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Hospital resilience: public versus private sector dynamics

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Abstract
This paper evaluates the recovery of elective admissions in Italian hospitals following the disruptions caused by the COVID-19 pandemic, with a particular focus on the dynamics between the public and private healthcare sectors. Employing a recovery metric that compares elective admission volumes in 2021 and 2022 to pre-pandemic levels, we observe significant regional variability in recovery rates, as well as disparities between public and private hospitals. Our analysis reveals that public hospitals experienced slower recovery rates, and suggests that the proximity of private healthcare providers further hindered their recovery capacity. Higher staffing intensity is positively associated with recovery, while hospitals serving older populations show weaker recovery performance. By quantifying recovery patterns and examining these influencing factors, this study enhances our understanding of healthcare system resilience. The findings highlight critical disparities in recovery across sectors and provide actionable insights for policymakers to improve coordination between public and private providers, thereby strengthening healthcare system preparedness for future crises.

Keywords Private and public health care sector · Hospital resilience · NHS · COVID-19

1 Introduction

Organizational resilience refers to an institution's capability to anticipate, effectively respond to, and rapidly recover from unexpected disruptions such as crises and emergencies. Through this proactive stance, organizations safeguard business continuity by mitigating the adverse consequences of such disturbances. Assessing organiza-

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tional resilience enhances situational awareness and fortifies the institution's capacity to mitigate and adapt to evolving threats. The COVID-19 pandemic exposed systemic vulnerabilities across global healthcare infrastructures, revitalizing scholarly and policy discussions concerning health system resilience—particularly in systems characterized by a blend of public and private service provision (OECD 2023). Broadly conceptualized, resilience represents the healthcare system's capacity to absorb shocks, adapt to changing conditions, and recover from disruptions while sustaining essential functions (Blanchet et al. 2017; OECD 2023). This adaptive capability is crucial in systems where the public and private sectors coexist, as exemplified by Italy's dual-structured healthcare model. Empirical evidence suggests that private healthcare institutions generally exhibit greater resilience than their public counterparts (Doğrusöz and Omay 2022).

The objective of this paper is to assess healthcare system resilience in the context of a dual public–private market by evaluating the recovery of elective admissions in Italian hospitals following the disruptions caused by the COVID-19 pandemic. Using a comprehensive dataset of 1026 Italian hospitals spanning 2017–2022, our analysis aims to explore how resilience is exhibited across public and private sectors, highlighting disparities in their recovery capacities and the factors influencing these differences.

Investigating the recovery dynamics of public and private hospitals in the aftermath of significant shocks is relevant for several reasons. First, the COVID-19 pandemic exposed critical vulnerabilities in healthcare systems worldwide, highlighting the pivotal role of hospitals not only at the onset of the crisis but also throughout the recovery phase, where maintaining their functionality is crucial (Ravaghi et al. 2023). The radical reorganization of healthcare service delivery during the pandemic and the financial challenges involved make hospitals a particularly suitable subject for studying organizational resilience and recovery dynamics.

Moreover, the relationship between public and private hospitals has emerged as a key aspect of emergency management. In many countries, governments have turned to the private sector for support in handling crises, fostering collaborations between public and private healthcare systems. In this context, private providers have played a crucial role in sustaining healthcare services (Winkelmann et al. 2022; Waitzberg et al. 2022). For instance, in Italy, private facilities provided ICU and acute care beds, repurposed departments for COVID-19 treatment, and managed non-COVID patients transferred from public hospitals, especially in regions with a significant private hospital presence (Bobini et al. 2020). More specifically, in Lombardy, private hospitals contributed to expanding capacity, testing, and vaccination efforts, highlighting the benefits of integrated public–private partnerships (Signorelli et al. 2024). Similarly, in Uttar Pradesh, India, partnerships with private laboratories and hospitals expanded access, though smaller providers faced challenges in engagement (Meghani et al. 2022).

However, while these forms of collaboration were crucial in addressing the crisis, they were often implemented hastily, leading to coordination issues and a lack of long-term perspective, as well as deviating usual good governance standards (Baxter and Casady 2020). This was the case in countries such as the UK, Israel, and Austria, where public–private collaboration models had to be adopted urgently, compromising adherence to key governance principles—transparency, equity, and competition—and raising concerns about their appropriateness and sustainability beyond emergencies (Tille et al. 2021). Moreover, as seen in Lithuania, public–private coordination efforts often exposed institutional weaknesses and unstructured approaches, underscoring the need for sustainable frameworks (Maciukaite-Zviniene and Valys 2022). Despite these challenges, such collaborations aligned with WHO recommendations, demonstrating the potential for private sector involvement to enhance resilience during crises (Signorelli et al. 2024).

Finally, analyzing recovery dynamics within a dual market structure highlights the challenges faced by the public sector. During the pandemic, Italian public hospitals carried a disproportionate burden, reallocating resources to emergency care while private providers were able to resume elective procedures more swiftly (Signorelli et al. 2024; Bianchi et al. 2024). Elective procedures, essential for preventing long-term morbidity, experienced significant delays, exacerbating disparities in care delivery and recovery rates (Lai et al. 2020; Siciliani et al. 2023). These delays underscore the need to examine recovery dynamics, particularly the tension between public hospitals' slower recovery and private providers' proximity advantages.

Building on these insights, this study makes several key contributions to the literature on healthcare system resilience and recovery, particularly in the context of Italy's dual public–private healthcare market.

First, it provides a robust quantitative assessment of healthcare system recovery, representing the first comprehensive effort to evaluate the ability of Italian hospitals to restore elective admissions post-COVID-19. By incorporating a mixed-market perspective, this study offers a critical benchmark for assessing resilience in systems where public and private sectors are integral to service delivery.

Second, the research identifies key drivers of recovery, adding to the understanding of resilience dynamics. On the supply side, significant disparities were observed between public and private hospitals, with public hospitals showing recovery rates approximately 20% lower than private facilities. On average, public hospitals reached only 80% of their pre-pandemic activity levels in 2021, compared to 94% for private facilities. By 2022, public hospitals improved to 91%, while private hospitals reached a recovery rate of 98%. This disparity underscores the differential impacts of the pandemic and highlights the need for targeted policy interventions to support public hospitals. We also show that larger hospitals, but most importantly those with higher staffing intensity, achieved better recovery rates. On the demand side, demographic factors such as gender and age composition significantly influenced recovery outcomes, revealing the complex interplay between population characteristics and healthcare system performance.

Third, the study underscores the role of spatial dynamics in shaping recovery. Proximity to private providers with higher volumes of elective activity appears to be associated with slower recovery among neighboring hospitals. While the association is detected under broader market definitions (50 and 70 km radii) but not under narrower ones (30 km), it still motivates broader reflection on accessibility, equity, and competition in mixed public–private systems, where market dynamics may exacerbate existing disparities.

Finally, by situating these findings within the broader global context of public–private healthcare dynamics, the study contributes to a deeper understanding of resilience and recovery. It aligns with global lessons that demonstrate the importance of structured public–private collaborations and provides actionable insights for policymakers and administrators. These include strategies to strengthen system preparedness, foster equitable partnerships, and ensure sustainable healthcare delivery during future crises.

The rest of the paper is structured as follows: Sect. 2 presents the institutional context. Section 3 describes the data used. Section 4 outlines the methodology, while Sect. 5 presents the main results and additional robustness checks. Finally, Sect. 6 concludes with a discussion of the findings and their implications for healthcare policy and future research.

2 Institutional setting

Founded in 1978, the Italian National Health System (SSN) guarantees universal coverage for all Italian citizens and residents, offering comprehensive medical services through public providers, university hospital trusts, the tertiary care and research centers (IRCCSs), and private-accredited providers, which are mainly concentrated in the northern and central regions of the country. The organization and management of the health system are shared between the national government and the regions. The national government defines the principles and standards of the healthcare system, including the essential basket of services that must be provided by the regions. The 19 regions and two autonomous provinces are responsible for planning, organizing, and delivering services through networks of local health units. As a result, each region can establish its own priorities and goals within the framework set by the national government, which may lead to differences in quality across regions (see De Belvis et al. 2022).

The Italian health system is financed through national and regional taxation.[1] All citizens have access to medical services either free of charge or with a copayment (a cost-sharing arrangement between the patient and the National Health System). However, following the public expenditure cuts starting in 2008 and the resulting increase in waiting times, a growing share of the population has purchased voluntary private health insurance to access supplementary services (Brenna 2025). According to ISTAT, in 2023, 74% of health expenditure in Italy is publicly funded, while 26% is privately financed, of which 23% is paid directly by households through out-of-pocket expenses and 3% through private spending mediated by health funds and insurance schemes. Public financing of the SSN was reinforced in the aftermath of the COVID-19 crisis. The pandemic struck Italy after years of stringent spending reviews and cost-containment measures that had progressively reduced hospital capacity, and blocked staff turnover. A central challenge during the emergency was the shortage of intensive care unit (ICU) facilities, which were increased by nearly 65% in the initial phase

[1] While national taxes serve an equalizing function, regional taxation creates disparities: Compared to poorer southern regions, wealthier northern regions supported by stronger GDP levels have a broader tax base and can supplement central government funding.

of the pandemic (Aimone Gigio et al. 2020). The first case of COVID-19 infection was reported on February 21. Given the rapid spread of the virus, several containment measures were adopted, beginning with a regional lockdown in Lombardy—where the first case was detected—and followed by a nationwide lockdown on March 10, which entailed the closure of non-essential business activities, the suspension of educational services, and restrictions on interregional mobility. The spread of COVID-19 was uneven across the country, displaying a clear North–South gradient: The highest incidence occurred in the northern regions, with Lombardy being the most heavily affected, while the lowest levels were observed in the South and on the islands (Guccio et al. 2025; Prezioso et al. 2020). This pattern reflected multiple independent introductions of the virus in northern Italy (Bosa et al. 2022).

3 Data

Our empirical analysis is based on a monthly panel dataset of 1026 hospitals, from 2017 to 2022, which integrates information from several sources. The primary source is the Italian Agency for Regional Healthcare Services (AGENAS), from which we collected data on the monthly number of hospital admissions, both elective and urgent, for each public and private accredited hospital in Italy, with volumes disaggregated by Major Diagnostic Categories (MDCs).[2] We have enriched this dataset by incorporating additional information on hospital facilities, including staffing levels and bed availability, to account for the supply side of hospital services. These data were obtained from the New Health Information System (NSIS) of the Italian Ministry of Health. Furthermore, we integrated this with population data from the Italian National Institute of Statistics (ISTAT) database for the corresponding catchment areas, enabling us to consider the demand for healthcare services.

An essential step in analyzing recovery is to define the duration of the shock period and establish the timeframe in which recovery is likely to have commenced. For this study, we identify 2020 as the shock year and measure hospital recovery during 2021 and 2022. While this choice involves a degree of judgment, it is based on the assumption that the acute phase of the shock had subsided by 2021, allowing for a transition to the recovery phase of elective healthcare services.

The year 2020 brought major disruptions to the Italian healthcare system as a result of the COVID-19 pandemic. This period witnessed the most severe waves of the crisis in terms of mortality. As shown in Fig. 8, the monthly mortality rate reached a peak of 33 deaths per 100,000 inhabitants—equivalent to more than 20,000 deaths in a single month—and, except for the summer months, consistently stayed above 20 deaths per 100,000. Hospitals, unprepared for the magnitude of the emergency, had to reallocate resources to care for COVID-19 patients. This shift caused significant interruptions to

[2] MDCs are part of the Diagnosis Related Groups (DRGs) classification of hospital admissions, used in Italy and in other countries. All possible principal diagnoses, represented by various DRGs, are divided into mutually exclusive MDCs, with each MDC generally corresponding to a specific organ system and often associated with a particular medical specialty. There are 25 MDCs and the full list, for the classification currently used in Italy, can be consulted at https://www.trovanorme.salute.gov.it/norme/renderPdf.spring?seriegu=SG&datagu=28/01/2013&redaz=13A00528&artp=1&art=1&subart=1&subart1=10&vers=1&prog=001.

normal operations, with elective hospitalizations decreasing by about 27% nationwide compared to the pre-pandemic average from 2017 to 2019 (Table 1).

The second wave of the pandemic, which began in October 2020, continued into the early months of 2021. However, by the first quarter of 2021, the most severe phases in terms of mortality had subsided, and the exceptionally high levels recorded in the previous year were not reached again. According to the Istituto Superiore di Sanità and ISTAT, the subsequent waves were less severe thanks to the nationwide vaccination campaign launched in December 2020 (Istituto Superiore di Sanità & ISTAT 2022). As shown in Fig. 9, by May 2021, approximately 80% of the at-risk population—defined as individuals aged 60 and above—had received at least one dose of the vaccine.

Moreover, during 2021, many Italian regions had implemented guidelines and plans to reorganize hospital services, prioritizing the resumption of elective procedures (Cicchetti and Di Brino 2021). These efforts enabled hospitals to gradually restore their operational capacity (Ministero della Salute 2023). This trend is supported by empirical data (Table 1): While in 2020 elective procedures declined by about 27% compared to pre-pandemic levels, the reduction was less pronounced in 2021 (18%) and further decreased to 13% in 2022. Taken together, these developments provide a foundation for identifying 2021 as the starting point for measuring recovery, reflecting the premise that hospitals had begun reorganizing their activities in a more systematic manner by that time. Additionally, we include both 2021 and 2022 in our analysis of recovery rates to capture the broader recovery process—encompassing the initial adjustments made in the year immediately following the crisis and the subsequent stabilization or improvements observed in the following year.

To measure recovery, we compare the number of monthly elective admissions during 2021 and 2022, to the average pre-pandemic activity volumes (from 2017 to 2019), and we develop an indicator that evaluates hospitals' ability to recover to pre-shock average activity levels. This indicator, which we call the Recovery Rate (RR), is constructed as the ratio between the number of hospital-level elective admissions in each month m of 2021 and 2022, and the average number of elective admissions in the same hospital h and month m over the 3 years preceding the pandemic (2017–2019):

$$\mathrm{RR}_{\mathrm{h,m,y}} = \frac{n_{\mathrm{h,m,y}}}{n_{\mathrm{h,m,2017-2019}}} \tag{1}$$

where the year, denoted by the subscript y, is either 2021 or 2022. Given its construction, the RR can take a value of one or greater if the post-pandemic activity volumes have fully recovered, or exceeded, the pre-pandemic average levels. Conversely, the RR will be between 0 and 1 if the hospital h has not fully recovered its previous levels, indicating that the activity level is equivalent to RR*100% of the average volumes for the same month m in the three preceding years.

We choose to focus on elective procedures because they consist of planned treatments and surgeries that were postponed or deferred during the emergency. These procedures were particularly impacted by the disruptions in healthcare services caused by COVID-19 and are likely to contribute to broader health consequences stemming from the pandemic. By examining the dynamics of elective admissions, we can assess how hospitals have managed to return to normal levels of scheduled activity after the crisis. Emergency admissions are excluded from this analysis, as their trends may not accurately reflect the recovery of hospital operations and can be influenced by different dynamics, such as variations in emergency demand related to the pandemic itself.

In order to investigate factors influencing resilience, we complete our dataset by including a set of supply and demand-side factors.

As for the supply-side variables, we gathered data on hospital ownership to determine whether a facility is public or private. The data also allow for distinguishing between different subtypes of public hospitals, which are further classified as Independent Hospitals (Aziende Ospedaliere-AO), University Hospitals (Aziende Ospedaliere Universitarie-AOU), Local Health Authority Hospitals (Presidi Ospedalieri-PO), and Research Hospitals (Istituti di Ricovero e Cura a Carattere Scientifico-IRCCS). We also incorporated information on the number of doctors, nurses, and acute care beds for each hospital.

Finally, the NSIS dataset includes precise geolocation data for hospitals, enabling the construction of proximity distance matrices to assess spatial competition among healthcare providers. By leveraging this information, we can calculate the capacity and activity levels of neighboring hospitals, offering valuable insights into the competitive dynamics within local healthcare markets. This approach allows for the identification of clusters of hospitals operating within overlapping catchment areas, where competition for patients may influence service delivery, resource allocation, and recovery strategies. Proximity-based analysis also facilitates an examination of how nearby hospitals' capacities—such as the number of available beds, staff levels, or surgical theaters—might affect a hospital's ability to attract and serve patients. For example, if a hospital is located near higher-capacity competitors, it may face greater challenges in recovering elective activity levels or maintaining patient inflows. Additionally, the distance matrices can be employed to study the effects of competition on efficiency and service quality. Hospitals in areas with significant competition may be incentivized to innovate, optimize processes, and invest in patient care to maintain their market share. Conversely, hospitals in regions with minimal competition might face less pressure to adapt, potentially impacting recovery trajectories. Moreover, incorporating proximity data into the analysis allows for a better understanding of patient choice dynamics. Factors such as travel distance, perceived quality of care, and availability of specialized services could shape patient preferences, influencing hospital recovery patterns. This spatial lens enhances our ability to examine the interplay between competition and recovery, providing a more nuanced understanding of how external market forces contribute to variations in hospital performance during the post-shock period.

For the demand-side factors, the main data source is the demographic surveys conducted by ISTAT, from which we have gathered demographic variables at the provincial level related to the populations of provinces in which the hospital is located. In particular, we have collected data on the percentage of women, the percentage of individuals over 65, and the percentage of foreigners people in the province. Lastly, we gathered information on per-capita income at the provincial level provided by the Department of Finance of the Italian Ministry of Economy and Finance. All the demand-side variables are measured as of 2019 to avoid bias in the analysis.

Table 12 presents a descriptive summary of our data, with the exception of recovery rates, which are discussed in Sect. 5.1.

4 Empirical strategy

This study aims to evaluate the recovery of elective admissions in Italian hospitals after the COVID-19 outbreak, with a specific focus on comparing recovery patterns between public and private hospitals. To investigate the factors influencing recovery capacity, we employ an empirical strategy based on Ordinary Least Squares (OLS) regression analysis:

$$Log(\mathrm{RR}_{\mathrm{h,m,y}}) = \beta_1 SupplyFactors'_{\mathrm{h}} + \beta_2 DemandFactors'_{\mathrm{h}} + \tau_{\mathrm{y}} + \mu_{\mathrm{m}} + \rho_{\mathrm{r}} + \epsilon_{\mathrm{h,m,y}} \tag{2}$$

$Log(\mathrm{RR}_{\mathrm{h,m,y}})$ is the log of the monthly hospital recovery rate, as defined in (1). The year, denoted by the subscript y, is either 2021 or 2022.

$SupplyFactors'_{\mathrm{h}}$ denotes a vector of hospital-level supply variables. It includes a binary indicator for whether the facility is public or privately accredited. The vector further comprises the logarithm of the number of acute care beds in each hospital, which serves as a proxy for hospital size. To capture medical staffing resources, we include the ratio of total medical staff (physicians and nurses) to the number of beds.[3] All variables are measured in 2019 to provide a predetermined baseline. This choice aims to mitigate concerns about omitted-variable bias and limits potential endogeneity due to the COVID-19 pandemic's impact on both supply factors and recovery outcomes.

To evaluate the role of nearby providers' capacity on hospital recovery rates, we construct two measures of local competition, distinguishing between competition from public and from private providers. These measures are defined as the logarithm of the sum of monthly elective admissions from providers located within a pre-specified radius. This specification allows us to assess whether the presence of elective services from surrounding facilities is correlated with differences in recovery dynamics. The choice of the radius is informed by the geographic distribution of public and private hospitals across Italy (Fig. 10). The figure highlights a stronger presence of private providers in northern regions and around major metropolitan areas, while the lower density of providers in rural areas—especially in central and southern Italy—suggests that narrower definitions, such as a 30 km radius, may be overly restrictive, as this threshold would often include only a small number of facilities overall, and none—or very few—private hospitals. For this reason, and following previous literature on hospital competition (Guida et al. 2019; Kessler and Geppert 2005), our main specification adopts a 50 km radius. Nonetheless, we also conduct sensitivity analyses using alternative radii proposed in the literature (30 km and 70 km), as reported in Sect. 5.3 (Robustness Checks).

$DemandFactors'_{\mathrm{h}}$ is a vector of demand variables related to the province where the hospital is located, used here as a proxy for the hospital's catchment area. The vector includes the share of females in the population, the proportion of individuals aged 65 and above, the share of foreign residents, and provincial per capita income. Consistent with the treatment of supply-side factors, demand-side variables are measured

[3] In alternative specifications, we consider physicians-to-beds and nurses-to-beds separately. Results are available upon request.

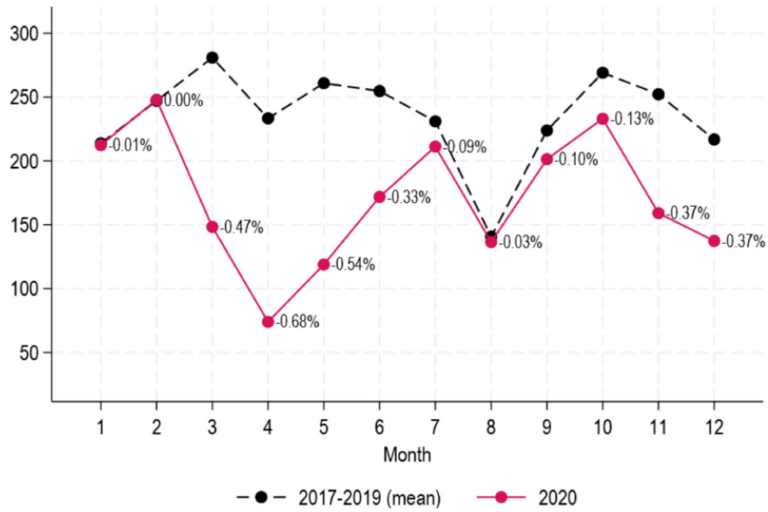

Fig. 1 Trend of elective admissions by month for the years 2017–2019 (average) and 2020. *Notes:* The figure shows the total number of elective admissions (in thousands) in Italian hospitals. The black dashed line represents the number of admissions averaged over the 2017–2019 period. The red line represents the admissions in 2020. Admissions related to MDC 14 (pregnancy, childbirth and the puerpuerium) are excluded

in 2019 to mitigate endogeneity concerns, since the pandemic may have simultaneously affected both the demographic composition of hospital patients and recovery outcomes.

Additionally, we include month-fixed effects μ_{m} to account for the seasonality in admission numbers, year-fixed effects τ_{y} to capture time-specific shocks, and region-fixed effects ρ_{r} to control for time-invariant unobserved heterogeneities at the regional level.

5 Results

5.1 Descriptive statistics

In this section, we will provide descriptive evidence of the trends in monthly hospital admissions across Italy, using aggregated data to analyze national and macro-regional patterns both before and after the pandemic outbreak. We then shift our focus to the hospital level, presenting preliminary descriptive insights on individual hospitals' recovery rates.

In Fig. 1, we plot the national trend in elective hospital admissions, comparing the monthly averages from the pre-pandemic years (2017–2019) with the monthly admissions recorded in 2020. The data reveal a notable drop in elective admissions, especially during the first COVID-19 wave in March–April 2020, when the reduction reached up to 68%. Figure 2 compares the national trends from 2017–2019 with those from the post-pandemic years, specifically 2021 (red line) and 2022 (blue line). This

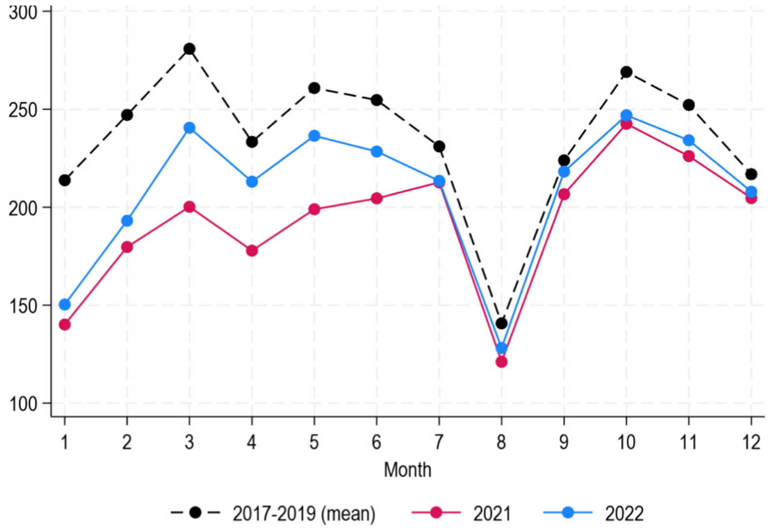

Fig. 2 Trend of elective admissions by month for the years 2017–2019 (average), 2021 and 2022. *Notes:* The figure shows the total number of elective admissions (in thousands) in Italian hospitals. The black dashed line represents the number of admissions averaged over the 2017–2019 period. The red (blue) line represents the admissions in 2021 (2022). Admissions related to MDC 14 (Pregnancy, childbirth and the puerpuerium) are excluded

figure indicates a gradual recovery in elective procedures, although admission levels have not yet returned to pre-pandemic figures.

Table 1 outlines the percentage reduction in overall activity by macro-region and for Italy as a whole. Overall, 2020 saw a reduction of about 27%, equating to a decrease of approximately 800,000 admissions nationwide. The north-western area, which was hit hardest and earliest, saw the largest drop, with a 34% reduction in elective admissions. The southern area experienced the second largest drop (28%), despite a lower spread of the virus (Ottaiano et al. 2021). A partial recovery in activity was observed in 2021 and 2022, with reductions of approximately 18% and 13%, respectively, compared to the pre-pandemic average.

Shifting our focus to hospital-level recovery, Fig. 3 depicts the recovery rates of hospital activity, averaged at the provincial level, distinguishing between public and private facilities. As shown in Panel (a), public hospitals in northern Italy faced significant service disruptions, with several provinces operating at less than 70% of their pre-pandemic capacity, equating to around 30% fewer admissions. Again, this was likely a consequence of being one of the earliest and hardest-hit COVID-19 hotspots in Europe (?), which led to extreme strain on healthcare services. Notably, despite being less affected in the early stages of the pandemic, public hospitals in southern Italy also reported severe service disruptions, with several provinces reporting similarly low recovery rates and reductions in admissions, again exceeding 30% below pre-COVID levels. When comparing recovery of public and private hospitals, a clear and persistent gap emerges, with public hospitals consistently reporting lower recovery rates. Most public hospitals had recovery rates below 0.85 (Panel a), whereas in

Table 1 Percentage change in total elective admissions after COVID-19, relative to the 2017–2019 average

Macroregion	# 2017–2019	# 2020	# 2021	#2022	% Var 2020	% Var 2021	% Var 2022
North-West	896, 030	587, 498	678, 790	762, 561	−0.34	−0.24	−0.18
North-East	624, 117	484, 849	514, 303	561, 820	−0.22	−0.18	−0.11
Center	524, 127	407, 574	445, 026	477, 876	−0.22	−0.15	−0.1
South	556, 391	399, 945	472, 086	498, 306	−0.28	−0.15	−0.12
Islands	223, 475	171, 883	204, 772	209, 764	−0.23	−0.08	−0.07
Italy	2, 824, 139	2, 051, 749	2, 314, 977	2, 510, 327	−0.27	−0.18	−0.13

The table presents the total number of elective admissions averaged over the years 2017–2019, along with the data for the years 2020, 2021, and 2022. It also shows the percentage change in elective admissions for each year relative to the 2017–2019 average. Admissions related to MDC 14 (Pregnancy, childbirth, and the puerpuerium) are excluded from the count

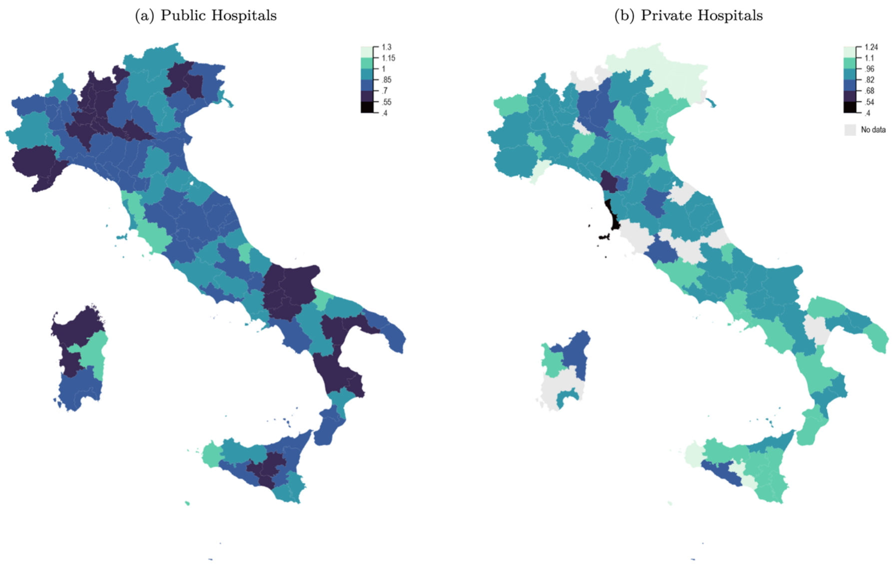

Fig. 3 Elective care recovery rates (2021–2022). *Notes:* The maps display recovery rates (RR) in public and private Italian hospitals averaged at the provincial level

nearly all provinces private facilities exceeded this threshold, and some even surpassed pre-pandemic activity levels (Panel b).

Table 2 and Fig. 4 provide a more detailed overview of hospitals' recovery rates for elective procedures, broken down by year and major diagnostic category. Overall, the recovery rate improved from 0.88 in 2021 to 0.95 in 2022, reflecting a gradual normalization of elective hospital services. This suggests that, on average, Italian hospitals had around 10 % fewer admissions compared to pre-pandemic levels by 2021, and 5% by 2022. When examining recovery rates for individual MDCs, most show recovery rates above 0.9 by 2021, and above 1 by 2022.

Table 2 Descriptive statistics—recovery rate (RR)

MDC	Description	RR2021				RR2022			
		#Obs	#Hsp	Mean	SD	#Obs	#Hsp	Mean	SD
01	Nervous System	8377	861	0.92	0.98	8424	858	0.93	0.95
02	Eye	2465	336	1.02	1.77	2540	336	0.98	1.36
03	Ear Nose Mouth Throat	4418	507	0.90	1.14	4470	503	0.99	1.28
04	Respiratory System	6596	748	1.39	3.74	6563	742	1.08	2.26
05	Circulatory System	7799	814	0.95	0.84	7963	810	1.11	3.67
06	Digestive System	7768	768	0.93	0.82	7980	774	1.01	0.94
07	Hepatobiliary System	7261	737	0.95	0.69	7506	736	1.04	0.88
08	Musculoskeletal System	9958	917	1.07	2.11	10,062	924	1.18	2.32
09	Skin, Subcutaneous Tissue and Breast	6094	703	1.03	0.99	6124	708	1.09	1.16
10	Endocrine, Nutritional and Metabolic System	5543	672	1.23	2.09	5718	673	1.44	3.30
11	Kidney And Urinary Tract	6490	693	1.16	1.45	6619	694	1.22	1.56
12	Male Reproductive System	5259	564	1.03	0.94	5275	545	1.17	1.16
13	Female Reproductive System	5646	574	1.05	1.16	5708	577	1.10	1.08
15	Newborn	544	128	1.13	0.95	496	120	1.07	0.97
16	Blood	3021	545	0.95	0.65	3068	513	0.96	0.68
17	Myeloproliferative DDs	4481	598	1.01	1.01	4568	581	1.01	1.00
18	Infectious and Parasitic DDs	3306	570	1.50	3.25	3590	547	1.67	4.05
19	Mental Diseases	2888	422	0.90	0.76	2982	417	0.94	0.85
20	Alcohol/Drug Use	591	127	0.97	0.88	607	130	1.09	1.38
21	Injuries, Poison	3002	543	1.04	0.81	3068	516	1.12	1.16
22	Burns	147	49	1.13	0.72	149	40	1.11	0.77
23	Factors Influencing Health Status	7141	830	1.12	1.99	7319	832	1.28	2.65
24	Multiple Significant Trauma	81	48	1.00	0.48	75	43	1.02	0.53
25	Human Immunodeficiency Virus Infection	156	56	0.79	0.54	172	53	0.78	0.49
Total	All Elective Admissions	11,866	1016	0.88	0.60	11,933	1026	0.95	1.07

The table shows the average hospitals' recovery rates in 2021 and 2022, for each MDC and overall. These rates are calculated for each hospital by dividing the number of monthly elective admissions in 2021 and 2022 by the average number of elective admissions in the same month over the three years before the pandemic (2017–2019)

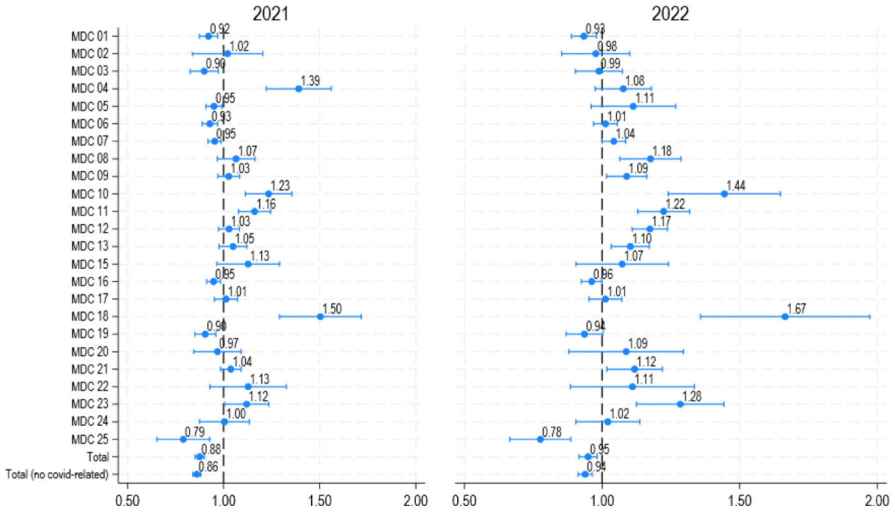

Fig. 4 Recovery rate. *Notes:* The figure shows the average monthly Recovery Rate (RR) for 2021 and 2022 separately. The RR is calculated as the ratio of elective admissions in each month of 2021 and 2022 to the average admissions in the same month and hospital over the pre-pandemic years (2017–2019). The figure shows the RRs for each individual MDC, for the total elective activity, and for the total excluding COVID-19-related admissions (MDC 04 and 18)

However, a detailed examination of recovery rates by hospital type—public versus accredited private—shows significant variation within the overall average, in line with the patterns previously illustrated. Figure 5 shows the average recovery rates for each MDC in 2021 and 2022, distinguishing between public and accredited private hospitals. Accredited private hospitals generally reported recovery rates above one across nearly all MDCs, with an overall recovery rate of about 0.94 (as shown in the "Total" row). These hospitals almost fully restored their elective activities by 2022. In contrast, public hospitals generally had lower recovery rates, although many approached the value of 1. The overall recovery rate for public hospitals was 0.80 in 2021, rising to 0.91 in 2022. This means that, on average, public hospitals performed roughly 20% fewer admissions compared to the pre-COVID three-year average in 2021. The lowest recovery rates were observed for MDCs 03 (ear, nose, mouth and throat), 06 (digestive system), 07 (hepatobiliary system and pancreas), 12 (male reproductive system), 19 (mental diseases and disorders), and 25 (HIV infection).

Notably, MDCs 04 and 18 (respiratory system diseases and infectious and parasitic diseases, respectively) had recovery rates significantly above 1, indicating that the number of hospitalizations for these MDCs post-2020 was higher than in previous years. This increase likely reflects the rise in hospitalizations related to COVID-19. As noted by AGENAS and ISTAT (2022), the most frequent diagnoses associated with COVID-19 hospitalizations were indeed respiratory and infectious diseases.

Nonetheless, the overall recovery rate remains relatively unchanged when excluding MDCs 04 and 18 (i.e., COVID-related admissions), as evidenced by the "Total (no-COVID related)" row.

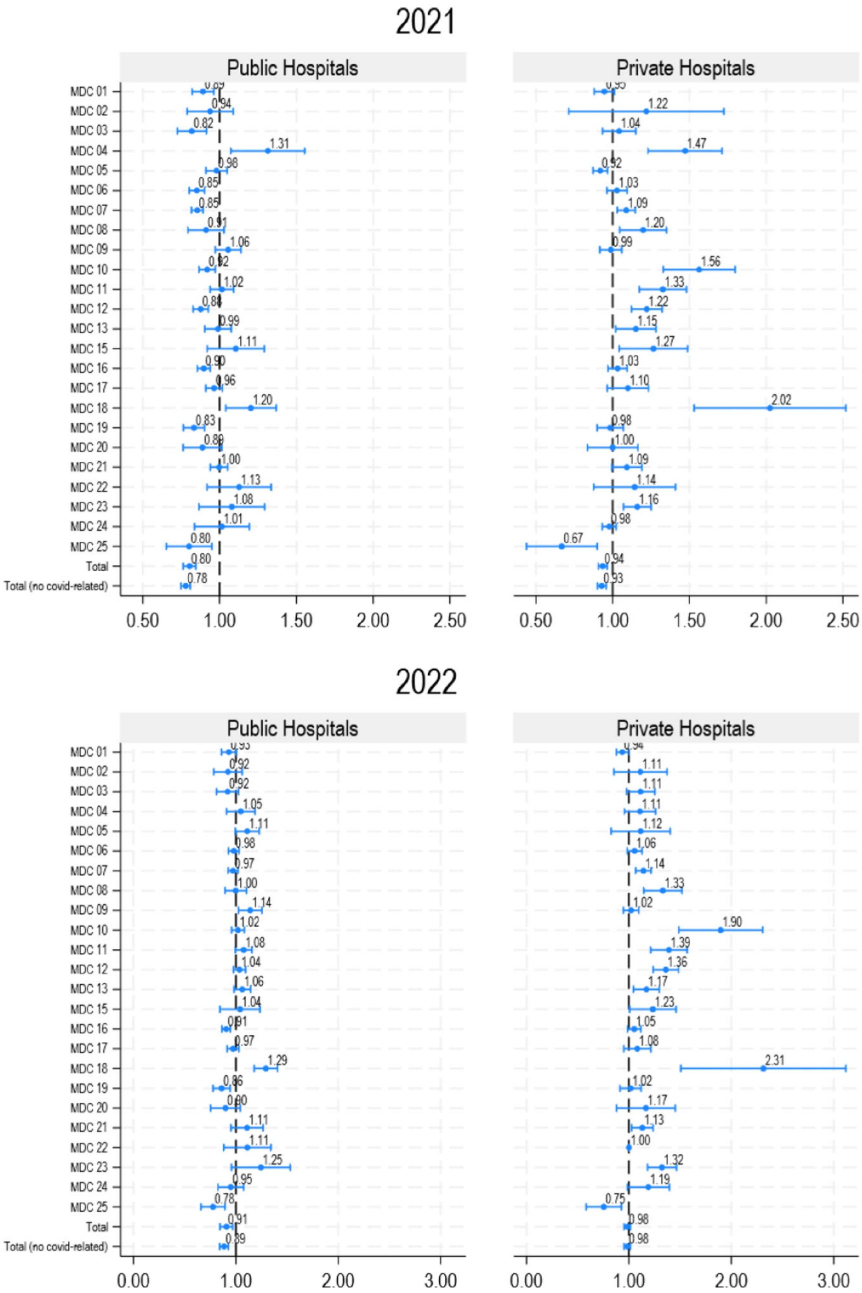

Fig. 5 Recovery rate by type of healthcare facility. *Notes:* The figure shows the average monthly Recovery Rate (RR) for 2021 and 2022 separately, distinguishing between public and accredited private hospitals. The RR is calculated as the ratio of elective admissions in each month of 2021 and 2022 to the average admissions in the same month and hospital over the pre-pandemic years (2017–2019). The figure shows the RRs for each individual MDC, for the total elective activity, and for the total excluding COVID-19-related admissions (MDC 04 and 18)

Table 3 Main results

	RR 2021–22	RR 2021	RR 2022
Female (%)	0.079	0.066	0.098**
	(0.048)	(0.054)	(0.048)
Age 65+ (%)	− 0.024*	− 0.010	− 0.040***
	(0.013)	(0.016)	(0.012)
Foreign (%)	0.016	0.018	0.014
	(0.011)	(0.012)	(0.011)
Per-capita income	− 0.000	− 0.000	− 0.000
	(0.000)	(0.000)	(0.000)
Medical staff per bed	0.045**	0.049**	0.041*
	(0.020)	(0.019)	(0.022)
Beds (log)	0.030*	0.032*	0.028
	(0.017)	(0.019)	(0.018)
Public hospital	− 0.213***	− 0.256***	− 0.173***
	(0.046)	(0.051)	(0.047)
Nearby private admissions (50 km)	− 0.031***	− 0.041**	− 0.024**
	(0.011)	(0.016)	(0.010)
Nearby public admissions (50 km)	0.035*	0.043	0.021
	(0.020)	(0.027)	(0.020)
Observations	14,693	7340	7353
R-squared	0.115	0.119	0.112

The dependent variable is the recovery rate (RR), calculated as the ratio of elective admissions in each month of 2021 and 2022 to the average admissions in the same month and hospital over the pre-pandemic years (2017–2019). Robust standard errors clustered at the hospital level. Year, month, and region fixed effects are included

***$p < 0.01$, **$p < 0.05$, *$p < 0.1$

5.2 Main results

Table 3 presents the baseline results of our estimates. The first column shows the monthly recovery rates for both post-shock years, 2021 and 2022. The second and third columns display the results for 2021 and 2022 separately.

When considering supply factors, our estimates indicate that supply-side characteristics are systematically related to recovery performance. Hospitals with higher medical staff-to-bed ratios achieve higher recovery rates: One additional staff member per bed is associated with an increase of about 4.5 percent in recovery outcomes. Moreover, hospital size, proxied by the log number of beds, is positively correlated with recovery, with a 1 percent increase in beds corresponding to roughly a 3 percent increase in recovery rates. However, this latter effect is only weakly significant and does not persist in 2022. Importantly, we find that public providers had recovery rates about 21% lower than private accredited ones. This result is robust across all specifications, indicating that in 2021 and 2022, public hospitals generally struggled more than private accredited ones to return to pre-pandemic activity levels.

Additionally, we find that a higher number of elective admissions performed by private providers within a 50 km radius are associated with lower recovery rates. This result, combined with the lower recovery rate of public facilities, suggests a potential shift in demand from public to private hospitals. While public hospitals struggled to return to their pre-pandemic activity levels, private hospitals were capturing at least part of the healthcare demand that public hospitals were unable to meet.

The difference in recovery performance between public and private hospitals can be attributed to several factors. One major aspect is that public hospitals in Italy bore a heavier burden of COVID-19 patients, which necessitated reallocating resources away from elective procedures. Moreover, inherent differences in institutional goals and managerial practices between public and private facilities may have played a relevant role in different recovery performances (Lucifora 2023; Giudice et al. 2023). Private hospitals, due to their market-oriented nature, may have had stronger incentives to regain full operational capacity as quickly as possible. Their higher operational flexibility and decision-making autonomy, as well as fewer bureaucratic constraints, allowed to make quicker decisions regarding resource allocation, staffing, and scheduling, facilitating a more rapid return to pre-pandemic elective activity levels.

Additionally, during the emergency phase, government policy measures were implemented to expand the role of private healthcare providers, with the aim of strengthening the hospital care network and easing the burden on overstrained public hospitals. These policies allowed regional authorities to purchase healthcare services from private facilities (both accredited and non-accredited), bypassing usual spending limits, enabling private providers to take on a greater share of healthcare services (Bobini et al. 2020).[4] These factors, which characterized emergency management in 2020, may have led to a shift in how elective healthcare demand is distributed between public and private providers. Our results indicate that this shift has persisted through 2022. Unfortunately, our current dataset does not allow for a deeper exploration of these issues. Specifically, we lack the necessary information to understand what types of activities are now performed by private entities that were not conducted before the pandemic.

Regarding demand variables, the share of women in the hospital's province shows a positive association with recovery, although statistical significance emerges only in the 2022 specification. Estimates indicate a one percentage point increase in the share of females is associated with a 9.8% higher recovery rate.

On the other hand, we find that a higher proportion of individuals aged 65 and older correlates negatively with monthly recovery rates (a one percentage point increase in the elderly population share is associated with a 2.4% reduction in monthly recovery rates).

These results may reflect COVID-19's greater impact on older adults, particularly men, leading to higher mortality rates in this group (Gebhard et al. 2020; Yanez et al. 2020; Biswas et al. 2021; Statsenko et al. 2022). Consequently, areas with a higher share of elderly residents would have experienced greater healthcare burdens and more prolonged disruptions in elective care. In contrast, provinces with a higher share of females might have faced less strain on their healthcare systems, facilitating a quicker

[4] One of the key policies in this regard was *Cura Italia* decree (Law Decree of March 17, 2020).

return to normal elective activity levels. Additionally, women generally use healthcare services more frequently than men (Bertakis et al. 2000), which could have driven a faster return to pre-pandemic levels of elective activity. For example, women may have been more proactive in rescheduling or seeking out elective procedures that were postponed during the pandemic's peak.

Finally, we perform additional analyses to investigate the heterogeneities between types of public hospitals and across geographical macro-areas. The results of these analyses are reported in "Appendix."

In Table 13, we account for different types of public healthcare providers.[5] The estimated coefficient for recovery is negative and statistically significant for both types of public hospitals. The magnitude of the coefficient is generally larger for smaller hospitals, mostly managed by local health authorities, particularly in 2021. However, in 2022, the coefficients are closer (0.151 and 0.176) and show no statistical difference between the two types.

In Table 14, we present the results separately by macro-regions of Italy. The findings highlight that public hospitals in the Northwest and South exhibit lower recovery rates. The negative correlation with private elective activity is statistically significant in all areas except the South.

5.3 Robustness checks

The recovery capacity of hospitals can be affected by the extent of disruption they faced during the pandemic. To account for this factor, in this section, we perform a robustness check by including a measure of the impact that COVID-19 had on each hospital during 2020.

We calculate an Impact Rate (IR) which represents the percentage variation in elective activity each hospital experienced during 2020. It is calculated as the difference between the number of elective admissions in each month m of 2020 and the average number of elective admissions in the same month over the three years prior to the shock (2017–2019), divided by the average number of elective admissions in the same month during that three-year period:

$$\mathrm{IR}_{\mathrm{h,m}} = \frac{n_{\mathrm{h,m2020}} - n_{\mathrm{h,m2017-2019}}}{n_{\mathrm{h,m}}2017 - 2019}$$

This measure captures the relative change in elective admissions due to the impact of COVID-19, normalized by the historical average. A negative impact ratio indicates a reduction in activity volumes in 2020.[6]

[5] We classify public providers into two main groups. The first group includes 52 AO and AOU, which are generally larger and more complex facilities, with an average of 750 beds. The second group consists of PO and IRCCS, which are generally smaller, with an average of about 250 beds. Specifically, PO forms the largest category of healthcare institutions in our dataset, totaling 401, while there are only 24 public IRCCS. The reference category is private healthcare facilities, which number 582. Figure 12 displays the share of elective admissions performed each year by each of the considered groups.

[6] For example, $\mathrm{IR}_{\mathrm{h,m}} = -0.3$ means that hospital h experienced a 30% reduction compared to the average volumes of the same month m in the previous 3 years.

Table 4 Descriptive statistics—impact rate

MDC	Description	#Obs	#Hsp	Mean	SD
01	Nervous System	6839	858	– 0.13	0.85
02	Eye	1884	336	– 0.17	0.99
03	Ear Nose Mouth Throat	3380	503	– 0.23	1
04	Respiratory System	5452	742	0.5	4.59
05	Circulatory System	6377	810	– 0.22	0.71
06	Digestive System	6210	774	– 0.22	0.79
07	Hepatobiliary System	5713	736	– 0.19	0.67
08	Musculoskeletal System	8056	924	– 0.12	1.62
09	Skin, Subcutaneous Tissue and Breast	4813	708	– 0.08	0.93
10	Endocrine, Nutritional and Metabolic System	4292	673	– 0.09	1.05
11	Kidney And Urinary Tract	5260	694	– 0.05	0.97
12	Male Reproductive System	4041	545	– 0.14	0.78
13	Female Reproductive System	4421	577	– 0.13	1.16
15	Newborn	465	120	– 0.01	0.86
16	Blood	2427	513	– 0.07	0.64
17	Myeloproliferative DDs	3748	581	– 0.03	0.9
18	Infectious and Parasitic DDs	2668	547	0.46	4.12
19	Mental Diseases	2309	417	– 0.18	0.71
20	Alcohol/Drug Use	502	130	– 0.09	0.61
21	Injuries, Poison	2278	516	– 0.01	0.72
22	Burns	105	40	0.06	0.71
23	Factors Influencing Health Status	5580	832	0.03	1.38
24	Multiple Significant Trauma	75	43	0.03	0.59
25	Human Immunodeficiency Virus Infection	153	53	– 0.14	0.7
Total	All Elective Admissions	9862	1026	– 0.24	1.33

The table shows the average impact rates for each MDC and overall. The impact rate reflects the percentage decrease in hospital monthly admissions in 2020 compared to the average for the three years prior (2017–2019)

Descriptive statistics are presented in Table 4 and Fig. 6. Figure 7 shows the impact values separately for public and private hospitals. There was an average reduction of 24% in overall elective admissions, 33% in elective admissions in public hospitals, and 17% in private hospitals.

We estimate equation (2), this time including the average IR in 2020 among the control variables. For ease of interpretation, the IR is multiplied by – 1. The results of the new estimates are presented in Table 5. These results remain consistent with those shown in the main results section. Although public hospitals faced a higher burden of COVID-19 patients and experienced a greater reduction in elective activities, public hospitals still exhibit statistically lower recovery rates compared to private hospitals. The negative correlation between recovery rates and elective activity by nearby private hospitals remains significant as well.

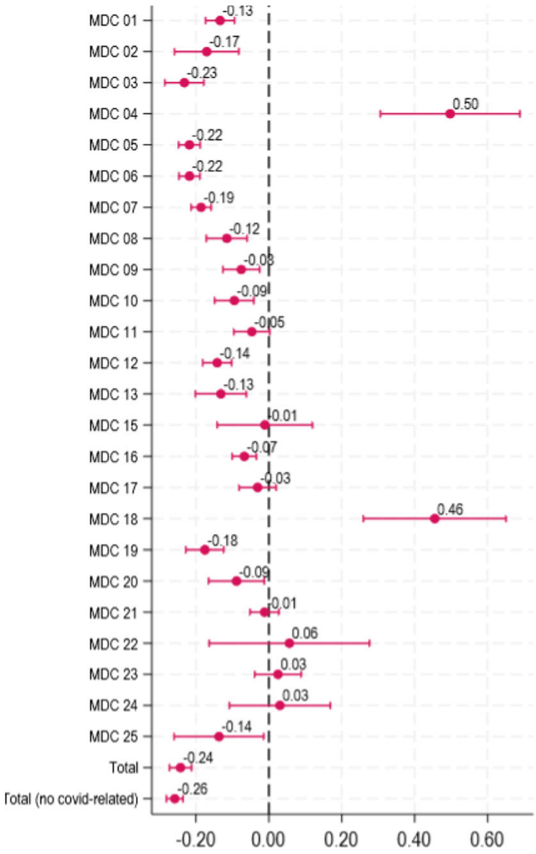

Fig. 6 Impact rate (% variation in elective admissions in 2020). *Notes:* The figure shows the average monthly Impact Rate (IR) for 2020. The IR represents the percentage variation in elective admissions experienced by hospitals during 2020, compared to the pre-pandemic period. The figure shows the IRs for each individual MDC, for the total elective activity, and for the total excluding COVID-19-related admissions (MDC 04 and 18)

This analysis suggests that, even after accounting for the greater impact of the pandemic on elective activities in public hospitals, their performance in terms of recovery continues to lag behind that of private hospitals.

To ensure the robustness of our findings on the recovery of elective hospital activities post-2020, we conduct an additional analysis excluding COVID-19-related hospitalizations. Specifically, we calculate a recovery rate for elective activity, this time excluding admissions associated with respiratory system diseases (MDC 04) and infectious diseases (MDC 18).[7]

The rationale behind this approach is that including COVID-19 hospitalizations in the recovery may not accurately reflect the recovery of normal pre-pandemic elective activities. Instead, the outcome is partially confounded by the increased number of

[7] As shown in Fig. 6, during 2020, the number of hospitalizations for respiratory system diseases (MDC 04) and infectious and parasitic diseases (MDC 18) increased by approximately 50% compared to the previous three years. A similar increase occurred during 2021 and 2022, with recovery rates exceeding 1 (Fig. 4), indicating that the number of hospitalizations for these MDCs post-2020 was higher than in preceding years. These are likely COVID-19-related admissions, as observed in the report by AGENAS and ISTAT (2022), which notes that the most frequent diagnoses associated with COVID-19 hospitalizations were respiratory system diseases and infectious and parasitic diseases.

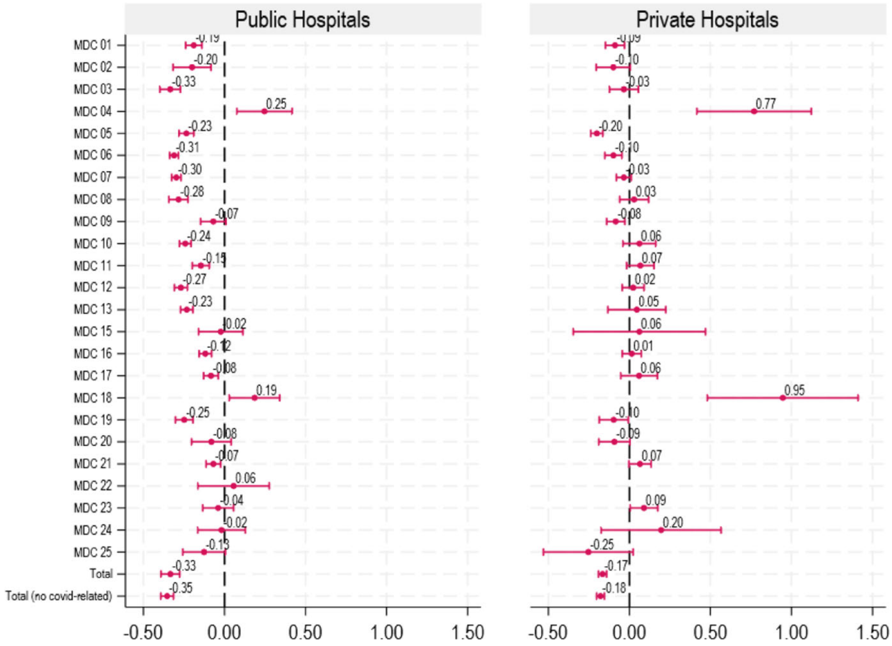

Fig. 7 Impact rate by type of healthcare facility (% reduction in elective admissions in 2020). *Notes:* The figure shows the average monthly Impact Rate (IR) for 2020, distinguishing between public and accredited private hospitals. The IR represents the percentage variation in elective admissions experienced by hospitals during 2020, compared to the pre-pandemic period. The figure shows the IRs for each individual MDC, for the total elective activity, and for the total excluding COVID-19-related admissions (MDC 04 and 18)

elective admissions for COVID-19 patients. Moreover, this could represent an issue also because private hospitals have significantly increased the number of elective admissions in COVID-related MDCs, especially in MDC 18 (see Fig. 5). Therefore, the risk is that the difference between public and private hospitals highlighted in the main estimates might be driven by the rise in COVID-related hospitalizations in private hospitals.

By excluding COVID-19-related hospitalizations, we aim to obtain a more accurate assessment of the healthcare system's capacity to resume regular elective services, thus providing a more precise evaluation of the recovery of elective hospital activities to their pre-pandemic levels.

Results are shown in Table 6. Also when considering this new specification of the outcome variable, results align closely with those outlined in our main specification. This robustness check seems to suggest that differences in the recovery rates between public and private hospitals are not driven by the increase in COVID-19-related admissions in private hospitals.

As an additional robustness check, we consider post-pandemic changes in both supply and demand factors. Specifically, we replicate the analysis by incorporating time-varying supply- and demand-side control variables instead of fixing them at their 2019 baseline levels. The use of 2019 values in the baseline model aimed to

Table 5 Robustness check controlling for the reduction in elective activity volumes in 2020 (impact rate)

	RR 2021-22	RR 2021	RR 2022
Impact rate	– 0.163**	– 0.162**	– 0.164***
	(0.066)	(0.077)	(0.055)
Female (%)	0.052	0.040	0.070
	(0.044)	(0.050)	(0.044)
Age 65+ (%)	– 0.017	– 0.004	– 0.033***
	(0.012)	(0.015)	(0.011)
Foreign (%)	0.014	0.016	0.012
	(0.010)	(0.011)	(0.010)
Per-capita income	– 0.000	– 0.000	– 0.000
	(0.000)	(0.000)	(0.000)
Medical staff per bed	0.044**	0.048**	0.040*
	(0.020)	(0.020)	(0.023)
Beds (log)	0.044***	0.047***	0.043**
	(0.016)	(0.018)	(0.017)
Public hospital	– 0.215***	– 0.259***	– 0.174***
	(0.043)	(0.049)	(0.045)
Nearby private admissions (50 km)	– 0.030***	– 0.040**	– 0.023**
	(0.011)	(0.016)	(0.010)
Nearby public admissions (50 km)	0.038**	0.047*	0.024
	(0.019)	(0.026)	(0.018)
Observations	14,672	7330	7342
R-squared	0.170	0.168	0.176

The dependent variable is the Recovery Rate (RR), calculated as the ratio of elective admissions in each month of 2021 and 2022 to the average admissions in the same month and hospital over the pre-pandemic years (2017–2019). The explanatory variable Impact Rate represents the % reduction in the hospital elective activity in 2020, with respect to the 2017-2019 average. Robust standard errors clustered at the hospital level. Year, month, and region fixed effects are included

***$p < 0.01$, **$p < 0.05$, *$p < 0.1$

reduce concerns about simultaneity and reverse causality, since the pandemic affected resource allocation, demographic composition, and recovery capacity at the same time. However, changes within hospitals in supply conditions after the onset of COVID-19, as well as shifts in demand across provinces, could also influence recovery rates. If these variations systematically differ between public and private hospitals, our baseline estimates may be biased. To address this issue, we estimate an alternative specification in which supply and demand variables are measured at the start of each year (January 2021 and January 2022).[8] This approach captures post-pandemic variations in hospital resources and local demographic dynamics while reducing simultaneity bias by using variables recorded at the beginning of the year rather than contemporaneous with the outcome measures. The results, shown in Table 7, remain broadly consistent with those from the baseline specification.

[8] Descriptive statistics are presented in Table 15.

Table 6 Robustness check excluding COVID-19-related admissions

	RR 2021–22	RR 2021	RR 2022
Female (%)	0.083*	0.068	0.104**
	(0.045)	(0.051)	(0.045)
Age 65+ (%)	− 0.020	− 0.006	− 0.035***
	(0.013)	(0.015)	(0.012)
Foreign (%)	0.017	0.020	0.013
	(0.011)	(0.012)	(0.011)
Per-capita income	− 0.000*	− 0.000	− 0.000
	(0.000)	(0.000)	(0.000)
Medical staff per bed	0.047**	0.054***	0.040*
	(0.020)	(0.019)	(0.022)
Beds (log)	0.042**	0.045**	0.039**
	(0.017)	(0.019)	(0.018)
Public hospital	− 0.232***	− 0.280***	− 0.187***
	(0.044)	(0.051)	(0.047)
Nearby private admissions (50 km)	− 0.027**	− 0.035**	− 0.022**
	(0.011)	(0.016)	(0.010)
Nearby public admissions (50 km)	0.034*	0.039	0.021
	(0.020)	(0.027)	(0.019)
Observations	14,661	7,316	7,345
R-squared	0.120	0.129	0.110

The dependent variable is the Recovery Rate (RR) excluding COVID-19-related admissions (MDC 4 and 18). The RR is calculated as the ratio of elective admissions in each month of 2021 and 2022 to the average admissions in the same month and hospital over the pre-pandemic years (2017–2019). Robust standard errors clustered at the hospital level. Year, month, and region fixed effects are included
$^{***}p < 0.01$, $^{**}p < .05$, $^{*}p < 0.1$

Finally, we conduct a sensitivity check on the choice of the distance radius used to construct the local competition variables. While the main specification relies on a 50 km radius, we now measure local competition by considering the elective activity of hospitals within a narrower definition (30 km; Bloom et al. 2015; Bosque-Mercader et al. 2025), and a broader one (70 km; Guida et al. 2019; Brekke et al. 2021; Kessler and Geppert, 2005 use 50 km or broader radii).[9]

Results are reported in Table 8. In the 30-km specification, the coefficient for the elective activity of nearby private providers is negative but not statistically significant. As previously discussed, this might reflect the lower density of private hospitals in some parts of the country, where a 30 km radius captures very few or no private hospitals, potentially making such a definition overly restrictive for the Italian context. By contrast, the coefficient becomes statistically significant once the radius is expanded to 70 km, consistent with the baseline finding that recovery rates are lower where surrounding private hospitals perform more elective activity. Overall, the estimates

[9] Descriptive statistics are reported in Table 16.

Table 7 Estimates including time-varying supply and demand controls

	(1) RR 2021–22	(2) RR 2021	(3) RR 2022
Female (%)	0.088*	0.072	0.111**
	(0.047)	(0.051)	(0.047)
Age 65+ (%)	– 0.029**	– 0.013	– 0.045***
	(0.013)	(0.015)	(0.012)
Foreign (%)	0.015	0.019	0.012
	(0.011)	(0.012)	(0.011)
Per-capita income	– 0.000*	– 0.000*	– 0.000
	(0.000)	(0.000)	(0.000)
Medical staff per bed	0.051***	0.066***	0.038**
	(0.016)	(0.018)	(0.017)
Beds (log)	0.036**	0.036**	0.036*
	(0.017)	(0.017)	(0.019)
Public hospital	– 0.226***	– 0.276***	– 0.182***
	(0.043)	(0.049)	(0.044)
Nearby private admissions (log)	– 0.030***	– 0.041***	– 0.023**
	(0.011)	(0.016)	(0.010)
Nearby public admissions (log)	0.036*	0.044	0.023
	(0.020)	(0.027)	(0.019)
Observations	15,081	7504	7577
R-squared	0.124	0.129	0.121

In this specification we include time-varying supply- and demand-side controls, measured at the beginning of each year rather than fixed in 2019. Robust standard errors clustered at the hospital level. Year, month, and region fixed effects are included

$***p < 0.01$, $**p < 0.05$, $*p < 0.1$

point to a negative association between nearby private providers' elective activity and hospital recovery rates, as coefficients are consistently negative across specifications. However, the magnitude and significance of this relationship are robust only under broader market definitions, while narrower thresholds do not yield statistically significant evidence, calling for cautious interpretation.

5.4 Recovery rates by major diagnostic categories

We now leverage the detailed MDC breakdown of our dataset to examine the recovery rates of elective procedures for each specific MDC. Our goal is to investigate whether the results observed so far can be attributed to a generalized pattern across all MDCs or if some specific MDCs are driving the observed results. Unfortunately, however, we lack detailed information on the specific procedures performed by the hospitals, as our data are aggregated into these broader diagnostic categories.

Table 8 Alternative distance thresholds

	RR 2021–22	RR 2021	RR 22	RR 2021–22	RR 2021	RR 22
Female (%)	0.088*	0.083	0.094*	0.078	0.064	0.094*
	(0.052)	(0.057)	(0.050)	(0.049)	(0.054)	(0.049)
Age 65+ (%)	– 0.022	– 0.010	– 0.035***	– 0.026**	– 0.011	– 0.042***
	(0.014)	(0.016)	(0.013)	(0.013)	(0.015)	(0.012)
Foreign (%)	0.015	0.016	0.014	0.016	0.019*	0.013
	(0.010)	(0.012)	(0.011)	(0.010)	(0.011)	(0.011)
Per-capita income	– 0.000*	– 0.000*	– 0.000	– 0.000*	– 0.000**	– 0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Medical staff per bed	0.045**	0.050***	0.041*	0.040**	0.044**	0.037*
	(0.019)	(0.019)	(0.021)	(0.019)	(0.019)	(0.021)
Beds (log)	0.026	0.028	0.026	0.034**	0.035*	0.034*
	(0.017)	(0.019)	(0.018)	(0.017)	(0.018)	(0.018)
Public hospital	– 0.214***	– 0.264***	– 0.168***	– 0.215***	– 0.254***	– 0.178***
	(0.047)	(0.052)	(0.049)	(0.046)	(0.051)	(0.048)
Nearby private (30 km)	– 0.001	– 0.001	– 0.001			
	(0.005)	(0.006)	(0.006)			
Nearby public (30 km)	0.004	0.001	0.005			
	(0.005)	(0.006)	(0.005)			
Nearby private (70 km)				– 0.054***	– 0.070**	– 0.044**
				(0.020)	(0.027)	(0.020)
Nearby public (70 km)				0.050*	0.073**	0.029
				(0.029)	(0.029)	(0.019)
Observations	14,693	7340	7353	15,108	7545	7563
R-squared	0.110	0.114	0.109	0.114	0.119	0.111
Region FE	Yes	Yes	Yes	Yes	Yes	Yes
Month FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	–	–	Yes	–	–

Robust standard errors clustered at the hospital level. Year, month, and region fixed effects are included
$^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$

The results are displayed in Table 9.[10] Our analysis indicates that public hospitals show significantly lower recovery rates for MDCs 6, 7, and 8, which are related to diseases of the digestive system, hepatobiliary system, and musculoskeletal system, respectively. MDC 25 (HIV) also shows a negative and statistically significant coefficient, though this should be interpreted with caution due to the small sample size. A lower recovery rate for public hospitals is also observed for MDC 12 and 13 (male and female reproductive disorders, respectively), although these coefficients are only weakly significant.

[10] The table presents the results only for those MDCs that in 2020 experienced at least a 10% average monthly reduction in activity volumes, compared to the three-year average in 2017–2019. Results for other MDCs are provided in Table 17.

Table 9 Results by MDC, monthly recovery rate 2021–2022

	MDC 1	MDC 2	MDC 3	MDC 5	MDC 6	MDC 7	MDC 8	MDC 12	MDC 13	MDC 19	MDC 25
Female (%)	0.131*	− 0.039	0.133	0.075	0.092	0.112*	0.197***	− 0.034	0.030	0.040	0.177
	(0.077)	(0.222)	(0.136)	(0.081)	(0.080)	(0.065)	(0.069)	(0.106)	(0.103)	(0.138)	(0.183)
Age 65+ (%)	− 0.031	0.027	0.012	− 0.014	− 0.020	− 0.042***	− 0.049***	− 0.022	− 0.010	− 0.015	0.132**
	(0.021)	(0.049)	(0.028)	(0.021)	(0.021)	(0.016)	(0.017)	(0.031)	(0.021)	(0.036)	(0.058)
Foreign (%)	0.007	0.015	0.009	0.003	0.011	0.024*	0.018	0.006	− 0.011	− 0.003	0.047
	(0.016)	(0.052)	(0.023)	(0.020)	(0.018)	(0.015)	(0.015)	(0.023)	(0.018)	(0.024)	(0.050)
Per-capita income	− 0.000	0.000	− 0.000	− 0.000	− 0.000	− 0.000	− 0.000	− 0.000	0.000	− 0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Medical staff per bed	− 0.006	0.099**	− 0.003	0.121***	0.058*	0.015	0.028	0.018	0.005	− 0.003	0.188
	(0.033)	(0.048)	(0.048)	(0.027)	(0.035)	(0.036)	(0.033)	(0.046)	(0.038)	(0.043)	(0.158)
Beds (log)	− 0.009	− 0.169**	− 0.022	0.048*	0.031	− 0.038	− 0.022	− 0.001	0.035	− 0.025	− 0.001
	(0.023)	(0.074)	(0.040)	(0.028)	(0.028)	(0.027)	(0.025)	(0.040)	(0.036)	(0.037)	(0.072)
Public hospital	0.002	0.011	− 0.136	− 0.020	− 0.195***	− 0.164***	− 0.255***	− 0.161*	− 0.133*	− 0.090	− 0.418**
	(0.070)	(0.154)	(0.103)	(0.070)	(0.062)	(0.060)	(0.065)	(0.089)	(0.075)	(0.107)	(0.202)
Nearby private (50 km)	− 0.026	− 0.095**	0.020	0.019	0.007	0.003	− 0.047***	− 0.007	− 0.030	− 0.034	− 0.016
	(0.019)	(0.045)	(0.023)	(0.020)	(0.016)	(0.013)	(0.014)	(0.019)	(0.037)	(0.028)	(0.029)
Nearby public (50 km)	0.014	0.075	− 0.022	0.000	− 0.013	− 0.015	− 0.003	− 0.003	− 0.049*	0.050	− 0.091
	(0.032)	(0.107)	(0.047)	(0.034)	(0.027)	(0.028)	(0.022)	(0.035)	(0.029)	(0.052)	(0.062)
Observations	10,590	3388	5740	10,019	9627	8982	12,215	6722	7142	3955	213
R-squared	0.031	0.117	0.098	0.090	0.078	0.074	0.114	0.084	0.055	0.078	0.453

Robust standard errors clustered at the hospital level. Year, month, and region fixed effects are included
$^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$

Table 10 Results by MDC, monthly recovery rate 2021

	MDC 1	MDC 2	MDC 3	MDC 5	MDC 6	MDC 7	MDC 8	MDC 12	MDC 13	MDC 19	MDC 25
Female (%)	0.128	−0.026	0.138	0.024	0.085	0.119*	0.173**	−0.055	0.019	−0.018	0.642*
	(0.081)	(0.212)	(0.148)	(0.090)	(0.087)	(0.066)	(0.070)	(0.110)	(0.108)	(0.137)	(0.326)
Age 65+ (%)	−0.028	0.027	0.017	−0.006	−0.014	−0.040**	−0.041**	−0.002	−0.006	−0.011	0.056
	(0.021)	(0.048)	(0.028)	(0.022)	(0.023)	(0.016)	(0.018)	(0.032)	(0.022)	(0.037)	(0.074)
Foreign (%)	0.015	0.029	0.002	−0.004	0.022	0.028*	0.016	0.018	−0.011	−0.009	0.060
	(0.018)	(0.050)	(0.026)	(0.021)	(0.019)	(0.016)	(0.016)	(0.024)	(0.019)	(0.024)	(0.059)
Per-capita income	−0.000	0.000	−0.000	−0.000	−0.000	−0.000	−0.000	−0.000	0.000	0.000	−0.000*
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Medical staff per bed	0.004	0.062	0.017	0.127***	0.052	0.016	0.041	0.029	0.018	−0.008	0.164
	(0.035)	(0.050)	(0.055)	(0.028)	(0.036)	(0.033)	(0.033)	(0.050)	(0.044)	(0.045)	(0.316)
Beds (log)	−0.018	−0.185**	−0.026	0.044	0.014	−0.039	−0.039	−0.015	0.045	−0.016	0.013
	(0.025)	(0.087)	(0.045)	(0.029)	(0.031)	(0.029)	(0.026)	(0.043)	(0.038)	(0.041)	(0.112)
Public hospital	−0.049	0.016	−0.211*	−0.043	−0.235***	−0.216***	−0.281***	−0.219**	−0.198**	−0.112	−0.388
	(0.075)	(0.166)	(0.108)	(0.075)	(0.068)	(0.065)	(0.067)	(0.092)	(0.084)	(0.116)	(0.297)
Nearby private (50 km)	−0.040**	−0.124**	0.030	0.028	−0.001	−0.008	−0.065***	−0.012	−0.040	−0.065**	−0.134
	(0.018)	(0.058)	(0.039)	(0.022)	(0.019)	(0.018)	(0.018)	(0.034)	(0.044)	(0.032)	(0.149)
Nearby public (50 km)	0.021	0.136	−0.035	−0.012	0.001	0.003	−0.003	−0.003	−0.055*	0.060	0.146
	(0.031)	(0.094)	(0.051)	(0.034)	(0.029)	(0.028)	(0.022)	(0.040)	(0.030)	(0.055)	(0.241)
Observations	5289	1667	2846	4981	4759	4446	6085	3361	3575	1935	101
R-squared	0.038	0.145	0.107	0.090	0.111	0.092	0.134	0.109	0.070	0.084	0.519

Robust standard errors clustered at the hospital level. Month and region fixed effects are included
$^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$

Table 11 Results by MDC, monthly recovery rate 2022

	MDC 1	MDC 2	MDC 3	MDC 5	MDC 6	MDC 7	MDC 8	MDC 12	MDC 13	MDC 19	MDC 25
Female (%)	0.140*	− 0.032	0.136	0.129	0.109	0.112	0.228***	0.006	0.047	0.100	− 0.002
	(0.082)	(0.256)	(0.138)	(0.082)	(0.084)	(0.076)	(0.075)	(0.110)	(0.112)	(0.153)	(0.237)
Age 65+ (%)	− 0.035	0.017	0.006	− 0.024	− 0.029	− 0.047**	− 0.060***	− 0.050	− 0.015	− 0.020	0.163*
	(0.022)	(0.056)	(0.033)	(0.022)	(0.022)	(0.020)	(0.018)	(0.032)	(0.024)	(0.041)	(0.091)
Foreign (%)	− 0.003	0.003	0.016	0.009	0.000	0.019	0.019	− 0.007	− 0.010	0.003	0.020
	(0.016)	(0.061)	(0.024)	(0.021)	(0.019)	(0.017)	(0.017)	(0.024)	(0.018)	(0.027)	(0.071)
Per-capita income	− 0.000	0.000*	− 0.000	− 0.000	− 0.000	− 0.000	− 0.000	0.000	0.000	− 0.000	0.000**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Medical staff per bed	− 0.015	0.132**	− 0.023	0.117***	0.065*	0.015	0.015	0.003	− 0.009	0.001	0.357*
	(0.035)	(0.052)	(0.046)	(0.029)	(0.038)	(0.044)	(0.037)	(0.045)	(0.037)	(0.047)	(0.196)
Beds (log)	0.000	− 0.157**	− 0.021	0.052*	0.048*	− 0.035	− 0.003	0.012	0.024	− 0.034	0.021
	(0.024)	(0.072)	(0.043)	(0.030)	(0.029)	(0.029)	(0.026)	(0.041)	(0.038)	(0.040)	(0.095)
Public hospital	0.049	0.007	− 0.067	− 0.001	− 0.161**	− 0.118*	− 0.237***	− 0.108	− 0.069	− 0.071	− 0.316
	(0.072)	(0.158)	(0.111)	(0.074)	(0.064)	(0.065)	(0.071)	(0.095)	(0.075)	(0.112)	(0.210)
Nearby private (50 km)	− 0.015	− 0.081*	0.018	0.014	0.014	0.010	− 0.035***	− 0.001	− 0.026	− 0.011	0.011
	(0.023)	(0.043)	(0.021)	(0.022)	(0.017)	(0.011)	(0.012)	(0.015)	(0.036)	(0.028)	(0.036)
Nearby public (50 km)	− 0.002	− 0.009	− 0.029	0.004	− 0.035	− 0.036	− 0.011	− 0.028	− 0.047	0.034	− 0.176**
	(0.038)	(0.128)	(0.054)	(0.040)	(0.029)	(0.033)	(0.026)	(0.038)	(0.033)	(0.058)	(0.084)
Observations	5301	1721	2894	5038	4868	4536	6130	3361	3567	2020	112
R-squared	0.032	0.116	0.101	0.094	0.061	0.068	0.094	0.068	0.052	0.085	0.544

Robust standard errors clustered at the hospital level. Month and region fixed effects are included
$^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$

The findings are generally consistent when examining recovery rates for 2021 (Table 10) and 2022 (Table 11) separately. Furthermore, the activity of nearby private providers within a 50 km radius shows a negative and statistically significant coefficient for MDC 8 (musculoskeletal system diseases) and MDC 2 (eye diseases).

Overall, these findings reveal significant variability in recovery rates across different MDCs, suggesting that patterns in recovery rates are closely tied to the specific types of care provided by hospitals and the specialities involved.

6 Conclusions

Health systems around the world were put to an unprecedented test due to COVID-19 pandemic, drawing attention to the need for resilient healthcare delivery. Our study investigated how Italian hospitals recovered elective admissions following the massive interruptions occurred during the pandemic, with a focus on the interplay between public and private healthcare sectors. The aim was to assess whether Italian hospitals could return to pre-pandemic activity levels and to identify supply and demand factors driving differences in recovery across providers.

We built a comprehensive monthly panel data set covering hospitals in Italy between 2017 and 2022. The final dataset incorporates information from several sources, the main one being the Italian Agency for Regional Health Services (AGENAS), from which we collected data on the monthly number of planned hospitalizations. We measured recovery by comparing elective admission after the shock, in 2021 and 2022, against those in the pre-pandemic period spanning from 2017 through 2019. Data on the supply side (hospital characteristics, workforce, beds) and on the demand side (population demographics) were drawn from the New Health Information System (NSIS) and ISTAT, respectively.

Our analysis yielded several key results. First, our findings suggest substantial differences in recovery rates between private and public hospitals. The estimates suggest that recovery rates are roughly 20% lower in public hospitals than in private ones. This gap may be partially explained by the higher incidence of COVID-19 cases at public health facilities which mainly handled emergency cases during the pandemic. In this respect, public hospitals faced tougher challenges reallocating resources to restore elective services. This result holds across a range of specifications and robustness checks, and public providers display worse recovery indicators also when accounting for the percentage reduction in elective activities performed in 2020. Using MDC aggregated data, we find that the disparity between public and private recovery is mainly driven by elective admissions for diagnostic categories such as digestive, hepatobiliary, and musculoskeletal diseases.

Additionally, we found that higher activity of private hospitals within a 50 km radius was negatively associated with recovery rates in nearby facilities. This might imply a scenario where patients switched from public to private providers as they were more prompt in resuming elective admissions. However, the evidence is sensitive to narrower market definitions and should be regarded as suggestive.

Focusing further on supply-side factors, we document a positive association between staffing intensity and hospital recovery, with hospitals with higher medical staff-to-bed ratios achieving systematically better recovery rates. We also find some evidence that larger hospitals, proxied by the number of beds, recovered more rapidly.

On the demand side, areas with a greater proportion of elderly populations experienced slower recovery, and this is likely due to older adults being disproportionately affected by COVID-19. Conversely, provinces with higher proportions of female residents had better recovery rates.

Our study has several limitations that warrant consideration and provide avenues for future research. Firstly, we do not observe individual patient-level data, which limits our ability to analyze factors such as patient characteristics, specific medical conditions, or procedural details that may influence recovery patterns. Additionally, we lack information on the specific types of elective procedures performed by each hospital, which could provide valuable insights into which services were most affected and how recovery varied across different medical specialties. Finally, data quality and consistency across regions may affect comparability, highlighting the need for harmonized reporting standards. While regional monitoring systems showed a certain degree of homogeneity—since the central government required uniform reporting of key indicators such as daily new COVID-19 cases, hospitalizations, ICU admissions, deaths, discharges, and testing—they also displayed heterogeneity in the screening methods used to detect new cases and control viral spread (Bosa et al. 2021).

Future studies incorporating more granular data could provide further insights into recovery dynamics and help identify targeted interventions for specific patient groups or medical procedures. Furthermore, qualitative research exploring hospital administrators' decision-making processes and patients' care-seeking behaviors during the recovery period could complement our quantitative findings and provide a more comprehensive picture of the challenges and strategies involved in restoring elective services and enabling a quantitative assessment of resilience capacity (Cavalieri et al. 2025). Such research would also allow for a deeper understanding of the differences in regional healthcare policies, which likely influenced both the spread of the virus and extent of recovery.

However, this study offers important policy implications for healthcare system resilience and recovery in the face of large-scale disruptions. Our findings highlight the need for targeted interventions to support public hospitals in restoring elective services, potentially through resource reallocation or temporary capacity expansions. While public–private collaboration during COVID-19 proved essential for expanding healthcare capacity, the subsequent recovery phase exposed weaknesses in the public sector and provided an opportunity for the private sector to gain market share. Private facilities not only recovered more quickly but even surpassed previous activity levels, particularly in clinical areas such as digestive, hepatobiliary, and musculoskeletal diseases.

This divergence may stem from several factors, including organizational rigidity in public institutions, slower adaptation to changing service demands, and differences in resource allocation strategies. The relatively slower recovery of the public sector entails considerable risks, including the aggravation of existing healthcare inequalities and reduced access for vulnerable groups. In contrast, the private sector, benefiting from greater flexibility, stronger financial capacity, and the ability to introduce new resources and technologies without lengthy approval processes, is often better positioned to lead cross-sector collaborations during crises. While the public sector continues to play a crucial role in safeguarding equity and universal access, the private sector's speed, adaptability, and specialized expertise make it a key driver of coordinated responses (Wang et al. 2022).

To foster overall resilience, as a sustained capacity to absorb, adapt, and transform, health systems must embrace structured cooperation between public and private sectors. In the short term, informal partnerships can stabilize supply chains and accelerate the mobilization of resources. Over the medium term, formal agreements should support shared infrastructure and joint innovation platforms. In the long run, global alliances among diverse stakeholders can harmonize strategies and expand healthcare capacity (Baxter and Casady 2020).

Achieving this requires the implementation of clear, transparent regulatory frameworks that guide resource distribution (Maresso 2023), ensure high-quality service delivery, and align with the epidemiological needs of the territory (Bobini et al. 2020).

Additionally, our results highlight the importance of staffing endowment for hospital resilience. Policies that strengthen the hospital workforce are warranted, not only in light of the well-documented positive effects on patient outcomes (Kane et al. 2007; Dall'Ora et al. 2022), but also as a strategy to enhance resilience. Strengthening workforce capacity allows hospitals to distribute workload more effectively and to reduce risk of excessive strain during periods of sudden pressure.

Finally, the geographic patterns of recovery underscore the importance of region-specific strategies, particularly in areas with aging populations or limited provider options. These insights can inform the development of more robust and adaptive healthcare policies to enhance system resilience and ensure equitable access to care in future crises.

Appendix: Additional figures and tables

See Figs. 8, 9, 10, 11 and 12 and Tables 12, 13, 14, 15, 16 and 17.

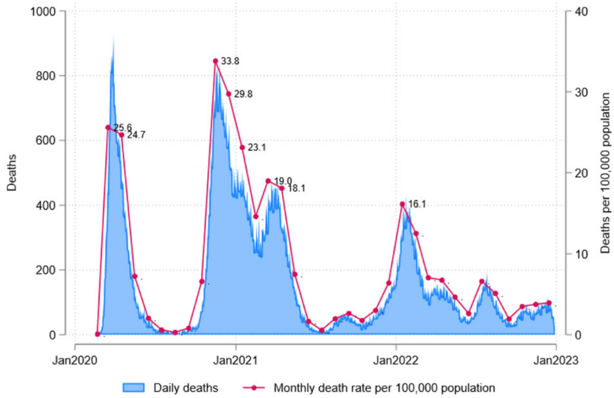

Fig. 8 Daily deaths and monthly death rate per 100,000 inhabitants (2020–2022). *Source:* authors' computation on data provided by Istituto Superiore di Sanità (ISS): https://www.epicentro.iss.it/coronavirus/sars-cov-2-dashboard (Accessed 29/09/2025)

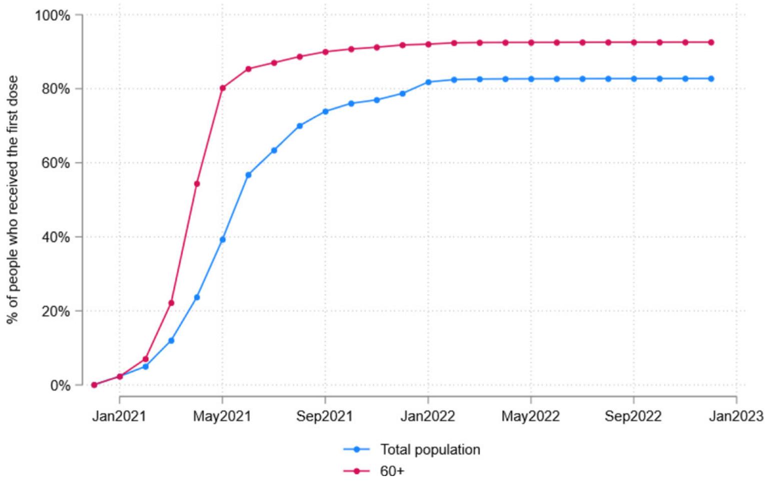

Fig. 9 Share of population (total and 60+) with at least one vaccine dose (2021-2022). **Source:* authors' computation on data provided by the Italian Ministry of Health https://github.com/italia/covid19-opendata-vaccini/tree/master (Accessed 29/09/2025)

Fig. 10 Geographic distribution of public and private hospitals in Italy

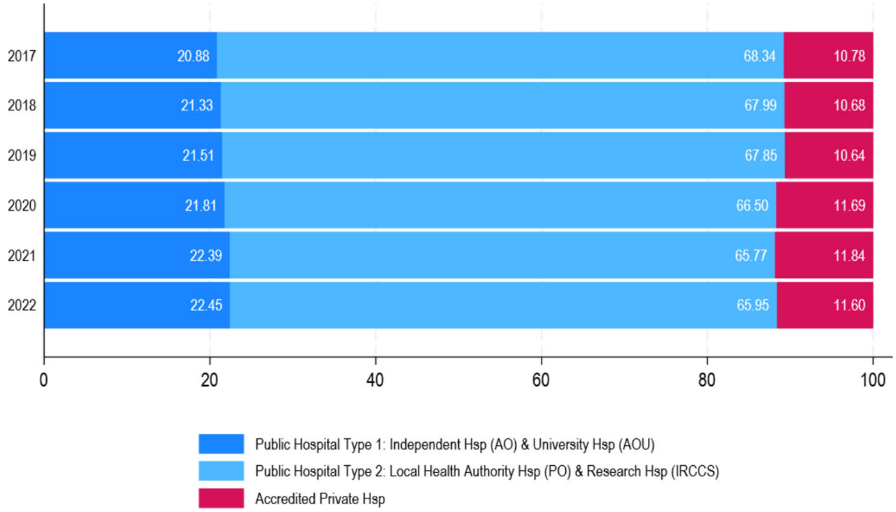

Fig. 11 Emergency admissions (%) by type of healthcare facility and year

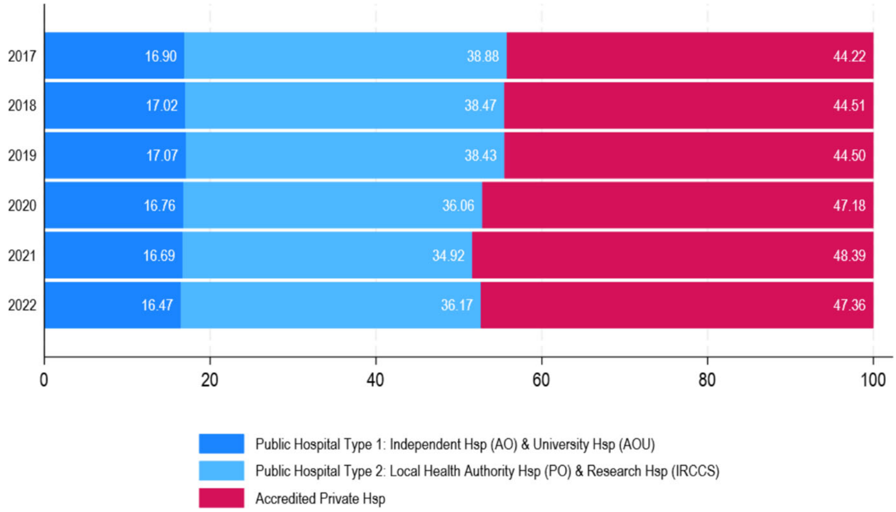

Fig. 12 Elective admissions (%) by type of healthcare facility and year

Table 12 Descriptive statistics

	#Obs	Mean	SD
Demand Side			
% Females (2019)	25,104	51.29	0.49
% Foreigners (2019)	25,104	7.98	3.53
% 65+ (2019)	25,104	22.82	2.38
Per Capita Income (2019)	25,216	10884.39	2563.66
Supply Side			
# Beds (log) (2019)	24,144	4.00	2.00
# Medical Staff per Bed (2019)	22,368	1.83	1.34
Public Hospital	25,216	0.45	0.50
Private Accredited Hospital	25,216	0.55	0.50
Public Hospital Type 1 *(Independent and University Hospitals)*	25,216	0.05	0.22
Public Hospital Type 2 *(Local Health Authority Hospitals and Research Hospitals)*	25,216	0.40	0.49
# Adm. Nearby Private (log)	17,782	7.55	1.72
Elective admissions in private hospitals within a 50 km radius			
# Adm. Nearby Public (log)	18,282	7.46	1.48
Elective admissions in public hospitals within a 50 km radius			

Table 13 Facility sub-types

	RR 2021–22	RR 2021	RR 2022
Female (%)	0.079	0.066	0.097**
	(0.048)	(0.054)	(0.047)
Age 65+ (%)	– 0.024*	– 0.010	– 0.040***
	(0.013)	(0.016)	(0.012)
Foreign (%)	0.016	0.017	0.014
	(0.011)	(0.012)	(0.011)
Per-capita income	– 0.000	– 0.000	– 0.000
	(0.000)	(0.000)	(0.000)
Medical staff per bed	0.043**	0.047**	0.040*
	(0.020)	(0.020)	(0.022)
Beds (log)	0.024	0.021	0.027
	(0.017)	(0.019)	(0.018)
Public Hospitals Type 1	– 0.150***	– 0.151***	– 0.151***
	(0.051)	(0.056)	(0.054)
Public Hospitals Type 2	– 0.217***	– 0.262***	– 0.176***
	(0.046)	(0.051)	(0.048)
Nearby private admissions (50 km)	– 0.031***	– 0.042***	– 0.024**
	(0.011)	(0.016)	(0.010)
Nearby public admissions (50 km)	0.034*	0.043	0.020
	(0.020)	(0.026)	(0.020)
Observations	14,669	7328	7341
R-squared	0.116	0.122	0.112

Results accounting for different categories of public facilities. Public Hospitals Type 1 denotes bigger public facilities: Independent Hospitals (Aziende Ospedaliere-AO) and University Hospitals (Aziende Ospedaliere Universitarie-AOU). Public Hospitals Type 2 consists of smaller public facilities: Local Health Authority Hospitals (Presidi Ospedalieri-PO) and Research Hospitals (Istituti di Ricovero e Cura a Carattere Scientifico-IRCCS). Private accredited facilities are the reference group. Robust standard errors clustered at the hospital level. Year, month, and region fixed effects are included

***$p < 0.01$, **$p < 0.05$, *$p < 0.1$

Table 14 Results by macro-area

f	(1) North-West	(2) North-East	(3) Central	(4) South
Female (%)	0.141*	0.156	− 0.069	0.044
	(0.084)	(0.094)	(0.123)	(0.106)
Age 65+ (%)	− 0.038*	− 0.007	− 0.054	− 0.016
	(0.021)	(0.023)	(0.037)	(0.028)
Foreign (%)	0.002	0.046**	0.012	0.021
	(0.015)	(0.021)	(0.018)	(0.038)
Per-capita income	− 0.000	− 0.000	0.000	− 0.000
	(0.000)	(0.000)	(0.000)	(0.000)
Medical staff per bed	0.007	0.025	0.087***	0.030
	(0.029)	(0.025)	(0.022)	(0.053)
Beds (log)	0.020	− 0.051*	0.044	0.052
	(0.027)	(0.026)	(0.028)	(0.036)
Public hospital	− 0.148*	− 0.033	− 0.125	− 0.305***
	(0.075)	(0.073)	(0.079)	(0.106)
Nearby private admissions (50 km)	− 0.031***	− 0.089***	− 0.030**	− 0.026
	(0.009)	(0.033)	(0.012)	(0.040)
Nearby public admissions (50 km)	0.042	0.070*	0.034	0.041
	(0.034)	(0.040)	(0.034)	(0.031)
Observations	3442	2941	3067	5243
R-squared	0.139	0.198	0.133	0.123

Robust standard errors clustered at the hospital level. Year, month, and region fixed effects are included
$^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$

Table 15 Descriptive statistics (time-varying controls)

	#Obs	Mean	SD
Demand side			
% Females	25,216	51.23	0.48
% Foreigners	25,104	7.98	3.53
% 65+	25,216	23.49	2.26
Per Capita Income	25,216	11021.27	2526.53
Supply side			
# Beds (log)	22,724	4.8	0.98
# Medical Staff per Bed	22,724	1.72	1.26

The table shows descriptive statistics for demand- and supply-side variables measured at the beginning of each year (2021 and 2022), rather than fixed at their predetermined 2019 values. These variables enter the estimates in Table 7

Table 16 Descriptive statistics (alternative distance thresholds)

	#Obs	Mean	SD
# Adm. Nearby Private (log) 30 km	17,782	6.11	2.05
# Adm. Nearby Public (log) 30 km	18,282	5.98	2.02
# Adm. Nearby Private (log) 70 km	18,258	8.02	1.43
# Adm. Nearby Public (log) 70 km	18,402	8.01	1.25

The table shows descriptive statistics for local competition measures (log elective admissions in nearby public and private providers) based on alternative distance thresholds to the 50 km baseline. These variables enter the estimates in Table 8

Table 17 Results by MDC (other MDCs), monthly recovery rate 2021–22

	MDC 4	MDC 9	MDC 10	MDC 12	MDC 15	MDC 16	MDC 17	MDC 18	MDC 20	MDC 21	MDC 22	MDC 23	MDC 24
Female (%)	0.139	0.039	0.169	−0.034	−0.361	0.069	0.122	−0.056	0.132	0.221***	−0.136	0.075	0.238
	(0.114)	(0.105)	(0.114)	(0.106)	(0.514)	(0.066)	(0.106)	(0.096)	(0.285)	(0.074)	(0.468)	(0.090)	(0.228)
Age 65+ (%)	−0.077***	−0.029	−0.010	−0.022	0.051	−0.031**	−0.033	−0.037	−0.091	−0.071***	0.031	0.022	0.055
	(0.026)	(0.025)	(0.029)	(0.031)	(0.133)	(0.015)	(0.026)	(0.026)	(0.073)	(0.020)	(0.086)	(0.023)	(0.058)
Foreign (%)	−0.004	−0.006	0.038	0.006	−0.005	−0.013	−0.001	−0.029	−0.159***	−0.009	−0.016	0.015	−0.025
	(0.029)	(0.028)	(0.025)	(0.023)	(0.050)	(0.019)	(0.022)	(0.026)	(0.032)	(0.016)	(0.041)	(0.025)	(0.047)
Per-capita income	−0.000	−0.000	−0.000	−0.000	−0.000	0.000	−0.000*	0.000	−0.000	−0.000	−0.000	0.000	−0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Medical staff per bed	0.076*	0.038	0.110**	0.018	0.349**	−0.016	0.018	−0.023	0.146**	0.035	0.064	−0.049	0.070
	(0.042)	(0.048)	(0.047)	(0.046)	(0.165)	(0.032)	(0.056)	(0.054)	(0.062)	(0.039)	(0.121)	(0.037)	(0.100)
Beds (log)	−0.088**	0.081**	−0.069*	−0.001	−0.155**	−0.106***	−0.016	−0.163***	0.059	−0.106***	0.300**	−0.024	−0.078
	(0.037)	(0.034)	(0.038)	(0.040)	(0.071)	(0.028)	(0.045)	(0.046)	(0.068)	(0.027)	(0.146)	(0.033)	(0.129)
Public hospital	−0.016	−0.017	−0.137	−0.161*	−0.360	−0.010	0.030	−0.078	−0.482**	0.057	−0.240	0.025	−0.315
	(0.087)	(0.080)	(0.091)	(0.089)	(0.227)	(0.060)	(0.114)	(0.096)	(0.226)	(0.077)	(0.264)	(0.076)	(0.218)
Nearby private (50 km)	−0.028	−0.021	−0.010	−0.007	−0.053	0.043***	−0.011	0.019	−0.057	−0.020	−0.043	−0.022	0.032
	(0.023)	(0.017)	(0.022)	(0.019)	(0.063)	(0.016)	(0.024)	(0.025)	(0.081)	(0.023)	(0.097)	(0.020)	(0.134)
Nearby public (50 km)	−0.006	0.017	0.053	−0.003	0.169	−0.005	0.012	0.040	−0.045	0.012	− − − − − − −0.003	0.073*	0.013
	(0.046)	(0.040)	(0.041)	(0.035)	(0.157)	(0.028)	(0.037)	(0.048)	(0.097)	(0.025)	(0.098)	(0.040)	(0.155)
Observations	8,194	7,687	7,325	6,722	627	4,014	5,710	4,562	992	4,216	189	9,250	82
R-squared	0.045	0.054	0.068	0.084	0.193	0.069	0.048	0.097	0.239	0.064	0.236	0.055	0.401

Robust standard errors clustered at the hospital level. Year, month and region fixed effects are included

$^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$

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