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Abstract

This study analyzes 3,470 public-sector hospitals in Brazil, comparing those with high and low intra-hospital mortality rates. It uses SUS administrative data from 2023 and 2013, supplemented with matched 2013 World Management Survey data for 260 hospitals. In 2023, hospitals with a high risk-standardized intra-hospital mortality rate (RSMR) were predominantly large, urban facilities with high patient volumes, longer hospital stays, and greater ICU capacity, suggesting they treat more critically ill patients. However, RSMR varied considerably within each hospital size group, particularly among large hospitals, indicating substantial heterogeneity in performance. Mortality patterns also differed by disease groups and state, and mortality worsened within-hospitals between 2013 and 2023, particularly in rural and small hospitals. Hospitals with high intra-hospital mortality in 2013 had stronger management practices, particularly in performance monitoring and target setting. These findings highlight the need for targeted policy interventions, improved resource allocation, staffing strategies, and management practices to address disparities in hospital performance and patient care quality. Our analysis also highlights the importance of developing reliable and routine measures of hospital performance, including for quality of care.

Keywords: Hospital performance, healthcare quality, hospital management, Brazil.

JEL codes: I11, I18, H51, O54

1. Introduction

Many middle-income countries are concerned about the low and variable efficiency and quality of their public sector hospitals. Identifying hospitals that perform well or poorly is critical to target policy, inform citizens and patients, and to encourage the spread of best practices. However, there is limited rigorous evidence in middle-income settings on what kinds of hospital perform well or poorly.

We conduct a positive deviance analysis to descriptively compare the characteristics of public sector hospitals in Brazil with high and low quality, as measured by risk-adjusted intra-hospital mortality (RSMR) in 2023. Specifically, we categorize hospitals based on their RSMR, and then use descriptive statistics and regression analysis to characterize hospitals in each category. We also compare the change in hospitals' quality between 2013 and 2023 and, for a subset of hospitals, examine the association of quality with hospital management measured in the World Management Survey (WMS) of Brazilian hospitals in 2013 (1).

Hospital performance has been examined in Latin America using a range of data sources and indicators, even when formal risk-standardized profiling is not common. In Chile, hospitals with higher patient-to-nurse ratios had significantly higher odds of in-hospital mortality and emergency readmission, and lower patient satisfaction, underscoring the importance of staffing and work environments for outcomes (2). In Brazil, analyses in São Paulo and in São Paulo/Rio Grande do Sul suggest that larger and teaching or specialized hospitals perform differently from smaller general facilities, and that mortality is strongly associated with case-mix, ICU use, and whether care is publicly financed (3,4). In Mexico, a longitudinal analysis of a national hospital accreditation program found no improvement in quality attributable to accreditation and even observed an increase all-cause in-hospital mortality rates post-accreditation (5). Together, these studies show that outcomes are closely linked to hospital characteristics—such as size, service scope, and staffing mix—but they rarely use RSMR measures.

In high-income countries, hospital profiling is more institutionalized and often relies on risk-standardized outcomes such as hospital standardized mortality ratios (HSMRs) or condition-specific risk-standardized mortality rates (RSMRs). In Canada, HSMRs are routinely used to monitor hospital quality; a longitudinal assessment of large teaching and community hospitals found that higher HSMRs were associated with worse readmission and length-of-stay profiles (6). In the United States, analyses of Medicare beneficiaries have used publicly reported 30-day risk-standardized mortality rates for conditions such as acute myocardial infarction, heart failure and pneumonia to compare hospitals; one study found that major teaching hospitals had modestly lower 30-day mortality than non-teaching hospitals after adjustment for patient characteristics, despite treating more complex patients (7). Accreditation is also widely used as a profiling tool, yet an observational study in US hospitals found that accreditation status was not clearly associated with lower risk-adjusted mortality and showed only small differences in readmissions, suggesting that organizational culture and clinical processes may matter more for outcomes than accreditation labels alone (8).

Recent evidence also suggests that hospital management affects hospital performance. In Brazil, outsourcing of hospital management to the private sector improved productivity and efficiency without worsening quality (9). In Chile, competitive recruitment and better compensation for public hospital managers reduced mortality by 8% (10). An analysis in the United States using World Management Survey found that hospitals with stronger management practices, such as monitoring and accountability, achieved significantly lower mortality rates (11).

Our analysis contributes to the broader literature on organizational performance and attributes of high and low-performing hospitals. First, we provide rigorous evidence on public sector hospitals in Brazil, which operates a comprehensive and sophisticated health system (12) and is the most populous country in LAC with about one-third of the region's population. Second, we characterize changes in quality over time within the same hospitals, in addition to providing cross-sectional analyses. Third, we provide evidence on hospital management, which has been studied mostly in high-income settings (1,11) but remains under-appreciated and under-researched in middle-income settings despite its likely importance (10,13). Fourth, our analysis highlights the value of – and need for more research on – reliable and routine measures of hospital and health system performance, such as intra-hospital mortality (14), as well as a better understanding of hospital management and other factors that determine quality of care in these establishments.

2. Methodology

We calculated the RSMR as the ratio of observed in-hospital deaths to the expected in-hospital deaths (see Appendix A for details and robustness checks). Following similar calculations in Canada, we first identified conditions – based on 3-digit ICD-10 codes – that together account for 80% of the national in-hospital mortality (Appendix Table B1) (15,16). For admissions with these conditions, we estimated the predicted probability of death using both logistic regression and random-forest model on patient-level variables, including sex, age, admissions category (elective or emergency), primary diagnosis ICD-10 chapters, and the Charlson Comorbidity Index (Appendix C). Based on model performance (Appendix Table A2), we use the random-forest predictions to aggregate the predicted probabilities at the hospital level and calculate the expected number of deaths, which we used to calculate the RSMR as observed in-hospital deaths divided by expected deaths, multiplied by the national mortality rate.

We categorized hospitals into high and low mortality based on their RSMR distribution. We split the sample at the median RSMR and also considered the top and bottom 20th percentiles of the national RSMR distribution. To minimize classification sensitivity, hospitals were labeled as high or low mortality only when both models produced the same classification; results were highly consistent across methods (Appendix Table A2). Within each group, we used bi-variate descriptive analyses of the distribution of hospitals and the average RSMR to explore differences between high and low-mortality hospitals at different hospital components including location (urban/rural), hospital size, service utilization (hospitalization, length of stay), and infrastructure characteristics (bed and health staff volume). Hospital size was defined by available beds: small (<50), medium (50-150), and large (>150). We also examined differences in disease-specific patterns in hospitalizations and mortality, as well as differences in RSMR across Brazilian states.

We examined shifts over time within the same hospitals, we descriptively compared changes in hospital classification (high- and low-mortality) between 2013 and 2023 . To further analyze the drivers of these shifts, we conducted a regression analysis where the dependent variable was the change in RSMR between 2013 and 2023. Covariates included the hospital location (urban/rural), hospital size (all available bed terciles), service utilization, capacity intensity (ICU beds per hospitalization) and infrastructure characteristics (working hours, equipment, rooms and staff volume), while controlling for state fixed effects.

We also examine the association between hospital characteristics and performance classification, using a logistic regression model in which the dependent variable is an indicator for low- versus high-mortality hospitals. The model incorporated robust standard errors and state fixed effects to account for unobserved regional factors.

In a secondary analysis on a subset of hospitals in 2013, we examine the association of being classified as a high or low mortality hospital and management characteristics collected as part of the 2013 WMS. This survey has been fielded in hospitals in the US, UK and Brazil (in 2013) and has been used in several prior analyses (1,11). The WMS scores 18 key management practices in three key areas: monitoring, targets and incentives / people management. The implementation uses a double-blind approach, where hospital managers are not told how they are being scored and are only asked open-ended questions. Similarly, enumerators are not told about the organization's performance: they only receive the hospital's name and contact information.

As in other studies and policy settings, the reliability of the classification according the RSMR is a critical factor in our analysis. There are several methodological challenges regarding the estimation of RSMR. In particular, the relatively low number of in-hospital deaths leads to class imbalance, which reduce model precision and affect hospital-level estimates. Additionally, variation in coding practices or unmeasured patient characteristics may not be fully accounted for by the model. These challenges can lead to misclassification. We examine the sensitivity of the classification to different modeling approaches and data, e.g., using logistics models and repeating the RSMR estimation using only hospitals with emergency admissions (Appendix A). Then we split the sample at the median and top and bottom 20th percentile, and use descriptive analysis to explore differences between groups and classifications. In addition, our comparison of changes within hospital between 2013 and 2023 accounts for observed and unobserved hospital and patient characteristics that are constant over time.

3. Data

We used hospital administrative data in 2013 and 2023 from the Hospital Information System (SIH) available through DATASUS, the Brazilian Unified Health System (SUS) public health data system. This data allows us to classify hospitals as high or low-mortality based on their risk-standardized mortality rate (Appendix B). We limited our data to hospitals with more than 25 admissions, general hospitals, elective and emergency admissions, excluding those for newborns under 30 days old, and hospitalizations exceeding 365 days. We also restricted the analysis to diagnosis groups that accounted for approximately 80% of national in-hospital deaths in 2013 and 2023, categorized by three-digit ICD-10 codes. This last filtering step had the largest impact on the number of hospitals in the final analysis sample although it did not significantly reduce the number of hospitalizations under consideration. The final analysis sample contains 79% of the hospitalizations and 30% of the hospitals included in the data source. The filtering steps and their impact on the dataset are documented in Appendix Table B2.

We obtained data on infrastructure and resources for hospitals that reported hospital admissions in 2023 from the National Registry of Health Establishments (CNES) (Appendix Table B3). These include the number and types of hospital beds, specialized services, basic (patient monitors) and high-technology medical equipment (imagining, life-support and anesthesia), and healthcare professionals, along with their workloads and geographic locations.

We further classified hospital admissions based on the primary ICD-10 diagnosis code. Each diagnosis was mapped to a single Global Burden of Disease (GBD) condition using a cross-walk provided by the Institute of Health Metrics and Evaluation, aligned with GBD Level 1 and Level 2 categories (17).

To examine the changes in hospitals' RSMR over time, we merged the 2023 final sample, after imposing filters, with the same final sample for 2013, at the establishment level. There are 3,470 hospitals in the 2023 data, and 3,502 in the 2013 data. Of these, 3,006 hospitals have data for both years.

We used the 2013 Brazil World Management Survey (WMS) to incorporate attributes of hospital management practices (11,13). This dataset provided information on operational, monitoring and target settings, people management and leadership. The WSM data only include information for 260 hospitals, 7.4% of the total hospitals in the hospitals data in 2013. Analyses involving these attributes were limited to this sample.

Finally, we also incorporated data from Meta's global urban areas dataset so as to classify hospitals as urban or rural based on geographic location (18). This allowed for spatial characterization of hospitals performance and analyze how geographic and demographic differences influences outcomes. Additional details on the data are available in Appendix Table B1 and B3.

4. Results

In both 2013 and 2023, the diagnoses accounting for 80% of national in-hospital deaths are broadly comparable (Appendix Table B4). Neoplasms are the largest contributor by ICD-10-chapter, accounting for more than 50% of these diagnoses in both years.

The random forest risk adjustment on all admissions (emergency and elective) performed well on performance metrics such as the Area Under the Curve (AUC) and specificity (Appendix Table A1). When comparing the classification based on the random forest risk adjustment with all admissions with other models (logistic) and data (emergency admissions only), we found a high degree of overlap in the designation of facilities as high or low mortality (Appendix Table A2). That is, the classification is not very sensitive to the specific approach to calculate RSMR.

4.1. Characteristics of hospitals with low or high intra-hospital mortality

We observed numerous differences in the characteristics of hospitals that have low or high RSMR (Table 1). The mean RSMR among high-mortality hospitals was 16% compared to 4.5% for low-mortality hospitals; this difference is statistically significant.

High-mortality hospitals (above-median RSMR) were more likely to be large urban facilities with high patient volume and longer average lengths of stay. These hospitals also had a greater number of beds: about twice as many total and clinical beds, three times as many surgical beds, and more than four times as many ICU beds per hospital as low-mortality hospitals. Additionally, high-mortality hospitals had higher staff-to-hospitalizations ratios, particularly among nurses.

In contrast, low-mortality hospitals tended to be smaller, located in rural areas, and had lower patient volumes, with an average of 676 total hospitalizations per facility versus 1,744 in high-mortality hospitals. These hospitals also exhibited shorter mean lengths of stay across all admissions (4.4 vs 6.9 days) and emergency admissions alone (4.4 vs 7.2 days). The volume of ICU resources was lower, with only 3.7 ICU beds per facility on average, compared to 16 in high-mortality hospitals.

These patterns are generally more pronounced when considering hospitals in the lowest or highest quintile of the RSMR distribution.

The type of diseases treated at low- and high-mortality hospitals were also different (Appendix Table D4). Among the diagnoses under consideration –those accounting for approximately 80% of national intra-hospital mortality– low-mortality hospitals had a higher percentage of hospitalizations due to communicable diseases (25%) compared to high-mortality hospitals (15%), especially respiratory infections and tuberculosis (17% vs 12%). In contrast, high-mortality hospitals treated more injuries cases (8%) than low-mortality hospitals (3.0%), possible reflecting differences in patient populations or hospital specialization. Both hospital groups had the same proportion of admissions for non-communicable diseases (NCD) (58%), but composition differed: low-mortality hospitals had more hospitalizations for other NCDs (7.1% vs 4.9%) and fewer digestive diseases (4.4% vs 5.7%). All differences are statistically significant.

Table 1. Characteristics of hospitals by mortality group, 2023

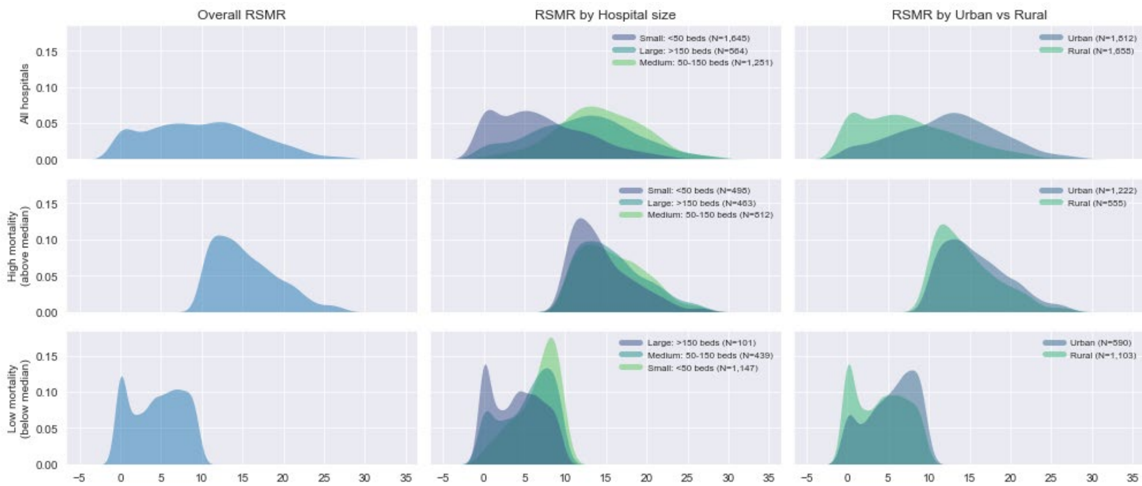
	All hospitals	Low mortality (Below median)	High mortality (Above median)	Lowest 20%	Highest 20%
Total number of hospitals	**3,470**	**1,693**	**1,777**	**621**	**651**
# in rural areas (% of hospitals)	47.8%	65.2%	31.2%	75.0%	24.6%
# in urban areas (% of hospitals)	52.2%	34.8%	68.8%	25.0%	75.4%
% of hospitals by size					
Large: > 150 beds	16.3%	6.0%	26.1%	2.3%	31.3%

Medium: 50-150 beds	36.1%	25.9%	45.7%	20.0%	48.7%
Small: < 50 beds	47.4%	67.7%	28.0%	77.6%	19.7%
% of hospitals by complexity					
Medium	98.6%	98.3%	98.9%	98.2%	99.4%
High	1.4%	1.7%	1.1%	1.8%	0.6%
Mortality rate					
Crude rate (mean)	9.56	4.10	14.75***	0.86	19.37***
RSMR (mean)	10.40	4.47	16.04***	0.98	21.33***
RSMR (median)	10.04	4.72	14.80***	0.34	19.86***
Health outcomes (per hospital)					
Elective and emergency admissions					
Total hospitalizations per hospital	1,223	676	1,744	347	1,751
Observed deaths per hospital	142	37	242	3	314
Expected deaths per hospital	141	76	202	36	200
Length of stay (mean)	5.7	4.4	6.9	3.7	8.1
Emergency admissions					
Total hospitalizations per hospitals	1,004	569	1,418	320	1,437
Observed deaths per hospitals	132	36	224	3	281
Expected deaths per hospitals	131	73	187	34	182
Length of stay (mean)	5.8	4.4	7.2	3.8	8.4
Infrastructure characteristics					
Hospital beds per 100 admissions	7.2	8.1	6.8	11.6	7.4
Hospital beds per hospital					
Total	87.7	55.1	118.7	40.3	130.1
ICU	9.9	3.7	15.7	1.5	19.2
Surgical	20.9	11.1	30.2	7.5	34.0
Clinical	32.7	22.7	42.1	16.0	44.1
Complementary	12.6	5.1	19.7	2.6	24.3
Health staff per hospital					
Total	354	169	530	87	573
Doctors	140	70	206	31	201
Nurses	43	20	64	11	75
Average working hours	25.8	25.8	25.7	26.4	26.3
Equipment per hospital	184	86	277	42	297

Source: Author's own elaboration.
Notes: Two-sided tests of group differences for mortality metrics only: Welch's t test for means; Mann–Whitney U for medians. Significance thresholds: $p < 0.05$ (*), $p < 0.01$ (**), $p < 0.001$ (***). Equipment refers to installed inpatient units reported in CNES (2023), including imaging (X-ray/CT/MRI/ultrasound), life-support/anesthesia (ventilators, defibrillators, anesthesia machines), and patient monitors.

Within high-mortality hospitals, the average RSMR was slightly higher in urban hospitals (15%) than rural hospitals (14%) (Figure 1). In contrast, among low-mortality hospitals, the urban-rural difference was less than one percentage point. Across hospital sizes, high-mortality hospitals of medium size (50-150 beds) had the highest RSMR (16%) compared to smaller hospitals (14%). Among low-mortality hospitals, larger hospitals (>150 beds) showed higher RSMR (5.5%) compared to smaller hospitals (3.7%) (Appendix Table D2).

Figure 1. Risk-standardized mortality rate by groups, 2023



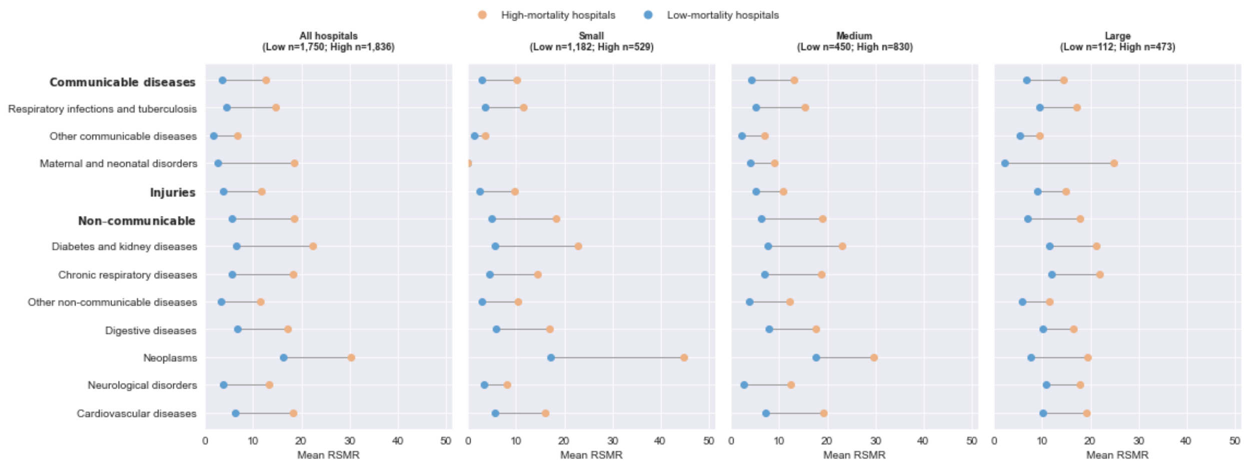
Source: Author's own elaboration.

Notes: Figure 1 presents the kernel density estimation (KDE) with Gaussian smoothing. The number of hospitals for each group is shown in parentheses.

Although high-mortality hospitals had roughly three times the patient volume compared to low-mortality hospitals (Table 1), the distribution of expected deaths across disease categories was similar between both groups, with some exceptions, suggesting differences in the types and severity of patients they admit (Appendix D4). Specifically, we observed that low-mortality hospitals had proportionally more expected deaths attributed to communicable, maternal, neonatal and nutritional conditions (CMNNs, 30% vs 20%), particularly respiratory infections and other communicable conditions. In contrast, high-mortality hospitals expected a slightly higher share of deaths from injuries (4.1% vs. 1.5%) and digestive diseases (5.2% vs. 3.5%).

In contrast, Figure 2 shows differences in RSMR between high- and low-mortality hospitals. Overall, RSMR in high-mortality hospitals was consistently at least three times higher than in low-mortality hospitals across all disease groups; for example, neoplasms averaged 31% in high-mortality hospitals versus 15% in low-mortality hospitals, and diabetes & kidney diseases averaged 22% versus 7%. These gaps vary by hospital size: in small hospital, RSMR is around four times higher for injuries (10% vs 2.3%) and diabetes and kidney diseases (22% vs 6%); in medium hospitals, neurological disorders are about five times higher (12% vs 2.3%); and in large hospitals, maternal and neonatal disorders are ten times higher in high-mortality hospitals (25% vs 2.4%).

Figure 2. Risk-standardized mortality rate by disease groups, 2023



Source: Author's own elaboration.

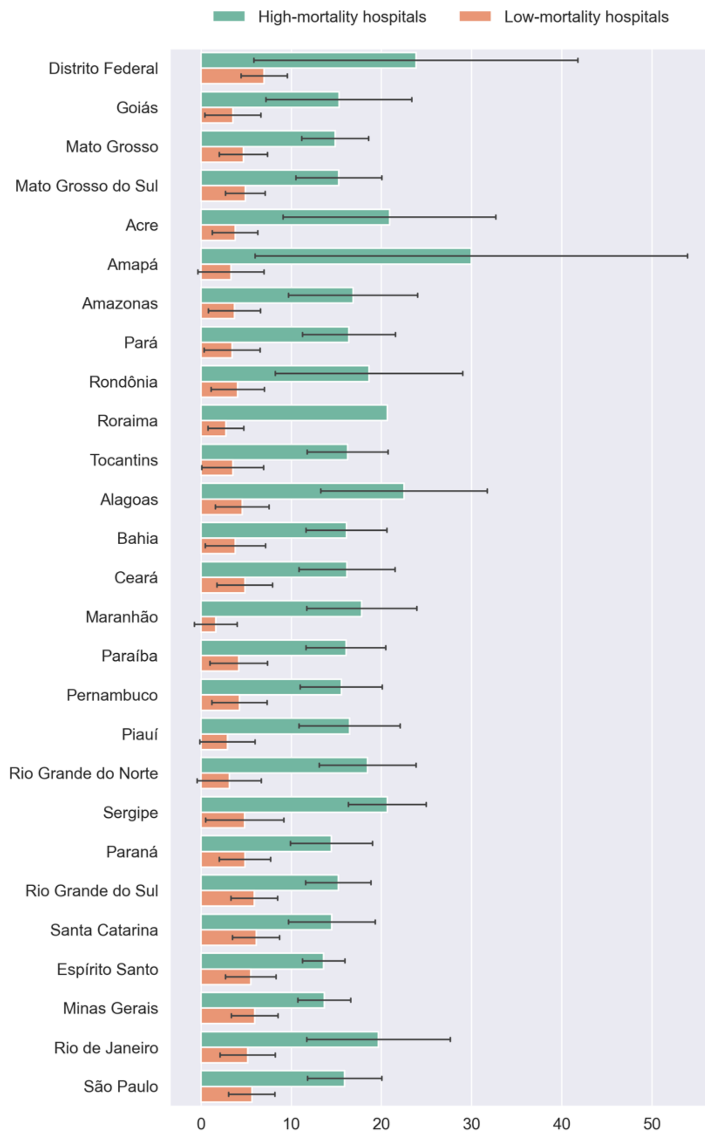
Notes: Figure show the mean RSMR (%) across hospitals within each disease group. Hospital admissions were classified based on the primary ICD-10 diagnosis code. Each diagnosis was mapped to a single Global Burden of Disease (GBD) condition using the official IHME mapping, aligned with GBD Level 1 and Level 2 categories.

4.2. Geographic differences

We observed significant variation in mortality rates and distribution of hospitals across states (*Unidade Federativa*, UF) (Figure 3). The highest RSMR values for high-mortality hospitals were observed in Amapa (30%) and Distrito Federal (24%), both of which also had 25% and 65% share of hospitals classified in the high-mortality group, respectively (Appendix Table D1). By contrast, Espiritu Santo and Minas Gerais reported the lowest RSMR among high-mortality hospitals and also a smaller share of facilities classified as high-mortality (under 50% of hospitals in each state).

In terms of the overall distribution, 3 states have at least 70% of hospitals in the high-mortality group, including Sergipe (75%), Sau Paulo (77%), and Rio de Janeiro (81%). Meanwhile, 11 states had at least 60% of hospitals in low-mortality group, with Roraima (83%) and Tocantins (79%) had a greater share of hospital in the low-mortality group. The Northeast and Southeast regions had a larger proportion of hospitals in the high-mortality group, whereas the North and Central-West regions showed a higher concentration of hospitals with high RSMR values. The South region showed a moderate concentration of high-mortality hospitals (35-65%), with RSMR values closer to the national median, indicating less pronounced performance gaps between high- and low-mortality hospitals compared to other regions.

Figure 3. Risk-standardized mortality rate by UF, 2023



Source: Author's own elaboration.
Notes: Bars represent the mean RSMR (%) by hospital groups for each state (Unidade federativa, UF). Horizontal lines indicate the 95% confidence intervals (CIs).

4.3. Factors associated with low or high mortality

Table 2 presents the key factors associated with hospital performance. We found that hospitals in urban areas were significantly more likely to be classified as high mortality, reinforcing the disparities in performance between urban and rural areas. Hospitals with more beds per hospitalization had lower odds of being classified as high mortality.

Higher hospitalization volume and longer lengths of stay was associated with a greater probability of a being a high mortality hospital. Among infrastructure characteristics, hospitals with higher average working hours by doctors and nurses were more likely to be classified as high mortality, indicating that increase workload may negatively affect mortality outcomes. The other infrastructure indicators, however, did not show strong associations with performance classification.

Table 2. Factors associated with high mortality among hospitals, 2023

	Coefficient	Marginal Effects	Odds Ratio	Std. Error	p-value	CI Lower	CI Upper
Urban area (ref: rural)	0.222	0.036	1.249	1.057	0.000	1.121	1.391
# of beds per hospitalizations	-0.079	-0.013	0.924	1.093	0.373	0.776	1.100
# of ICU beds per hospitalizations	0.257	0.042	1.292	1.116	0.019	1.043	1.602
Size (ref: large)							
Small: < 50 beds	0.016	0.003	1.016	1.079	0.839	0.874	1.180
Medium: 50-150 beds	-0.237	-0.039	0.789	1.103	0.015	0.652	0.955
Hospitalizations (ref: low volume)							
Medium volume	-0.044	-0.007	0.957	1.062	0.466	0.851	1.077
High volume	0.221	0.036	1.247	1.089	0.009	1.056	1.474
Average length of stay (ref: low)							
Medium	0.547	0.090	1.729	1.051	0.000	1.568	1.906
Long	1.035	0.170	2.815	1.063	0.000	2.497	3.174
Infrastructure characteristics							
Average working hours	0.130	0.021	1.139	1.047	0.005	1.040	1.247
# equipment per hospitalizations	-0.180	-0.030	0.835	1.143	0.178	0.642	1.085
# rooms per hospitalizations	-0.107	-0.018	0.899	1.081	0.172	0.771	1.048
# health staff per hospitalizations	-0.028	-0.005	0.972	1.106	0.781	0.797	1.186

Source: Author's own elaboration.

Notes: Dependent variable is 0 if RSMR is below median (low-mortality hospital), 1 if RSMR is above median (high-mortality hospital). Marginal effects represent the change in the predicted probability of low mortality for one-unit change in each variable, calculated as the average partial effect (APE) at the mean of independent variables. Hospitalization volume and average length of stay categories were defined using terciles.

4.4. Hospitals performance over time

Comparing the same hospitals in 2023 and 2013, we observed an increase in overall RSMR. Figure 1 shows that between 2013 and 2023, median RSMR increased, with a general upward shift in mortality rates across hospital categories, from a mean of 5.4 in 2013 to 10 in 2023. Within-hospital RSMR increased for 71% of hospitals and decreased for 24.8% of hospitals. The classification as high or low-mortality hospital also changed. Around 34% of hospitals that were classified as low mortality in 2013 remained in that category in 2023, while 11% of hospitals transitioned into a higher mortality classification. In contrast, 41% of hospitals that were classified as high mortality in 2013 remained in that category in 2023, and only 14% transitioned into a lower mortality group.

Figure 4. Change in the facility-level risk-standardized mortality rate between 2013 and 2023

Source: Author's own elaboration.

Notes: Hospitals were classified into high- and low-mortality groups based on their RSMR calculated separately for each year (2013 and 2023). In each year, we identified the set of conditions representing approximately 80% of national intra-hospital mortality, which remained consistently across both years (Appendix Table B2), and then calculated the RSMR accordingly.

The largest increases in RSMR over time were observed in rural areas, particularly among high-mortality hospitals, indicating that rural hospitals experienced worsening mortality trend compared to urban facilities (Appendix Tables D3 and D5). Among low mortality hospitals, large hospitals experienced an increase in RSMR. In contrast, among high-mortality hospitals, the greatest increase was observed in small hospitals.

4.5. Management score by hospital performance

To assess hospital management practices, we analyzed a subsample of 260 hospitals from the World Management Survey (WMS) for which data were available in 2013. The characteristics of hospitals in this subsample are broadly comparable to those in the overall analytical sample (Appendix Table D6).

The management scores in Table 3 show that hospitals above-median RSMR, high-mortality hospitals, had significantly higher overall management scores (2.27 vs 1.84, $p<0.0000$), and scored better on all subcomponents of the WMS. These results indicate that high-mortality facilities tend to have more structured management practices as measured by the WMS. However, this pattern largely reflects the composition of the sample: hospitals in these groups were predominantly large, urban, and high-complexity facilities, which may be characterized by more formalized administrative structures and reporting systems (Appendix Table D6). The empirically largest differences were found the monitoring and target setting, where high-mortality hospitals showed significantly higher scores in performance tracking, performance review, target time horizon, and process problem documentation ($p<0.0005$). There is significant differences in core operations (e.g., standardization of processes and rationally for adoption) and people management, including rewarding and retaining high-performing staff.

Table 3. Management score by mortality group, 2013

	Low mortality (Below median) (N=49)	High mortality (Above median) (N=216)	T-Statistic	P-value
Overall management score	**1.84**	**2.27**	**-4.46**	**0.0000**
Core operations				
Adoption of modern practices	2.19	2.45	-1.99	0.0506
Rationale for adoption	2.02	2.50	-3.45	0.0010
Standardization of processes	2.00	2.57	-3.93	0.0002
Good use of human resources	2.04	2.36	-2.61	0.0110
Monitoring and target setting				
Process problem documentation	2.09	2.64	-4.00	0.0002
Performance tracking	1.91	2.69	-5.09	0.0000
Performance review	1.94	2.61	-4.44	0.0000
Performance dialogue	1.89	2.46	-3.98	0.0002
Consequence management	2.02	2.58	-3.96	0.0002
Target balance	1.89	2.39	-3.38	0.0012
Target interconnection	1.70	2.27	-3.70	0.0004
Target time horizon	1.55	2.17	-4.18	0.0001
Target stretching	1.64	2.08	-3.34	0.0013
Performance clarity	1.26	1.51	-2.81	0.0063
People management				
Managing human capital	1.55	1.68	-1.04	0.3016
Rewarding high performance	2.26	2.56	-2.23	0.0286
Fixing poor performers	1.64	1.90	-2.41	0.0183
Promoting high performers	1.49	1.62	-1.26	0.2131
Attracting human capital	1.72	1.92	-1.65	0.1028
Retaining huma capital	2.00	2.38	-2.54	0.0136
Leadership				
Clearly defined accountability	1.72	1.91	-1.36	0.1768

Source: Author's own elaboration.
Notes: Table presents management scores means and two-sample t-tests compare means between low- and high-mortality hospitals (t-statistic and p-value reported).

5. Discussion

Hospitals are a critical part of health systems and ensuring high-quality hospital care is a foremost concern of policy makers, including in LAC. We used administrative data on hospital admissions to describe the characteristics of hospitals with high or low RSMR. We found that high-mortality hospitals in Brazil had an average RSMR of 16%, compared to 4.5% in low-mortality hospitals, and were primarily large, urban facilities with higher patient volumes, longer hospital stays, and greater ICU capacity. Between 2013 and 2023, overall hospital performance worsened, particularly in rural and small hospitals. High-mortality hospitals exhibited stronger management practices in monitoring and target setting without a clear link to improved patient outcomes.

When segmenting hospital by size, we observed consistent differences in RSMR across disease groups, but the magnitude and pattern of these gaps varied substantially. Smaller facilities showed sharper contrasts in conditions such as injuries and diabetes, while gaps in larger hospitals were most evident in maternal, neonatal, and neurological conditions. Across all hospital types, non-communicable diseases, particularly neoplasms and cardiovascular, diabetes and kidney conditions, accounted for roughly half of expected in-hospital deaths, with the largest absolute mortality burden concentrated in larger and more complex facilities. These results suggest that observed performance gaps may reflect not only the quality of care but also differences in patient profiles and service offered across hospital types rather than a single underlying factor.

Our findings have several implications. First, there is large variation in mortality across hospitals and geographies. This urgently merits further investigation to understand and remedy possible inequalities in access to high-quality care. Our risk-standardization accounts for a number of observable patient characteristics, suggesting that the variation in outcomes may not (only) be due to the composition of the patient populations (differences in the case-mix). However, current models still face challenges in accurately estimating expected mortality. In our case, the relatively low number of in-hospital deaths results in class imbalance, which can reduce model precision and affect hospital-level comparisons. Moreover, unmeasured factors such as patient severity or hospital-specific practices may not be fully captured by the variables used in the model. Further development of risk adjustment models should be a research priority and could support this additional analysis. Second, we find that hospitals' RSMR changes over the decade prior to 2023, and generally worsens. This also requires urgent policy attention and further analysis.

Finally, we find statistically significant yet modest differences in the management scores of hospitals with high or low RSMR. This aligns with the generally mixed findings of a recent systematic review of the relation of management practices and quality of hospital care (19). However, this review did not identify eligible studies on LAC countries and found substantial variation across settings, mostly between high-income settings (the United State and the United Kingdom) and lower-income settings. Moreover, the review also found that studies using the WMS were more likely to find statistically significant positive associations, compared to studies that adapted the WMS or used a different approach. This could indicate a need to develop measures of management for LAC and middle-income settings, and highlights an important evidence gap regarding the management of hospitals in LAC.

Our analysis has several limitations. First, the veracity of our measure of RSMR depends on how well the risk adjustment model works. Some patterns in the findings – such as the association of high RSMR and large hospitals and possibly also the higher management scores – suggest that there may be determinants of mortality that are unaccounted for in our approach, such as patient severity and case complexity. Future research could further segment hospitals by size or focus on specific high-impact conditions (e.g., acute myocardial infarction) to better isolate performance-related variation. Our sensitivity analyses did not yield qualitatively different findings and our within-hospital comparison between 2013 and 2023 accounts time-invariant unobserved characteristics of hospitals and their patient populations. However, improving the risk adjustment models and requisite data should be a priority for future research. Second, we use a single – if commonly used – measure of quality. Future research could examine additional quality indicators (14).

Overall, our findings indicate an urgent need to better understand hospital performance, ideally using standardized measures that are reliable and could be routinely monitored using administrative data. This should go alongside with additional investigations of determinants of quality of care, both to inform the measurement and identify hospitals and areas for targeted intervention.

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Appendix

Appendix A: Calculation of the hospital-specific risk-standardized mortality rate

For each hospital, we calculated the risk-standardized mortality rate (RSMR) as the product of the hospital standardized mortality rate (SMR) and the national average mortality rate. We estimate the RSMR using data administrative hospital for 2023.

Standardized mortality rate

We calculated the SMR as the ratio of the observed to the expected deaths. Following Canadian Institute for Health Information (CIHI) (16) and other authors (15) the expected number of deaths was estimated using a predictive model for patient i in hospital j. The model is specific as:

$$Y_{ij} = \mathrm{f}(\mu, X_{ij}, \alpha_j)$$

where Y_{ij} is a binary indicator for in-hospital death, and X_{ij} is a matrix of patient-level covariates including sex, age in 5-year groups, admission category, Charlson Comorbidity Index, the ICD-10 chapter of the primary diagnosis, and whether a patient was transferred from another hospitals. While some methodologies estimate separate models for each condition or diagnosis group (16,20), we used a single model that included the ICD-10 chapter of the primary diagnosis as a covariate. We considered multiple predicted models, including logistic regression and random forest, to estimate the expected number of deaths. The final model was chosen based on performance indicators as the area under the curve (AUC) and F1 score in a sensitivity analysis (see below).

Using the random forest model, we calculated the predicted probability of death for each patient i in hospital j, accounting for risks factors identified, by aggregating predictions from multiple decision trees. Each tree estimated this probability based on observed frequencies of deaths in similar patient groups, and the final probability was obtained by averaging across all trees. These probabilities are then summed across all patients within hospital j to obtain the expected number of deaths:

$$Expected\ deaths_j = \sum_{i=1}^{n_j} \hat{Y}_{ij}$$

The standardized mortality ratio (SMR) for each hospital was then calculated as:

$$SMR_j = \frac{Observed\ deaths_j}{Expected\ deaths_j}$$

Risk-standardized mortality rate

To enable comparison of hospital mortality rate to the national average, we multiplied the SMR by the overall outcome ratio. This RSMR for hospital j is given by:

$$RSMR_j = \frac{Observed\ deaths_j}{Expected\ deaths_j} \times National\ mortality\ rate$$

Model performance evaluation

To ensure the robustness of the expected mortality estimates, we compared the performance of logistic regression and random forest models (see Table A1). We observed that the random forest outperforms logistic regression at calculating expected mortality rates as it presents a higher AUC, indicating better overall predictive performance, and higher specificity, which reduces false positives when estimating deaths.

Table A1. Model performance metrics for mortality prediction

Model	Admission category	AUC	Precision	Recall	F1-Score
Logit	Emergency, elective	75.7%	11.3%	98.5%	20.3%
Logit	Emergency	74.1%	12.9%	98.4%	22.9%
Random Forest	Emergency, elective	77.9%	11.1%	95.7%	19.8%
Random Forest	Emergency	75.3%	12.7%	95.8%	22.4%

Source: Author's own elaboration.

Table A2. Low- and high-mortality classification based on model

			Logit				Random Forest			
			All		Emergency		All		Emergency	
Model	**Admission**	**Category**	**High**	**Low**	**High**	**Low**	**High**	**Low**	**High**	**Low**
Logit	Emergency, elective	High			93.3%	2.3%	96.9%	2.8%	93.0%	2.6%
Logit	Emergency, elective	Low			6.7%	97.7%	3.1%	97.2%	7.0%	97.4%
Logit	Emergency	High	97.7%	6.6%			98.4%	5.8%	98.9%	1.2%
Logit	Emergency	Low	2.3%	93.4%			1.6%	94.2%	1.1%	98.8%
Random Forest	Emergency, elective	High	97.0%	2.9%	94.1%	1.6%			94.6%	1.1%
Random Forest	Emergency, elective	Low	3.0%	97.1%	5.9%	98.4%			5.4%	98.9%
Random Forest	Emergency	High	97.4%	6.8%	98.8%	1.2%	98.9%	5.3%		
Random Forest	Emergency	Low	2.6%	93.2%	1.2%	98.8%	1.1%	94.7%		

Source: Author's own elaboration.

Notes: Table A2 compares the classification between models that split hospitals into high and low mortality at the median RSMR. Differences between Logistic regression and Random Forest were of less than 7 percentage points across all model specifications.

Appendix B. Supporting tables

Table B1. Diagnosis codes accounting for 80% of in-hospital deaths, 2023

ICD-10 Chapter	% deaths (1)	% deaths (2)	Principal diagnosis
I: Certain infectious and parasitic diseases	10.4	11.5	A15, A31, A41, A48, A49, B34
II: Neoplasms	53.8	56.0	C10, C15- C18, C20-C22, C24-C25, C32, C34, C43-C44, C49-C50, C53-C54, C56, C61, C64, C67, C71, C76, C78-C80, C90-C92
III: Diseases of the blood and blood-forming organs	0.6	0.3	D64
IV: Endocrine, nutritional, and metabolic diseases	1.1	0.9	E10, E14, E46, E87
VI: Diseases of the nervous system	0.9	0.6	G45, G91
IX: Diseases of the circulatory system	9.5	9.7	I20, I21, I26, I46, I50, I60, I61, I63, I64, I71, I74
X: Diseases of the respiratory system	9.8	10.8	J12, J15, J18, J44, J81, J90, J93, J96
XI: Diseases of the digestive system	3.7	2.8	K56, K65, K70, K72, K74, K76, K92
XIV: Diseases of the genitourinary system	2.9	2.9	N17, N18, N39
XVI: Certain conditions originating in the perinatal period	0.9	0.8	P07, P22
XVIII: Symptoms, signs, and abnormal clinical and laboratory findings, not elsewhere classified	1.9	1.7	R02, R10, R57
XIX: Injury, poisoning, and certain other external causes	2.9	1.9	S06, S72, T81

Source: Author's own elaboration based on 2023 administrative hospitalization data from SIHSUS-DATASUS.
Notes: The percentages under column (1) show the distribution of in-hospital deaths before data preprocessing, and under column (2) show the distribution after preprocessing data.

Table B2. Hospital-admissions case selection filters, 2023

Case selection	% of hospitalizations	% of hospitals
All admissions	100%	100%
At least 25 hospitalizations	98%	100%
General hospitals only	80%	84%
Elective and emergency admissions	80%	84%
Age at admission over 30 days	80%	81%
Length of stay of up to 365 days	80%	81%
80% of national in-hospital deaths	79%	30%

Source: Author's own elaboration.

Table B3. Data sources

Variables	Year	Source
Hospitals	2013, 2023	CNES-ST
Health outcomes	2013, 2023	SIHSUS
Hospitals characteristics		
Specialized services	2023	CNES-ST
Beds	2023	CNES-LT
Equipment	2023	CNES-EQ
Professionals	2023	CNES-PR
Management practices	2013	WMS

Source: Author's own elaboration.

Notes: Equipment refers to installed inpatient units reported in CNES (2023), including imaging (X-ray/CT/MRI/ultrasound), life-support/anesthesia (ventilators, defibrillators, anesthesia machines), and patient monitors. Counts reflect units registered to each facility; mobile/external units not linked to the hospital CNES record are excluded.

Table B4. Share of hospitalizations by diagnosis ICD-10-chapter, before and after data processing, 2023 vs 2013

		Before data processing		After data processing	
ICD-10 code	**ICD-10 Chapter**	**2013**	**2023**	**2013**	**2023**
I	Certain infectious and parasitic diseases	8.3%	10.4%	8.8%	11.5%
II	Neoplasms	52.6%	53.8%	54.8%	56.0%
III	Disease of the blood and blood-forming organs	0.5%	0.6%	0.2%	0.3%
IV	Endocrine, nutritional, and metabolic diseases	1.9%	1.1%	1.8%	0.9%
V	Mental and behavioral disorders	0.1%	0.1%	-	-
VI	Diseases of the nervous system	1.1%	0.9%	0.8%	0.6%
VII	Diseases of the eye and adnexa	0.0%	0.0%	-	-
VIII	Diseases of the ear and mastoid process	0.0%	0.0%	-	-
IX	Diseases of the circulatory system	10.6%	9.5%	11.1%	9.7%
X	Diseases of the respiratory system	10.7%	9.8%	11.8%	10.8%
XI	Diseases of the digestive system	4.3%	3.7%	3.4%	2.8%
XII	Diseases of the skin and subcutaneous tissue	0.4%	0.5%	0.2%	0.2%
XIII	Diseases of the musculoskeletal system and connective tissue	0.5%	0.4%	-	-
XIV	Diseases of the genitourinary system	2.2%	2.9%	2.2%	3.1%
XV	Pregnancy, childbirth and the puerperium	0.1%	0.1%	-	-
XVI	Certain conditions originating in the perinatal period	1.4%	0.9%	1.3%	0.8%
XVII	Congenital malformations, deformations and chromosomal abnormalities	0.2%	0.2%	-	-
XVIII	Symptoms, signs and abnormal clinical and laboratory findings	1.4%	1.9%	1.3%	1.7%
XIX	Injury, poisoning and certain other consequences of external causes	3.4%	2.9%	2.4%	1.9%
XX	External causes of morbidity and mortality	0.1%	-	-	-
XXI	Factors influencing health status and contact with health services	0.2%	0.2%	0.1%	-
XXII	Codes for special purposes	-	0.0%	-	-

Source: Author's own elaboration based on 2013 and 2023 administrative hospitalization data from SIHSUS-DATASUS.
Notes: Table shows the shares of hospitalizations within each ICD-10 chapter. "Before" and "After" reflect data processing steps described in Methods (e.g., validity checks and cleaning). Chapters shown are those accounting for ~80% of national in-hospital deaths.

Appendix C. Charlson Index score

We calculated the comorbidity score using the Charlson Comorbidity Index (CCI) score for each hospitalization based on the primary, secondary, and all the additional recorded diagnosis from the administrative admissions data. First, we mapped the 17 categories of medical conditions in the original CCI to the correspond International Classification of Diseases (ICD-10) codes following an R package for computing comorbidity scores (21). Each diagnosis code was assigned the appropriate score based on its mapped category (see Table C1). Second, to address duplications, we adjusted for patients with multiple diagnosis codes that fall under the same comorbidity category. After resolving duplicities, we summed the scores to calculate the total comorbidity score for each hospitalization. Third, we adjusted the total CCI to account for increased risk with age. Specifically, we added 1 point for every 10 years starting at 50 years old: 1 point for patients aged 50-59 years, 2 points for ages 60-69, 3 points for ages 70-79, and 4 points patients aged 80 years or older.

Table C1. Hospital-admissions case selection filters

Comorbidity group	Index Score	ICD-10 codes
Acute myocardial infarction	1	I21, I22, I252
Congestive heart failure	1	I099, I110, I130, I132, I255, I420, I425, I426, I427, I428, I429, I43, I50, P290
Peripheral vascular disease	1	I70, I71, I731, I738, I739, I771, I790, I792, K551, K558, K559, Z958, Z959
Cerebrovascular disease	1	G45, G46, H340, I60-I69
Dementia	1	F00-F03, F051, G30, G311
Chronic obstructive pulmonary disease	1	I278, I279, J40- J47, J60- J67, J684, J701, J703
Rheumatoid disease	1	M05, M06, M315, M32-M34, M351, M353, M360
Peptic ulcer disease	1	K25- K28
Mild liver disease	1	B18, K700- K703, K709, K713-K715, K717, K73, K74, K760, K762-K764, K768, K769, Z944
Diabetes without complications	1	E100, E101, E106, E108-E111, E116, E118-E121, E126, E128-E131, E136, E138-E141, E146, E148, E149
Diabetes with complications	2	E102-E105, E107, E112-E115, E117, E122- E125, E127, E132-E135, E137, E142-E145, E147
Hemiplegia or paraplegia	2	G041, G114, G801, G802, G81, G82, G830-G834, G839
Renal disease	2	I120, I131, N032- N037, N052- N057, N18, N19, N250, Z490, Z491, Z492, Z940, Z992
Cancer any malignancy	2	C00- C97
Moderate or severe liver disease	3	I850, I859, I864, I982, K704, K711, K721, K729, K765, K766, K767
Metastatic solid tumor	6	C77-C80
AIDS or HIV	6	B20-B22, B24

Source: Author's own elaboration.

Appendix D. Additional results

Table D1. Number and percentage of hospitals by mortality group and states (UF: Unidade Federativa), 2023

Federative units	All hospitals	Low mortality (Below median)	High mortality (Above median)	Lowest 20%	Highest 20%
North					
Rondônia	39	69%	31%	23%	13%
Acre	11	55%	45%	9%	18%
Amazonas	63	65%	35%	29%	8%
Roraima	6	83%	17%	50%	17%
Pará	152	64%	36%	32%	15%
Amapá	12	75%	25%	42%	17%
Tocantins	33	79%	21%	42%	9%
Northeast					
Maranhão	191	71%	29%	55%	15%
Piauí	62	63%	37%	37%	15%
Ceará	171	53%	47%	17%	17%
Rio Grande do Norte	62	44%	56%	26%	32%
Paraíba	67	36%	64%	13%	27%
Pernambuco	146	56%	44%	23%	14%
Alagoas	34	35%	65%	12%	47%
Sergipe	20	25%	75%	10%	65%
Bahia	340	45%	55%	21%	23%
Southeast					
Minas Gerais	433	53%	47%	9%	7%
Espirito Santo	57	47%	53%	14%	9%
Rio de Janeiro	149	19%	81%	5%	48%
São Paulo	440	23%	77%	5%	32%
South					
Paraná	230	64%	36%	20%	7%
Santa Catarina	155	48%	52%	8%	12%
Rio Grande do Sul	234	35%	65%	5%	22%
Central-West					
Mato Grosso do Sul	74	68%	32%	19%	11%
Mato Grosso	84	54%	46%	13%	14%
Goiás	188	66%	34%	31%	10%
Distrito Federal	17	35%	65%	6%	29%

Source: Author's own elaboration.

Table D2. Risk-standardized mortality rate (%) among hospitals by mortality group, 2023

	All hospitals	Low mortality (Below median)	High mortality (Above median)	Lowest 20%	Highest 20%
Total					
Crude rate (median)	8.8	3.9	13.8	0.2	18.6
Crude rate (mean)	9.6	4.1	14.8	0.9	19.4
Crude emergency rate (mean)	10.1	4.3	15.6	0.9	20.3
RSMR (median)	10.0	4.7	14.8	0.3	19.9
RSMR (mean)	10.4	4.5	16.0	1.0	21.3
RSMR emergency (mean)	9.0	4.0	13.9	0.9	18.2
General characteristics					
Rural	7.7	4.0	15.1	0.9	21.1
Urban	12.8	5.3	16.5	1.2	21.4
Health centers by size					
Large: > 150 beds	14.9	6.4	16.8	1.7	21.5
Medium: 50-150 beds	12.4	5.3	16.3	1.1	21.1
Small: < 50 beds	7.3	4.0	14.9	0.9	21.3
by GBD conditions					
CMNN	8.3	3.5	12.8	0.8	16.9
Respiratory infections and tuberculosis	9.8	4.3	14.9	1.0	19.5
Other communicable diseases	4.5	1.8	6.9	0.4	8.7
Maternal and neonatal disorders	15.2	2.3	18.5	0.7	12.9
Injuries	8.3	3.6	11.8	1.0	16.3
NCD	8.3	3.6	11.8	1.0	16.3
Diabetes and kidney diseases	12.2	5.4	18.7	1.3	25.1
Chronic respiratory diseases	14.9	6.5	22.3	1.6	28.6
Other non-communicable diseases	12.5	5.6	18.5	1.9	24.1
Digestive diseases	7.6	3.2	11.6	0.6	15.9
Neoplasms	12.3	6.4	17.2	1.4	22.4
Neurological disorders	24.6	14.6	30.5	2.3	35.2
Cardiovascular diseases	9.6	3.8	13.4	0.2	20.5

Source: Author's own elaboration.
Notes: Table shows the group specific mean RSMR for hospitals in that category. Hospital admissions were classified based on the primary ICD-10 diagnosis code. Each diagnosis was mapped to a single Global Burden of Disease (GBD) condition using the official IHME mapping, aligned with GBD Level 1 and Level 2 categories. CMNN stands for communicable, maternal, neonatal and nutritional deficiencies. NCD stands for non-communicable diseases.

Table D3. Change in risk-standardized mortality rate among hospitals by mortality group, 2023 vs 2013 (percentage points)

	All hospitals	Low mortality (Below median)	High mortality (Above median)	Lowest 20%	Highest 20%
Total					
Crude rate (median)	4.0	2.7	3.9	0.2	3.8
Crude rate (mean)	3.1	2.5	3.7	0.8	3.3
Crude emergency rate (mean)	3.0	2.7	3.6	0.8	2.8
RSMR (mean)	5.0	3.1	5.7	1.0	5.9
RSMR emergency (mean)	2.2	2.3	2.3	0.8	1.2
General characteristics					
Rural	3.8	2.5	5.8	0.8	4.3
Urban	3.2	3.4	3.9	1.1	4.3
Health centers by size					
Large: > 150 beds	0.9	4.3	2.2	1.6	3.8
Medium: 50-150 beds	4.1	3.1	4.8	1.0	4.6
Small: < 50 beds	3.6	2.5	6.0	0.9	4.4
by GBD conditions					
CMNN	2.4	2.3	2.7	0.8	2.0
Respiratory infections and tuberculosis	6.3	3.8	8.8	1.0	9.8
Other communicable diseases	-2.8	0.1	-5.5	0.3	-9.1
Maternal and neonatal disorders	6.9	0.2	8.8	0.7	1.8
Injuries	2.8	3.1	3.7	1.0	5.0
NCD	2.8	3.1	3.7	1.0	5.0
Diabetes and kidney diseases	4.3	3.0	5.8	1.2	6.3
Chronic respiratory diseases	5.7	3.0	8.3	1.3	9.0
Other non-communicable diseases	-0.7	0.1	2.4	1.5	4.9
Digestive diseases	0.2	0.9	0.0	0.5	-0.2
Neoplasms	8.3	5.4	10.8	1.3	13.0
Neurological disorders	14.1	11.3	14.2	2.1	10.5
Cardiovascular diseases	-0.8	1.0	-3.6	0.1	-3.9

Source: Author's own elaboration.

Notes: Table show 2023 − 2013 differences in RSMR, reported in percentage points (pp). Hospital admissions were classified based on the primary ICD-10 diagnosis code. Each diagnosis was mapped to a single Global Burden of Disease (GBD) condition using the official IHME mapping, aligned with GBD Level 1 and Level 2 categories. CMNN stands for communicable, maternal, neonatal and nutritional deficiencies. NCD stands for non-communicable diseases.

Table D4. Share of total hospitalizations and expected deaths by mortality groups and GBD conditions (%), 2023

	All hospitals	Low mortality (Below median)	High mortality (Above median)	Difference (High-Low mortality)	Lowest 20%	Highest 20%	Difference (Highest-Lowest 20%)
Total hospitalizations							
CMNN	17.9%	24.9%	15.3%	-9.6***	45.2%	16.2%	-28.4***
Respiratory infections and tuberculosis	13.4%	17.4%	11.9%	-5.5***	29.6%	13.4%	-16.1***
Other communicable diseases	4.4%	7.5%	3.3%	-4.1***	15.6%	2.8%	-12.4***
Maternal and neonatal disorders	0.1%	0.1%	0.1%	0.0	0.1%	0.1%	0.0***
Injuries	6.7%	3.0%	8.1%	5.1***	2.1%	9.8%	7.5***
NCD	58.1%	58.1%	58.1%	0.0	41.4%	53.1%	11.5***
Diabetes and kidney diseases	5.6%	5.1%	5.8%	0.8***	4.4%	6.8%	2.3***
Chronic respiratory diseases	3.5%	3.5%	3.5%	0.0	4.0%	3.6%	-0.3***
Other non-communicable diseases	5.5%	7.1%	4.9%	-2.2***	10.9%	5.0%	-5.6***
Digestive diseases	5.3%	4.4%	5.7%	1.3***	4.4%	6.0%	1.7***
Neoplasms	24.2%	24.4%	24.1%	-0.3***	7.0%	17.9%	10.1***
Neurological disorders	1.5%	1.2%	1.6%	0.4***	1.3%	1.7%	0.3***
Cardiovascular diseases	12.4%	12.4%	12.4%	0.0	9.4%	12.0%	2.9***
Expected deaths							
CMNN	22.4%	30.1%	19.7%	-10.4***	50.0%	19.3%	-29.3***
Respiratory infections and tuberculosis	13.4%	15.9%	12.4%	-3.5***	22.8%	13.4%	-9.3***
Other communicable diseases	9.0%	14.1%	7.2%	-6.9***	27.2%	5.9%	-20.1***
Maternal and neonatal disorders	0.0%	0.0%	0.0%	0.0*	0.0%	0.1%	0.0*
Injuries	3.4%	1.5%	4.1%	2.7***	0.9%	4.9%	4***
NCD	49.5%	50.5%	49.2%	-1.3***	36.2%	44.2%	7.1***
Diabetes and kidney diseases	3.1%	2.6%	3.3%	0.6***	2.3%	3.8%	1.5***
Chronic respiratory diseases	4.4%	4.5%	4.4%	-0.1*	5.4%	4.5%	-0.7***
Other non-communicable diseases	3.4%	3.9%	3.3%	-0.6***	5.1%	3.4%	-1.4***
Digestive diseases	4.8%	3.5%	5.2%	1.7***	3.2%	5.7%	2.6***
Neoplasms	21.9%	23.8%	21.2%	-2.5***	9.9%	15.7%	3.7***
Neurological disorders	0.6%	0.4%	0.7%	0.3***	0.3%	0.8%	0.4***
Cardiovascular diseases	11.3%	11.7%	11.1%	-0.6***	10.0%	10.4%	1.1***

Source: Author's own elaboration.

Notes: Table present aggregate shares. Differences are reported in percentage points (pp) (High-Low; Highest-Lowest 20%). Statistical significance is indicated by symbols ($p<0.05$ *, $p<0.01$ **, $p<0.001$ ***), based on two-sided tests of differences in proportions using aggregated counts. Hospital admissions were classified based on the primary ICD-10 diagnosis code. Each diagnosis was mapped to a single Global Burden of Disease (GBD) condition using the official IHME mapping, aligned with GBD Level 1 and Level 2 categories. CMNN stands for communicable, maternal, neonatal and nutritional deficiencies. NCD stands for non-communicable diseases.

Table D5. Factors associated with change over time in mortality group RSMR among hospitals

	Coefficient	Std. Error	p-value	CI Lower	CI Upper
Urban area	-0.130	1.142	0.327	0.677	1.139
# of beds per hospitalizations	0.287	1.190	0.099	0.947	1.873
# of ICU beds per hospitalizations	0.113	1.229	0.584	0.747	1.678
Size					
Small: < 50 beds	1.239	1.248	0.000	2.236	5.328
Medium: 50-150 beds	1.366	1.172	0.000	2.872	5.350
Hospitalization volume					
Medium volume	-0.320	1.156	0.028	0.546	0.966
High volume	-1.074	1.227	0.000	0.229	0.510
Average length of stay					
Medium	0.706	1.128	0.000	1.598	2.566
Long	1.274	1.153	0.000	2.703	4.725
Infrastructure characteristics					
Average working hours	0.035	1.112	0.745	0.840	1.276
# equipment per hospitalizations	-0.188	1.241	0.384	0.543	1.265
# rooms per hospitalizations	-0.563	1.178	0.001	0.413	0.786
# health staff per hospitalizations	-0.360	1.202	0.050	0.486	1.000

Source: Author's own elaboration.
Notes: Dependent variable is the change between the RSMR 2023 and RSMR 2013.

Table D6. Characteristics of health facilities with management score information by mortality group, 2013

	All hospitals	Low mortality (Below median)	High mortality (Above median)	Lowest 20%	Highest 20%
Total number of hospitals	**260**	**47**	**213**	**12**	**80**
# in rural areas	21.5%	46.8%	16.0%	50.0%	6.3%
# in urban areas	78.5%	53.2%	84.0%	50.0%	93.8%
# of hospitals by size					
Large: > 150 beds	31.2%	6.4%	36.6%	16.7%	57.5%
Medium: 50-150 beds	49.2%	42.6%	50.7%	33.3%	38.8%
Small: < 50 beds	17.3%	46.8%	10.8%	41.7%	3.8%
Mortality rate					
Crude rate (mean)	9.4	1.9	11.0	0.1	15.2
RSMR (mean)	9.7	2.5	10.9	0.0	16.1
RSMR (median)	10.0	2.3	11.7	0.1	16.5
Health outcomes					
Elective and emergency admissions					
Total hospitalizations per hospitals	1,846	636	2,113	314	2,645
Observed deaths per hospitals	203	14	245	0	383
Expected deaths per hospitals	189	54	218	23	264
Length of stay (mean)	5.9	3.9	6.3	4.5	7.6
Emergency admissions					
Total hospitalizations per hospitals	1,598	552	1,829	267	2,239
Observed deaths per hospitals	194	14	234	0	362
Expected deaths per hospitals	179	51	207	22	248
Length of stay (mean)	6.1	3.8	6.7	4.0	8.0
Infrastructure characteristics					
Hospital beds per hospitals					
Total	136.9	61.0	153.7	71.7	210.4
ICU	17.8	5.2	20.6	9.7	33.6
Surgical	37.6	14.8	42.6	25.2	62.1
Clinical	46.8	24.5	51.7	21.8	62.9
Complementary	21.5	6.5	24.8	10.8	39.8
Health staff per hospitals					
Total	652.2	124.9	768.6	124.8	1,173.0
Doctors	274.3	56.8	322.3	69.3	480.3
Nurses	72.6	13.2	85.7	13.0	136.0
Average working hours	24.5	24.8	24.4	27.3	24.8
Equipment per hospitals	32.2	18.5	35.2	21.5	44.4

Source: Author's own elaboration.