models specified in equations (1) and (4). In both tables, columns (1) and (2) present the estimates for the length of stay, columns (3) and (4) for ICU admission, and columns (5) and (6) for the use of mechanical ventilation.[4]

Column (2) of Table 8 indicates a statistically significant 22 percent increase in the length of hospital stay for patients in HIAE hospitals. This finding may be due to better medical practices or bed management that allows for longer hospital stays, which may be important for more severe cases. In addition, this finding may

[4]The results for the specification in Equation (2) are relegated to Table A.5 in the appendix.

be related to reduced strain on HIAE's public hospitals. Previous research has shown that hospital strain is related to shorter Intensive Care Unit (ICU) stays, primarily due to increased patient acuity (Bagshaw et al., 2018).

Columns (3) to (6) of Table 8 show that the treatment group is more likely to be admitted to the ICU and to use mechanical ventilation, respectively. However, these effects are not statistically significant.

When analyzing the interaction of the treatment group with bed occupancy rates, we observe, as shown Columns (1) and (2) of Table A.5 in the Appendix that the effect on lenght of stay is consistent across varying levels of bed occupancy. This result might suggest the existence of different medical practices between the two types of hospitals. However, as shown above, these different medical practices may only exert an impact on mortality when bed occupancy exceeds the the 90 percent threshold. Moreover, the decrease in mortality may also be playing a mechanical role in the increase of the length of stay.

Conversely, we find that the use of mechanical ventilators, similar to mortality effects, varies with bed occupancy as shown in Columns (5) and (6) of Table A.5. Nevertheless, Columns (3) and (4) indicate that ICU admissions, much like the length of hospital stays, are not influenced by bed occupancy levels.

In this context, our findings highlight the significance of effective management, particularly when the healthcare system is under stress at times of high bed occupancy. This underscores the necessity for the implementation of strategies to ensure optimal patient care and safety during periods of increased demand on healthcare resources. Additionally, considering the well-known reputation of Albert Einstein Hospital, it is plausible that the pandemic may have led to a self-selection of more severe cases at this facility.[5] If this is indeed the case, our results may underestimate the effect of admission to a HIAE-hospital on mortality.

[5]Table A.3 in the Appendix shows that patients in the treatment group are 10 percentage points more likely to present at least one risk factor. This is evidenced by significant differences in the likelihood of asthma, diabetes, cardiovascular diseases, kidney problems and obesity, among other conditions.

6 Expected lives saved

In this section, we calculate the expected lives saved for patients hospitalized in a HIAE-managed hospital. First, for each patient admitted to an HIAE hospital, we compute the change in the mortality probability compared to being admitted to another public hospital. Formally, we compute the change in mortality probability for COVID-19 patient i hospitalized in public hospital j in date t as

$$\begin{aligned} \Delta Mortality_{ijt} = Pr(Y_{ijt} = 1 | HIAE_{jt} = 1, bed\,occ_t) - \\ Pr(Y_{ijt} = 1 | HIAE_{jt} = 0, bed\,occ_t). \end{aligned}$$

We use four models to compute this change in mortality probability: i) A model with interactions with bed occupancy (Linear), as in equation (2), ii) A model with a quadratic interaction with bed occupancy (Quadratic), as in equation (3), iii) A model with interactions using dummy variables to indicate different levels of bed occupancy (dummies), as in equation (4), and iv) A dummies model using the coefficient only when bed occupancy is above 90% (dummies 90%).

Figure 7 shows the change in mortality probability for the four different models. All models show a decrease in mortality probability during periods of high bed occupancy and increases in mortality probability during periods of low bed occupancy. However, the increases in mortality are generally smaller in magnitude than the decreases, except in the linear model, which is symmetric by construction.

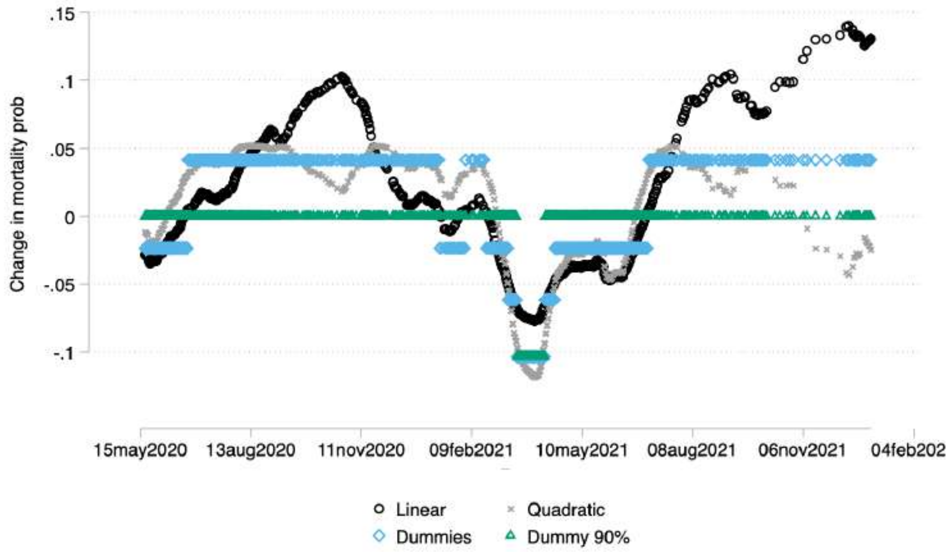

Figure 7: Change in mortality probability using different functional forms.

Second, we aggregate this change in mortality probability for each patient admitted to an HIAE hospital in t to obtain a measure of the expected lives saved in t, i.e.

$Expected\, lives\, saved_t = \Sigma_{i \in HIAE_{jt}}[-\Delta Mortality_{ijt}]$.

Figure 8 shows the expected number of lives saved for the different models. All models display similar patterns. As the larger decreases in mortality correspond to periods with a high number of hospitalizations, we observe a notable increase in the expected number of lives saved. Conversely, periods where our model predicts an increase in mortality coincide with periods of fewer hospitalizations, resulting in a smaller impact on aggregate mortality.

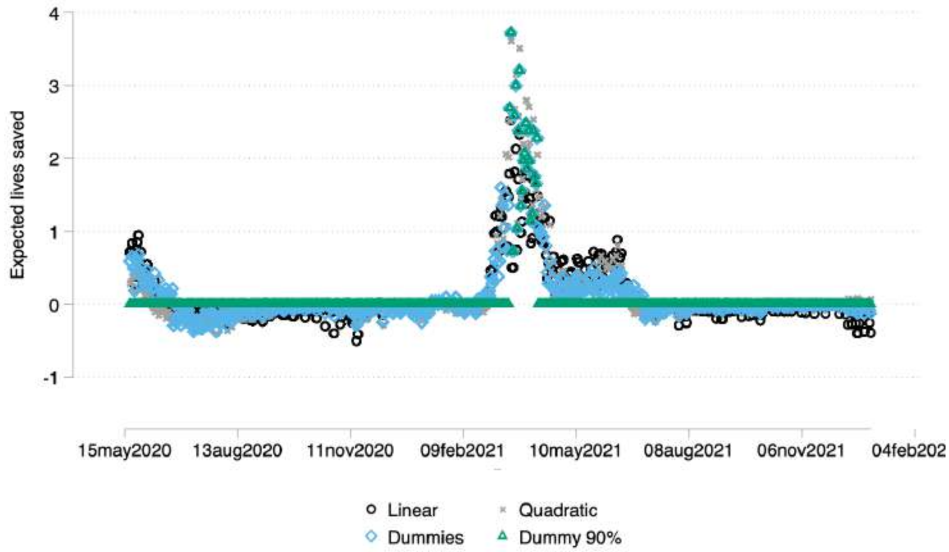

Figure 8: Expected lives saved using different functional forms.

To illustrate this point more clearly, Figure 9 shows bed occupancy (grey crosses) and lives saved using the quadratic model (black circles). We observe that peaks in bed occupancy coincide with larger numbers of lives saved.

Finally, we calculated the expected number of lives saved over the entire period from May 2020 to December 2021 for each model. The linear model is projected to save 68 lives, the quadratic model 72 lives, the model with dummy variables 70 lives, and the Dummies 90% model 46 lives.

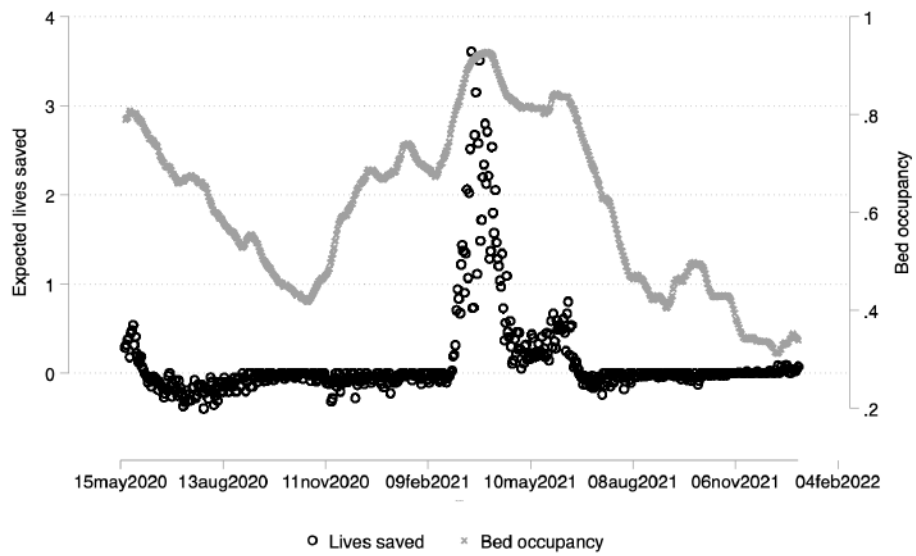

Figure 9: Expected lives saved using the quadratic model.

7 Conclusion

This paper studies the impact of Hospital Israelita Albert Einstein's (HIAE) management of public hospitals during the COVID-19 pandemic in Brazil. In the context of a global public health crisis, HIAE played a relevant role in expanding healthcare infrastructure, implementing rigorous health protocols, establishing a robust testing system, and conducting vital research on COVID-19.

The objective of this analysis is to address the question: What is the impact of public infrastructure managed by HIAE during the pandemic on the health of the population? To that end, we utilize publicly data on cases of COVID-19 involving residents in the Municipality of São Paulo who were hospitalized in public hospitals between March 2020 and December 2021. Specifically, the effects on mortality, ICU utilization, length of hospital stay, and use of mechanical ventilation are evaluated

Our findings indicate that patients hospitalized with COVID-19 in HIAE-managed public hospitals exhibit a reduced likelihood of mortality, although this effect is not statistically significant. Further investigation, taking into account the severity of the pandemic as measured by ICU bed occupancy rates, reveals a significant decrease in mortality rates when the bed occupancy rate exceeds 90 percent.

When we examine the differences in the use of medical resources, our results suggest that patients admitted to an HIAE-managed hospital have longer hospital stays, and greater use of mechanical ventilation.

Finally, we estimate the expected number of lives saved as a result of hospitalization in an HIAE-managed hospital. Using several functional forms, our estimates suggest that between 46 and 72 lives were saved, with our preferred specification suggesting that 70 lives were saved.

Our findings indicate that management strategies employed by HIAE were effective during periods of increased strain on the healthcare system. These insights provide valuable information that can be utilized in ongoing efforts to contain the pandemic and enhance healthcare delivery in challenging circumstances.

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Tables

Table 1: Summary statistics: Outcomes, treatment and demographics

Variables	Mean	s.d.	Min	Max	N
HIAE hospital	0.06	0.24	0	1	46,728
Bed occupancy	0.73	0.14	0	1	46,728
Clinical Outcomes					
Mortality	0.33	0.47	0	1	44,448
Length of stay	11.91	15.57	0	425	44,232
ICU	0.40	0.49	0	1	42,638
Mechanical ventilation	0.19	0.39	0	1	42,371
Demographics					
Age	58.41	17.23	0	107	46,683
Female	0.45	0.50	0	1	46,728
White	0.40	0.49	0	1	46,728
Mixed-race	0.37	0.48	0	1	46,728
Black	0.08	0.26	0	1	46,728
Other race	0.02	0.12	0	1	46,728
Race not reported	0.14	0.35	0	1	46,728

Note: This table reports descriptive statistics for outcomes, treatment, and demographics. The sample includes confirmed COVID-19 cases involving residents in the Municipality of São Paulo hospitalized in public hospitals between March 2020 and December 2021. HIAE hospital is a dummy that indicates a HIAE's public hospital (Hospital Municipal M'Boi Mirim, Hospital Municipal Vila Santa Catarina, and Pacaembu Temporary Hospital). Bed occupancy is the daily COVID-19 ICU bed occupancy in the Municipality of São Paulo.

Table 2: Summary statistics: Risk factors

Variables	Mean	s.d.	Min	Max	N
Risk factors					
Any risk factor	0.62	0.49	0	1	46,728
Asthma	0.03	0.16	0	1	46,728
Diabetes	0.26	0.44	0	1	46,728
Cardiovascular	0.36	0.48	0	1	46,728
Hematologic	0.01	0.08	0	1	46,728
Liver Disease	0.01	0.09	0	1	46,728
Neurological	0.03	0.18	0	1	46,728
Kidney	0.03	0.17	0	1	46,728
Other Pneumatopathy	0.03	0.18	0	1	46,728
Postpartum	0.00	0.05	0	1	46,728
Down syndrome	0.00	0.05	0	1	46,728
Immunodeficiency	0.02	0.14	0	1	46,728
Obesity	0.09	0.29	0	1	46,728
Other	0.22	0.41	0	1	46,728

Note: This table reports descriptive statistics for risks factors. The sample includes confirmed COVID-19 cases involving residents in the Municipality of São Paulo hospitalized in public hospitals between March 2020 and December 2021.

Table 3: Summary statistics: Symptoms

Variables	Mean	s.d.	Min	Max	N
Symptoms					
Respiratory distress	0.68	0.47	0	1	46,728
Diarrhea	0.11	0.31	0	1	46,728
Dyspnoea	0.79	0.41	0	1	46,728
Sore throat	0.16	0.37	0	1	46,728
Abdominal pain	0.04	0.20	0	1	46,728
Fatigue	0.22	0.41	0	1	46,728
Fever	0.52	0.50	0	1	46,728
Loss of smell	0.08	0.27	0	1	46,728
Loss of taste	0.08	0.28	0	1	46,728
Saturation O2 95% or less	0.72	0.45	0	1	46,728
Cough	0.74	0.44	0	1	46,728
Vomit	0.07	0.25	0	1	46,728

Note: This table reports descriptive statistics for symptoms at the time of hospitalization. The sample includes confirmed COVID-19 cases involving residents in the Municipality of São Paulo hospitalized in public hospitals between March 2020 and December 2021.

Table 4: Effect of AE's public hospital management on mortality.

	(1)	(2)	(3)	(4)	(5)	(6)
HIAE hospital	-0.0434	-0.0388	-0.0095	-0.0176	-0.0288	-0.0256
	(0.0342)	(0.0333)	(0.0386)	(0.0378)	(0.0324)	(0.0264)
Hospitalization week	Yes	Yes	Yes	Yes	Yes	Yes
Demographics	No	Yes	Yes	Yes	Yes	Yes
District of residence	No	No	Yes	Yes	Yes	Yes
Any risk factor	No	No	No	Yes	Yes	Yes
Individual risk factors	No	No	No	No	Yes	Yes
Symptoms	No	No	No	No	No	Yes
R^2	0.009	0.103	0.112	0.117	0.131	0.147
Mean DV	0.326	0.326	0.326	0.326	0.326	0.326
Observations	44,448	44,406	43,123	43,123	43,123	43,123

Note: This table reports OLS estimates of the effect AE's public hospital management on mortality. Standard errors, clustered by hospital, are reported in parentheses. Significance levels are indicated by $* < .1$, $** < .05$, $*** < .01$.

Table 5: Effect of AE's public hospital management on mortality. Linear interaction with bed occupation in SP.

	(1)	(2)	(3)	(4)	(5)	(6)
HIAE hospital	-0.0302	-0.0251	0.0061	-0.0005	-0.0122	-0.0086
	(0.0339)	(0.0325)	(0.0370)	(0.0357)	(0.0293)	(0.0243)
HIAE × occ.	-0.2894***	-0.3004***	-0.3220***	-0.3553***	-0.3440***	-0.3526***
	(0.0487)	(0.0418)	(0.0447)	(0.0449)	(0.0779)	(0.0897)
bed occupancy	0.1424	0.0676	-0.0066	0.0353	0.0099	-0.0255
	(0.2016)	(0.1894)	(0.2010)	(0.2018)	(0.2014)	(0.1997)
Hosp. week	Yes	Yes	Yes	Yes	Yes	Yes
Demographics	No	Yes	Yes	Yes	Yes	Yes
Dist. of residence	No	No	Yes	Yes	Yes	Yes
Any risk factor	No	No	No	Yes	Yes	Yes
Ind. risk factors	No	No	No	No	Yes	Yes
Symptoms	No	No	No	No	No	Yes
R^2	0.009	0.104	0.113	0.118	0.131	0.148
Mean DV	0.326	0.326	0.326	0.326	0.326	0.326
Observations	44,448	44,406	43,123	43,123	43,123	43,123

Note: This table reports OLS estimates of the effect AE's public hospital management on mortality. The model allows for interactions with bed occupation in the municipality, measured as the daily COVID-19 ICU bed occupancy in the Municipality of São Paulo. Standard errors, clustered by hospital, are reported in parentheses. Significance levels are indicated by $* < .1$, $** < .05$, $*** < .01$.

Table 6: Effect of AE's public hospital management on mortality. Quadratic interaction with bed occupation in SP.

	(1)	(2)	(3)	(4)	(5)	(6)
HIAE hospital	0.0018	-0.0000	0.0248	0.0195	0.0097	0.0176
	(0.0341)	(0.0316)	(0.0347)	(0.0334)	(0.0272)	(0.0239)
HIAE × occ.	-0.3975***	-0.3853***	-0.3801***	-0.4176***	-0.4131***	-0.4354***
	(0.0611)	(0.0549)	(0.0591)	(0.0620)	(0.0967)	(0.1089)
HIAE × occ^2.	-1.5629***	-1.2278***	-0.9755**	-1.0426**	-1.1479***	-1.3728***
	(0.4453)	(0.3804)	(0.4320)	(0.4398)	(0.4315)	(0.4422)
bed occupancy	0.1425	0.0689	-0.0010	0.0414	0.0171	-0.0167
	(0.1990)	(0.1874)	(0.1996)	(0.2000)	(0.1990)	(0.1968)
bed occupancy^2	-1.9175**	-1.3259	-0.8540	-0.8092	-0.7200	-0.7916
	(0.9212)	(0.8663)	(0.9710)	(0.9625)	(0.9391)	(0.9317)
Hosp. week	Yes	Yes	Yes	Yes	Yes	Yes
Demographics	No	Yes	Yes	Yes	Yes	Yes
Dist. of residence	No	No	Yes	Yes	Yes	Yes
Any risk factor	No	No	No	Yes	Yes	Yes
Ind. risk factors	No	No	No	No	Yes	Yes
Symptoms	No	No	No	No	No	Yes
R^2	0.010	0.104	0.113	0.118	0.131	0.148
Mean DV	0.326	0.326	0.326	0.326	0.326	0.326
Observations	44,448	44,406	43,123	43,123	43,123	43,123

Note: This table reports OLS estimates of the effect AE's public hospital management on mortality. The model allows for interactions with different levels of bed occupation in the municipality, measured as the daily COVID-19 ICU bed occupancy in the Municipality of São Paulo. Standard errors, clustered by hospital, are reported in parentheses. Significance levels are indicated by $* < .1$, $** < .05$, $*** < .01$.

Table 7: Effect of AE's public hospital management on mortality. Interactions with dummies for level of bed occupation in SP.

	(1)	(2)	(3)	(4)	(5)	(6)
HIAE $\times$ occ. $\leq .7$	0.0140	0.0220	0.0562	0.0546	0.0407*	0.0414*
	(0.0356)	(0.0330)	(0.0357)	(0.0329)	(0.0236)	(0.0242)
HIAE $\times$ $.70 <$ occ.$\leq .85$	-0.0406	-0.0397	-0.0141	-0.0232	-0.0326	-0.0236
	(0.0352)	(0.0337)	(0.0383)	(0.0378)	(0.0338)	(0.0278)
HIAE $\times$ $.85 <$ occ.$\leq .90$	-0.0708	-0.0655	-0.0356	-0.0462	-0.0556	-0.0616
	(0.0436)	(0.0412)	(0.0480)	(0.0491)	(0.0491)	(0.0406)
HIAE $\times$ occ.$> .9$	-0.1158***	-0.1046***	-0.0683*	-0.0812**	-0.0955**	-0.1034***
	(0.0301)	(0.0325)	(0.0403)	(0.0402)	(0.0393)	(0.0353)
$.70 <$ bed occ.$\leq .85$	-0.0387*	-0.0385**	-0.0396**	-0.0365*	-0.0375*	-0.0383*
	(0.0204)	(0.0188)	(0.0192)	(0.0193)	(0.0192)	(0.0197)
$.85 <$ bed occ.$\leq .90$	-0.0485	-0.0488	-0.0458	-0.0401	-0.0392	-0.0398
	(0.0350)	(0.0314)	(0.0313)	(0.0315)	(0.0308)	(0.0318)
bed occ.$> .9$	-0.0352	-0.0364	-0.0286	-0.0258	-0.0259	-0.0244
	(0.0394)	(0.0377)	(0.0384)	(0.0389)	(0.0382)	(0.0391)
Hosp. week	Yes	Yes	Yes	Yes	Yes	Yes
Demographics	No	Yes	Yes	Yes	Yes	Yes
Dist. of residence	No	No	Yes	Yes	Yes	Yes
Any risk factor	No	No	No	Yes	Yes	Yes
Ind. risk factors	No	No	No	No	Yes	Yes
Symptoms	No	No	No	No	No	Yes
R^2	0.009	0.104	0.113	0.118	0.131	0.148
Mean DV	0.326	0.326	0.326	0.326	0.326	0.326
Observations	44,448	44,406	43,123	43,123	43,123	43,123

Note: This table reports OLS estimates of the effect AE's public hospital management on mortality. The model allows for interactions with different levels of bed occupation in the municipality, measured as the daily COVID-19 ICU bed occupancy in the Municipality of São Paulo. Standard errors, clustered by hospital, are reported in parentheses. Significance levels are indicated by $* < .1$, $** < .05$, $*** < .01$.

Table 8: Effect of AE's public hospital management on resource variables

	Log(LOS)		ICU		Mech. Vent	
	(1)	(2)	(3)	(4)	(5)	(6)
HIAE hospital	0.1924***	0.2221***	0.0872	0.0680	0.0275	0.0487*
	(0.0659)	(0.0503)	(0.0659)	(0.0812)	(0.0406)	(0.0270)
Hospitalization week	Yes	Yes	Yes	Yes	Yes	Yes
Demographics	No	Yes	No	Yes	No	Yes
District of residence	No	Yes	No	Yes	No	Yes
Any risk factor	No	Yes	No	Yes	No	Yes
Individual risk factors	No	Yes	No	Yes	No	Yes
Symptoms	No	Yes	No	Yes	No	Yes
R^2	0.007	0.052	0.016	0.095	0.007	0.053
Mean DV	2.205	2.205	0.400	0.400	0.192	0.192
Observations	44,232	42,921	42,638	41,363	42,371	41,127

Note: This table reports OLS estimates of the effect AE's public hospital management on resource variables. Standard errors, clustered by hospital, are reported in parentheses. Significance levels are indicated by $* < .1$, $** < .05$, $*** < .01$.

Table 9: Effect of AE's public hospital management on resources. Linear interaction with bed occupation in SP.

	Log(LOS)		ICU		Mech. Vent	
	(1)	(2)	(3)	(4)	(5)	(6)
HIAE hospital	0.1946***	0.2261***	0.0929	0.0799	0.0194	0.0405
	(0.0719)	(0.0497)	(0.0637)	(0.0792)	(0.0411)	(0.0247)
HIAE $\times$ occ.	-0.0480	-0.0840	-0.1234	-0.2511**	0.1813***	0.1769**
	(0.1610)	(0.0764)	(0.0820)	(0.1142)	(0.0487)	(0.0829)
bed occupancy	0.1242	-0.0032	-0.5968*	-0.6050*	0.0688	-0.0103
	(0.4030)	(0.4208)	(0.3355)	(0.3178)	(0.2060)	(0.2277)
Hospitalization week	Yes	Yes	Yes	Yes	Yes	Yes
Demographics	No	Yes	No	Yes	No	Yes
District of residence	No	Yes	No	Yes	No	Yes
Any risk factor	No	Yes	No	Yes	No	Yes
Individual risk factors	No	Yes	No	Yes	No	Yes
Symptoms	No	Yes	No	Yes	No	Yes
R^2	0.007	0.052	0.016	0.095	0.008	0.053
Mean DV	2.205	2.205	0.400	0.400	0.192	0.192
Observations	44,232	42,921	42,638	41,363	42,371	41,127

Note: This table reports OLS estimates of the effect AE's public hospital management on (log) length of stay. The model allows for interactions with bed occupation in the municipality, measured as the daily COVID-19 ICU bed occupancy in the Municipality of São Paulo. Standard errors, clustered by hospital, are reported in parentheses. Significance levels are indicated by $* < .1$, ** $< .05$, *** $< .01$.

A Appendix

Table A.1: Raw differences between HIAE's and other public hospitals: Outcomes

	(1)		(2)		(1)-(2)	
	HIAE		Other pub hosp		Pairwise t-test	
Variable	N	Mean/(SE)	N	Mean/(SE)	N	Mean difference
Mortality	2708	0.291	41740	0.329	44448	-0.038***
		(0.009)		(0.002)		
Length of stay	2708	14.773	41524	11.719	44232	3.053***
		(0.365)		(0.075)		
ICU	2718	0.470	39920	0.395	42638	0.075***
		(0.010)		(0.002)		
Mechanical ventilation	2739	0.225	39632	0.190	42371	0.035***
		(0.008)		(0.002)		

Note: This table reports tests for difference in means between HIAE's public hospitals (treatment group) and other public hospitals (control group) for outcomes. Standard errors are reported in parentheses. Significance levels are indicated by $* < .1$, $** < .05$, $*** < .01$.

Table A.2: Raw differences between HIAE's and other public hospitals: Demographics

		(1) HIAE		(2) Other pub hosp		(1)-(2) Pairwise t-test
Variable	N	Mean/(SE)	N	Mean/(SE)	N	Mean difference
Age	2755	57.342 (0.343)	43928	58.481 (0.082)	46683	-1.139***
Female	2756	0.455 (0.009)	43972	0.447 (0.002)	46728	0.008
White	2025	0.474 (0.011)	38033	0.461 (0.003)	40058	0.013
Mixed-race	2025	0.392 (0.011)	38033	0.435 (0.003)	40058	-0.042***
Black	2025	0.114 (0.007)	38033	0.087 (0.001)	40058	0.027***
Other race	2025	0.021 (0.003)	38033	0.017 (0.001)	40058	0.003
Race not reported	2756	0.265 (0.008)	43972	0.135 (0.002)	46728	0.130***

Note: This table reports tests for difference in means between HIAE's public hospitals (treatment group) and other public hospitals (control group) for demographics. Standard errors are reported in parentheses. Significance levels are indicated by $* < .1$, $** < .05$, $*** < .01$.

Table A.3: Raw differences between HIAE's and other public hospitals: Risk factors

	(1)		(2)		(1)-(2)	
	HIAE		Other pub hosp		Pairwise t-test	
Variable	N	Mean/(SE)	N	Mean/(SE)	N	Mean difference
Any risk factor	2756	0.721	43972	0.615	46728	0.106***
		(0.009)		(0.002)		
Asthma	2756	0.038	43972	0.027	46728	0.012***
		(0.004)		(0.001)		
Diabetes	2756	0.300	43972	0.253	46728	0.047***
		(0.009)		(0.002)		
Cardiovascular	2756	0.460	43972	0.357	46728	0.103***
		(0.009)		(0.002)		
Hematologic	2756	0.007	43972	0.006	46728	0.000
		(0.002)		(0.000)		
Liver Disease	2756	0.009	43972	0.009	46728	0.000
		(0.002)		(0.000)		
Neurological	2756	0.040	43972	0.032	46728	0.008**
		(0.004)		(0.001)		
Kidney	2756	0.037	43972	0.027	46728	0.009***
		(0.004)		(0.001)		
Other Pneumatopathy	2756	0.036	43972	0.034	46728	0.002
		(0.004)		(0.001)		
Postpartum	2756	0.003	43972	0.002	46728	0.000
		(0.001)		(0.000)		
Down syndrome	2756	0.001	43972	0.002	46728	-0.001
		(0.001)		(0.000)		
Immunodeficiency	2756	0.054	43972	0.016	46728	0.038***
		(0.004)		(0.001)		
Obesity	2756	0.144	43972	0.087	46728	0.058***
		(0.007)		(0.001)		
Other	2756	0.234	43972	0.219	46728	0.015*
		(0.008)		(0.002)		

Note: This table reports tests for difference in means between HIAE's public hospitals (treatment group) and other public hospitals (control group) for risk factors. Standard errors are reported in parentheses. Significance levels are indicated by $* < .1$, $** < .05$, $*** < .01$.

Table A.4: Raw differences between HIAE's and other public hospitals: Symptoms

Variable	(1) HIAE N	(1) HIAE Mean/(SE)	(2) Other pub hosp N	(2) Other pub hosp Mean/(SE)	(1)-(2) Pairwise t-test N	(1)-(2) Pairwise t-test Mean difference
Respiratory distress	2756	0.585	43972	0.682	46728	-0.097***
		(0.009)		(0.002)		
Diarrhea	2756	0.091	43972	0.111	46728	-0.020***
		(0.005)		(0.001)		
Dyspnoea	2756	0.854	43972	0.789	46728	0.065***
		(0.007)		(0.002)		
Sore throat	2756	0.068	43972	0.164	46728	-0.097***
		(0.005)		(0.002)		
Abdominal pain	2756	0.027	43972	0.045	46728	-0.018***
		(0.003)		(0.001)		
Fatigue	2756	0.152	43972	0.222	46728	-0.070***
		(0.007)		(0.002)		
Fever	2756	0.549	43972	0.520	46728	0.029***
		(0.009)		(0.002)		
Loss of smell	2756	0.052	43972	0.082	46728	-0.031***
		(0.004)		(0.001)		
Loss of taste	2756	0.058	43972	0.085	46728	-0.027***
		(0.004)		(0.001)		
Saturation O2 95% or less	2756	0.808	43972	0.713	46728	0.095***
		(0.008)		(0.002)		
Cough	2756	0.705	43972	0.740	46728	-0.035***
		(0.009)		(0.002)		
Vomit	2756	0.064	43972	0.069	46728	-0.005
		(0.005)		(0.001)		

Note: This table reports tests for difference in means between HIAE's public hospitals (treatment group) and other public hospitals (control group) for symptoms. Standard errors are reported in parentheses. Significance levels are indicated by $* < .1$, ** $< .05$, *** $< .01$.

Table A.5: Effect of AE's public hospital management on resources

	Log(LOS)		ICU		Mech. Vent	
	(1)	(2)	(3)	(4)	(5)	(6)
HIAE × occ. ≤ .7	0.2122**	0.2557***	0.1311**	0.1427*	-0.0089	0.0149
	(0.0863)	(0.0449)	(0.0554)	(0.0735)	(0.0345)	(0.0170)
HIAE × .70 < occ.≤ .85	0.1908***	0.2161***	0.0736	0.0461	0.0262	0.0478
	(0.0636)	(0.0539)	(0.0658)	(0.0822)	(0.0451)	(0.0331)
HIAE × .85 < occ.≤ .90	0.1646***	0.1993***	0.0783	0.0513	0.0685	0.0874**
	(0.0624)	(0.0614)	(0.0819)	(0.0889)	(0.0490)	(0.0394)
HIAE × occ.> .9	0.1873***	0.2101***	0.0735	0.0440	0.0599	0.0780***
	(0.0566)	(0.0525)	(0.0781)	(0.0942)	(0.0363)	(0.0292)
.70 < bed occ.≤ .85	-0.0941**	-0.0933**	-0.0135	-0.0162	-0.0124	-0.0155
	(0.0409)	(0.0407)	(0.0184)	(0.0190)	(0.0183)	(0.0178)
.85 < bed occ.≤ .90	-0.0666	-0.0596	-0.0226	-0.0236	-0.0095	-0.0029
	(0.0510)	(0.0500)	(0.0361)	(0.0306)	(0.0349)	(0.0347)
bed occ.> .9	-0.0415	-0.0295	-0.0240	-0.0219	-0.0194	-0.0108
	(0.0718)	(0.0676)	(0.0484)	(0.0411)	(0.0336)	(0.0332)
Hospitalization week	Yes	Yes	Yes	Yes	Yes	Yes
Demographics	No	Yes	No	Yes	No	Yes
District of residence	No	Yes	No	Yes	No	Yes
Any risk factor	No	Yes	No	Yes	No	Yes
Individual risk factors	No	Yes	No	Yes	No	Yes
Symptoms	No	Yes	No	Yes	No	Yes
R^2	0.007	0.052	0.016	0.095	0.008	0.053
Mean DV	2.205	2.205	0.400	0.400	0.192	0.192
Observations	44,232	42,921	42,638	41,363	42,371	41,127

Note: This table reports OLS estimates of the effect AE's public hospital management on ICU hospitalization. The model allows for interactions with different levels of bed occupation in the municipality, measured as the daily COVID-19 ICU bed occupancy in the Municipality of São Paulo. Standard errors, clustered by hospital, are reported in parentheses. Significance levels are indicated by $* < .1$, $** < .05$, $*** < .01$.

Table A.6: Effect of AE's public hospital management on mortality by year.

	Mortality		Log(LOS)		ICU		Mech. Vent.	
	2020	2021	2020	2021	2020	2021	2020	2021
HIAE hospital	0.0390	-0.0390	0.3516***	0.1671***	0.2624***	-0.0186	0.1059**	0.0016
	(0.0378)	(0.0290)	(0.0694)	(0.0438)	(0.0697)	(0.0881)	(0.0445)	(0.0188)
HIAE × occ.	0.1056	-0.2839***	0.8185**	0.0447	0.6760***	-0.0075	0.5652***	0.3136***
	(0.2095)	(0.0584)	(0.3335)	(0.1479)	(0.2451)	(0.1231)	(0.1805)	(0.0991)
bed occupancy	0.3965	-0.2034	1.3586	-0.5057	0.1798	-0.8690**	1.0284***	-0.3656
	(0.3965)	(0.2208)	(0.8456)	(0.5034)	(0.5413)	(0.3504)	(0.3162)	(0.2635)
Hosp. week	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Demographics	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Dist. of residence	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Any risk factor	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Ind. risk factors	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Symptoms	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.194	0.134	0.077	0.049	0.125	0.099	0.071	0.057
Mean DV	0.311	0.335	2.191	2.212	0.354	0.424	0.164	0.207
Observations	15,766	27,353	15,690	27,227	14,525	26,834	14,494	26,629

Note: This table reports OLS estimates of the effect AE's public hospital management on mortality. The model allows for interactions with different levels of bed occupation in the municipality, measured as the daily COVID-19 ICU bed occupancy in the Municipality of São Paulo. Standard errors, clustered by hospital, are reported in parentheses. Significance levels are indicated by $* < .1$, $** < .05$, $*** < .01$.

Table A.7: Effect of AE's public hospital management on mortality by year.

	Mortality		Log(LOS)		ICU		Mech. Vent.	
	2020	2021	2020	2021	2020	2021	2020	2021
HIAE × occ. ≤ .7	0.0236	0.0367	0.2753***	0.1983***	0.1900***	0.0536	0.0222	-0.0233
	(0.0289)	(0.0264)	(0.0486)	(0.0412)	(0.0626)	(0.0905)	(0.0233)	(0.0254)
HIAE × .7 < occ.≤ .8	0.0312	-0.0776**	0.3643***	0.2541***	0.2875***	-0.0696	0.1415**	-0.0512**
	(0.0447)	(0.0378)	(0.0925)	(0.0654)	(0.0743)	(0.0926)	(0.0544)	(0.0240)
HIAE × occ.> .8	0.0771	-0.0737**	0.3698***	0.1591***	0.2722***	-0.0222	0.1554**	0.0442
	(0.0638)	(0.0344)	(0.0902)	(0.0551)	(0.0887)	(0.0885)	(0.0692)	(0.0313)
.7 < bed occ.≤ .8	-0.0420	-0.0370*	-0.1577	-0.0800*	-0.0329	-0.0137	0.0084	-0.0237
	(0.0428)	(0.0217)	(0.1055)	(0.0471)	(0.0461)	(0.0217)	(0.0312)	(0.0210)
bed occ.> .8	-0.0311	-0.0191	-0.1476	-0.0137	-0.0408	0.0202	0.0099	-0.0316
	(0.0490)	(0.0398)	(0.1090)	(0.0680)	(0.0520)	(0.0434)	(0.0386)	(0.0503)
Hosp. week	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Demographics	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Dist. of residence	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Any risk factor	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Ind. risk factors	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Symptoms	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.194	0.134	0.077	0.049	0.125	0.098	0.070	0.057
Mean DV	0.311	0.335	2.191	2.212	0.354	0.424	0.164	0.207
Observations	15,766	27,353	15,690	27,227	14,525	26,834	14,494	26,629

Note: This table reports OLS estimates of the effect AE's public hospital management on mortality. The model allows for interactions with different levels of bed occupation in the municipality, measured as the daily COVID-19 ICU bed occupancy in the Municipality of São Paulo. Standard errors, clustered by hospital, are reported in parentheses. Significance levels are indicated by $* < .1$, $** < .05$, $*** < .01$.

Table A.8: Effect of AE's public hospital management on mortality: Excluding Hospital Vila Santa Catarina

	(1)	(2)	(3)	(4)	(5)	(6)
HIAE hospital	-0.0556***	-0.0504***	-0.0230	-0.0277	-0.0305	-0.0160
	(0.0210)	(0.0176)	(0.0255)	(0.0256)	(0.0266)	(0.0269)
HIAE × occ.	-0.2684***	-0.2924***	-0.3167***	-0.3609***	-0.3925***	-0.4181***
	(0.0491)	(0.0436)	(0.0444)	(0.0418)	(0.0474)	(0.0474)
bed occupancy	0.1550	0.0944	0.0168	0.0613	0.0352	0.0000
	(0.2040)	(0.1907)	(0.2027)	(0.2032)	(0.2026)	(0.2008)
Hosp. week	Yes	Yes	Yes	Yes	Yes	Yes
Demographics	No	Yes	Yes	Yes	Yes	Yes
Dist. of residence	No	No	Yes	Yes	Yes	Yes
Any risk factor	No	No	No	Yes	Yes	Yes
Ind. risk factors	No	No	No	No	Yes	Yes
Symptoms	No	No	No	No	No	Yes
R^2	0.010	0.104	0.113	0.118	0.131	0.148
Mean DV	0.326	0.326	0.326	0.326	0.326	0.326
Observations	44,075	44,033	42,755	42,755	42,755	42,755

Note: This table reports OLS estimates of the effect AE's public hospital management on mortality. The model allows for interactions with different levels of bed occupation in the municipality, measured as the daily COVID-19 ICU bed occupancy in the Municipality of São Paulo. Standard errors, clustered by hospital, are reported in parentheses. Significance levels are indicated by $* < .1$, $** < .05$, $*** < .01$.