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The long-term effects of hospitalization on health care expenditures: An empirical analysis for the young-old population in Lombardy

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ABSTRACT

As the burden of acute care on government budgets is mounting in many countries, documenting the evolution of health costs following patients' hospital admission is essential for assessing overall hospital-related costs. In this paper, we investigate the short- and long-term effects of hospitalization on different types of health care expenditures. We specify and estimate a dynamic DID model using register data of the entire population of individuals aged 50–70 residing in Milan, Italy, over the period 2008–2017. We find evidence of a large and persistent effect of hospitalization on total health care expenditures, with future medical expenses mostly accounted for by inpatient care. Considering all health treatments, the overall effect is sizable and is about twice the cost of a single hospital admission. We show that chronically ill and disabled individuals require greater post-discharge medical assistance, especially for inpatient care, and that cardiovascular and oncological diseases together account for more than half of expenditures on future hospitalizations. Alternative out-of-hospital management practices are discussed as a post-admission cost-containment measure.

1. Introduction

Hospital care accounts, on average, for 28% of health care spending among OECD countries [1] and is often targeted by cost-containment measures to keep under control the growth in health spending that many countries have been facing in the last decades [2]. As suggested by Chandra et al. (2013) [3], such interventions are likely to be more effective if they address not only inpatient care, but also admission-related treatments undertaken after discharge, more rarely included in policy design. Some types of post-discharge care account for a significant portion of spending growth [3,4], and for some diseases, related expenses are comparable to those incurred for initial hospitalization [5]. More comprehensive evaluations covering both inpatient and post-discharge expenditures are therefore essential to inform policy makers about overall admission-related costs.

In this paper, we investigate the short- and long-term effects of hospitalization on health care expenditures (HCE). Previous evidence is mainly limited to the medical literature and, in particular, cost-of-illness studies with a time horizon of up to one year. Examples include research focused on heart failure, stroke and heart attack [6–8], cancer [9–11], hip and knee fracture [12,13], infections [14,15], and mental illnesses [16]. According to most available studies, HCE are mainly due to initial hospitalization, with the remaining resulting from different combinations of other services. For example, Corrao et al. (2014) [6] and Fattore et al. (2012) [8] show that initial hospitalization for heart failure and stroke represents 39% to 47% of the average one-year per capita costs, readmissions 3.74% to 53% and other services 8% to 35%. In agreement with Nathan et al. (2015) [11], index hospitalization for several types of

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cancer accounts for 67%−78% of total episode costs, physician services 8%−22%, and readmissions 5%−11%. Although these results differ in terms of one-year cost composition, they all demonstrate that overall admission-related expenditures are far larger than expenses for initial hospitalization alone.

We contribute to the existing literature using a rich 10-year administrative panel and considering the entire population of individuals aged 50–70 residing in the metropolitan area of Milan, Italy. First, by focusing on the young-old population, we explore a critical phase of individuals' lifespan in which the initial onset of health shocks may turn into chronic diseases. According to prior research, the first heart attack, stroke, and new onset of cancer occur in individuals between ages 50 and 64 [17], and 86% of the burden of chronic diseases is among people under 70 years of age [18]. In this setting, the hospitalization analyzed, called 'first' hospitalization in the rest of the paper, can be intended as an observable realization of such shocks. It can open up different scenarios, that is, the complete recovery of admitted individuals, the onset of chronic conditions or disabilities, future complications or premature death, each characterized by distinct and hardly predictable HCE patterns that we extensively document.

Second, we investigate a large set of diseases and examine different types of care, namely hospital and day hospital admissions, outpatient services, and pharmaceuticals. These analyses allow us to identify the most costly diseases, cover the majority of post-discharge treatments, and get insights into post-discharge care pathways for each health condition.

Third, we analyze hospital-related costs at the first admission and for several years thereafter, applying an empirical strategy based on a dynamic two-way fixed-effects difference-in-difference (DID) model, with first hospitalization used as treatment and variation in treatment timing. We follow a recent econometric literature [19–23] and develop a quasi-experimental design in which the expenditures of those who experience hospital access are compared to those of individuals who have not yet been admitted at the time of first hospitalization. In each period, the causal effect of first admission is the difference in estimated HCE between the two groups.

The paper is organized as follows. Section 2 explains the institutional context, describes the data and descriptive statistics, and presents our empirical strategy. Section 3 shows the main results. Section 4 discusses the findings, and Section 5 concludes.

2. Materials and methods

2.1. Institutional setting

The Lombardy health care system is designed as a network of public and private actors with a complete separation between the community and hospital levels. In both settings, access is facilitated by the financial contribution of the Italian health care system. Hospital service is free of charge for acute cases and under the presentation of physicians' referrals, while community care requires patient's contributions for prescribed pharmaceuticals and outpatient services, with exemptions from co-payment ensured for specific groups. Among them, the chronically ill are exempted for care related to their condition, while individuals with severe disabilities qualify for total exemption.

This organization has contributed to the construction of an articulated and differentiated supply structure that excels especially in the treatment of acute cases. However, the exponential growth of the elderly cohort and the parallel expansion of the chronic population have begun to pose new challenges. In 2012, chronic patients accounted for almost 80% of health care spending on hospitalizations, outpatient services, and pharmaceuticals [24]. In an attempt to address these demographic transitions and the changing needs and demands of the population, a number of interventions have been implemented. One of these is the rationalization of the inpatient setting to reduce unwarranted and inappropriate admissions and consequent costs. It has resulted in a 'de-hospitalization' phenomenon, with a progressive shift from hospital to less expensive community care. From 1999 to 2014, hospital beds were reduced by 20% (from 45,400 to 37,500) and hospitalizations by 26% (from 1,294,000 to 958,000), while outpatient services provided increased from 108 to 170 million [24].

2.2. Data, sample and descriptive statistics

For our analysis, we exploit a unique register drawn from the Health Information System of the Agency for Health Protection (ATS according to the Italian acronym) of the Milan metropolitan city. The dataset includes the whole population aged 50–70 residing in the area during 2008–2017 and consists of about 1,000,000 individuals, for a total of roughly 8,000,000 observations. The dataset provides information on demographic and health-related traits such as gender, age, year of demise, and number of co-morbidities, as well as disease- and disability-related exemptions and type of disease for which a hospital or day hospital admission is required. Information on individual volumes and expenditures for hospital and day hospital admissions, outpatient services, and pharmaceuticals is also available. In particular, we observe the volumes and expenditures covered by the ATS, with out-of-pocket expenses not included. However, since health care in Italy is largely free at the point of service, they represent a small share of individual total HCE [25].

The initial step to carry out our quasi-experimental design is the identification of our event of interest, i.e., the first admission. As volume data are recorded on an annual basis, the first admission corresponds to the first year in which at least one access is observed, regardless of the number of hospitalizations occurred. While the sample could be limited to individuals with only one access in the year of first hospitalization, we do not impose such a restriction to account for early readmissions (Fig. A1, panel e, in the Online Appendix A shows the results by number of accesses).

In a second step, we divide our sample into a group of hospitalized and a group of not-yet-hospitalized. Those in the former group experience their first admission in the period between 2011 and 2013, a time window ensuring a sufficiently long time span before and after the event of interest. Specifically, we consider four years after admission, which is the approximate time individuals with the most severe diseases, such as surviving cancer patients, are generally expected to achieve a stable condition [26,27].

The not-yet-hospitalized group is identified by selecting individuals as similar as possible to those in the admitted group and is composed of individuals with first hospital access from 2014 onward. They are randomly assigned a 'placebo' admission in 2011–2013 and their observations are included up to the year prior to their true hospitalization, which is excluded from the estimation sample. Hence, while in each pre-event period not-yet-treated observations of both groups are compared, in each post-event period the treated observations of the admitted group are compared to the untreated observations of the other group. The final sample includes 49,942 individuals in the hospitalized group and 54,492 in the not-yet-hospitalized group, for a total of nearly one million observations (in the Online Appendix B we provide further information on data and sample restrictions).

Table 1, panel a, shows some summary statistics for hospitalized individuals at the time of first admission. The total number of first accesses declines over time, from 20,884 in 2011 to 11,999 in 2013, most likely as a result of the 'de-hospitalization' process described in the previous section. Average total HCE, calculated as the sum of expenses for the treatments analyzed, amount to about €7850. Hospitalized individuals are on average 61 years old and most of them are admitted only once. Regarding health status, 16.50% and 1.80% obtain disease- and disability-related exemptions, respectively. Note that exemptions are used here as proxies for the onset of chronic conditions or disabilities. In addition to the pathologies included in the residual category 'Other', the most common leading causes of hospitalization are

Table 1
Summary statistics, hospitalized group.

	Panel a: first admission		
	N	Mean	SD
Number of first admissions:			
2011	20,884		
2012	17,059		
2013	11,999		
Expenditures[a] (€)			
Total HCE		7847	10,230
Hospital		6346	9193
Day hospital		143	925
Outpatient		1017	2471
Pharmaceutical		341	633
Number of accesses: (%)			
One	34,941	71.35	44.65
More than one	15,001	28.65	44.65
Age		61	5
Disease exemption (%)	8220	16.50	37.12
Disability exemption (%)	906	1.80	13.29
Leading cause of hospitalization (%):			
Infectious disease	413	0.86	9.19
Mental disorders	735	1.46	12.01
Nervous system	2636	5.36	22.51
Cancer	7980	16.16	36.79
CVD	9284	18.65	38.95
COPD	2374	4.69	21.14
Digestive system	7635	15.06	35.74
Musculoskeletal disease	3749	7.55	26.42
Other	15,136	30.20	45.91
	Panel b: subsequent health events		
	N	Mean	SD
Number of accesses (%)			
Zero	22,044	61.74	48.60
One	9209	26.88	43.80
More than one	4402	12.38	32.93
Disease exemption (%)	880	2.52	15.59
Disability exemption (%)	498	1.50	11.80
Deceased (%)	450	1.30	11.22

Note: The table shows annual averages for individuals experiencing the first hospitalization between 2011 and 2013. HCE: Health care expenditures. CVD: Cardiovascular disease. COPD: Chronic obstructive pulmonary disease.

[a] Expenditures data are deflated by dividing current expenditures by the Italian consumer price index for the health sector provided by the OECD [34]; the reference year is 2015.

cardiovascular disease (CVD) and cancer.

Panel b reports statistics for periods following the first admission and indicates that it is associated with subsequent health events: about 27% and 12% of individuals are readmitted once and two or more times, respectively; 2.52% and 1.50% obtain a disease- and a disability-related exemption, respectively; 1.30% die.

In Table 2, we investigate the differences between those hospitalized and those not yet hospitalized prior to first admission to detect between-group heterogeneity in the period without treatment. Differences are analyzed in terms of group composition and expenditures and are statistically significant for all variables. However, their size is negligible and no major variations are found in either individual characteristics or expenditures. This indicates a close similarity between the two groups before the first hospitalization, a key requirement for our quasi-experimental empirical strategy.

2.3. Empirical strategy

We analyze the effect of first hospitalization on individual HCE using a dynamic two-way fixed-effects DID design with first admission used as treatment and variation in treatment timing. In this quasi-experimental design, the causal effect of the event 'first hospitalization' is estimated by comparing the change in HCE over time between the group of admitted individuals and the group of the not-yet-admitted. The latter serves as a counterfactual and provides a reference for what would have happened to the first group in the absence of the event. The comparison is made conditionally on included controls and individual fixed effects and allows the causal effect of first admission to be isolated from other factors that may influence individual HCE. When information on the link between disease and health service used is not available, this strategy makes it possible to exclude out-of-hospital expenditures incurred for medical conditions unrelated to those leading to the initial hospitalization. In this way, it allows to accurately calculate overall hospital costs for the entire population of admitted individuals.

Table 2
Summary statistics for the hospitalized group and the not-yet-hospitalized group in the pre-admission period.

	Hospitalized	Not-yet-hospitalized	Diff.	P-value
Average age	59	58	1	0.00
Male (%)	52.73	51.96	0.76	0.00
Disease exemption (%)	38.08	35.42	2.66	0.00
Disability exemption (%)	4.93	3.94	0.99	0.00
Number of co-morbidities (%):				
0	59.76	63.33	−3.58	0.00
1	28.48	26.62	1.85	0.00
2	9.49	8.12	1.37	0.00
3+	2.27	1.92	0.36	0.00
Deceased (%)	0	0	0	0.00
Expenditures[a] (€):				
Total HCE	399	355	44	0.00
Hospital	0	0	0	0.00
Day hospital	23	21	2	0.00
Outpatient	239	209	30	0.00
Pharmaceutical	137	125	12	0.00

Note: The table shows annual averages for individuals experiencing the first hospitalization between 2011 and 2013 and those who are not yet hospitalized, as well as the differences (Diff.) between the averages and the associated p-value. HCE: Health care expenditures.

[a] Expenditures data are deflated by dividing current expenditures by the Italian consumer price index for the health sector provided by the OECD [25]; the reference year is 2015.

We estimate the following model:

$$Y_{it} = \alpha A_{it} + \beta c_{it} + \delta_s + \sum_{s \neq -1} \gamma_s \cdot Hosp_i + \eta_i + \nu_t + \varepsilon_{it}$$

The variables included in Eq. 1 are listed and described in Table 3. Y_{it} represents total HCE and expenses for hospital and day hospital admissions, outpatient services, and pharmaceuticals. Note that expenditures are expressed in levels to keep observations with zero expenses in the estimation sample, such as those of the group with no hospitalizations before 2014. A_{it} is the set of age dummies included to estimate the effect of first admission net of life-cycle patterns, while c_{it} is a continuous variable intended to control for unobserved linear trend prior to the true hospitalization [28,29]. An example is the trends generated by planned

Table 3
List of variables and description.

Variable	Description	Type	Categories
$\boldsymbol{Y_{it}}$	Outcomes of interest	Continuous	
$\boldsymbol{A_{it}}$	Individual age	Categorical	50 - 70
$\boldsymbol{c_{it}}$	Linear trend before hospitalization	Continuous	
$\boldsymbol{\delta_s}$	Event time	Categorical	−3 - +4
$\boldsymbol{Hosp_i}$	Hospitalized group	Binary	
$\boldsymbol{\eta_i}$	Individual fixed effects	Continuous	
$\boldsymbol{\nu_t}$	Calendar time	Categorical	2008 - 2017
$\boldsymbol{\varepsilon_{it}}$	Error term	Continuous	

Note: The table lists the variables used to estimate Equation 1 with their description, type, and categories for categorical variables. Omitted categories: age 50; event time s_{-1}; years 2008–2009.

admissions, usually preceded by several specialist visits or therapies to prepare the patient for hospital access. In the absence of information on the planned or emergency nature of hospitalization, including this variable allows us to control for the effect of scheduled hospitalizations, which, as discussed below, may bias our results (see the Online Appendix C for a more detailed description).

δ_s are event time dummies, while $Hosp_i$ is a binary variable indicating individuals in the hospitalized group (i.e., treated). We are interested in the coefficients γ_s of leads $s_{<0}$ and lags $s_{\geq 0}$ of treatment, which indicate the number of periods the individual is distant from true or placebo admission, occurring at $s = 0$. The γ_s estimate the difference in outcome change between admitted and not-yet-admitted individuals at a given s compared to the baseline difference, normalized to zero in $s = -1$. For $s < 0$, they show pre-admission trends; for $s \geq 0$, they capture the effective treatment effects, i.e., the dynamic impact of first admission on individual HCE. Finally, η_i and ν_i are individual and calendar time fixed effects, and ε_{it} is the error term. Standard errors are clustered at the individual level.

Given this setup, our identifying assumption is that, conditional on the included controls, the timing of the first hospitalization is as good as random. This implies both parallel trends between groups prior to first admission and no anticipatory knowledge about future treatments for hospitalized individuals. The pre-event groups' similarity, mentioned in the previous section, supports the hypothesis of parallel trends. Anticipatory behaviors are controlled for through the inclusion of the term c_{it}, which accounts for pre-admission increases in HCE generated by the occurrence of scheduled hospitalizations. It is therefore plausible to assume that individuals in the two groups would have followed the same HCE trend in the absence of treatment. In the empirical analysis, we confirm the validity of this assumption after testing for the presence of pre-trends, that is, differences in trends between the two groups before the first access (we present several robustness checks in the Online Appendix D).

With respect to more common strategies, our approach has some comparative advantages. Differently from static DID (e.g., see [30]), treatment effects can be estimated heterogeneously for each period over the entire time horizon. In addition, compared to the more traditional event study without a counterfactual group (e.g., see [31]), the inclusion of individual and time fixed effects does not preclude separate identification of the passage of calendar time t from the passage of relative time s to the event [19]. The dynamic effect of hospitalization can thus be estimated net of time-specific confounders and individual-specific factors, such as the permanent impact of previous health shocks, genetic traits, preferences, lifestyles, and all other between-individual time-invariant differences.

The average treatment effect on the treated is estimated by OLS, which, under the assumptions described below, yields an unbiased estimator that is also the most efficient under homoskedasticity. While homoskedasticity assumption is unrealistic in our setting, it has been shown [19] that using all available data makes the OLS estimator more efficient with heteroskedasticity than alternative estimators [20,21,23]. The latter have been applied on samples with restricted control groups and data only from the first period before treatment.

3. Results

3.1. Main results

Table 4 shows the dynamic effect of first hospitalization on total HCE and expenses for different health treatments. The estimated coefficients on the linear pre-trend c_{it} and pre-admission relative times $s < -1$ are generally not statistically significant, indicating that there are no anticipatory behaviors and that HCE of the two groups evolve in parallel prior to admission. It follows that, conditional on the included controls, the timing of the first hospitalization is as good as random.

The results reported in the table are also presented visually in Fig. 1. At the time of first hospitalization, total HCE (panel a) of those admitted rise by about €7300 relative to HCE of those not yet admitted. Then, they rapidly decrease by 69% one year after hospitalization and by 82% four years later, never returning to the pre-admission level. The primary driver of this evolution is the occurrence of readmissions. In $s = 0$, hospital expenditures (panel b) increase by about €6400 and, after an initial reduction in the first post-discharge year, remain stable and considerably high (about €1000 in $s = 4$). Expenses for the other treatments also contribute, but to a lesser extent. Day hospital expenditures (panel c) increase by nearly €145 in $s = 0$ and then decline rapidly. After an initial increase of about €650 in $s = 0$, outpatient expenditures (panel d) also decrease, but more slowly. One year after the admission, expenses reduce by 15%, by 65% two years later, and by 81% in the fourth year. Finally, pharmaceutical expenses (panel e) rise by about €170 in $s = 0$, increase in the year after hospitalization, and then settle slightly below the admission level. This last result is consistent with previous evidence documenting much higher persistence for pharmaceutical expenses than for other types of health care costs [32, 33].

Adding up the estimated coefficients for all health care treatments, we find that, for the average admitted individual aged 50–70, the total four-year hospital-related expenses are about €13,500, nearly twice the cost incurred for a single hospitalization.

Table 4
Estimation results.

	Total HCE		Hospital		Day hospital		Outpatient		Pharma.	
	Coeff.	P-value	Coeff.	P-value	Coeff.	P-value	Coeff.	P-value	Coeff.	P-value
Linear pre-trend	−17.17	0.2617	−21.11	0.0886	−4.69	0.0533	8.68	0.0806	−0.05	0.9823
Relative Time x Hospitalized group										
−3	−43.45	0.2386	−27.71	0.3568	1.76	0.7787	−12.44	0.3049	−5.07	0.3435
−2	−9.24	0.5606	1.57	0.9017	6.03	0.0482	−17.74	0.0018	0.90	0.7116
0	7328.27	0.0000	6362.50	0.0000	143.86	0.0000	649.85	0.0000	172.06	0.0000
1	2210.06	0.0000	1424.11	0.0000	55.15	0.0000	551.36	0.0000	179.44	0.0000
2	1365.04	0.0000	963.80	0.0000	34.68	0.0000	224.87	0.0000	141.69	0.0000
3	1398.55	0.0000	1059.32	0.0000	32.32	0.0000	168.44	0.0000	138.48	0.0000
4	1264.06	0.0000	987.13	0.0000	19.42	0.0000	118.46	0.0000	139.06	0.0000
Relative Time	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
Hospitalized Group	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
Age Dummies	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
Time FE	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
Individual FE	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
N	104,434		104,434		104,434		104,434		104,434	

Note: The table shows the estimation results from the baseline specification (Eq. 1). FE: Fixed effects.

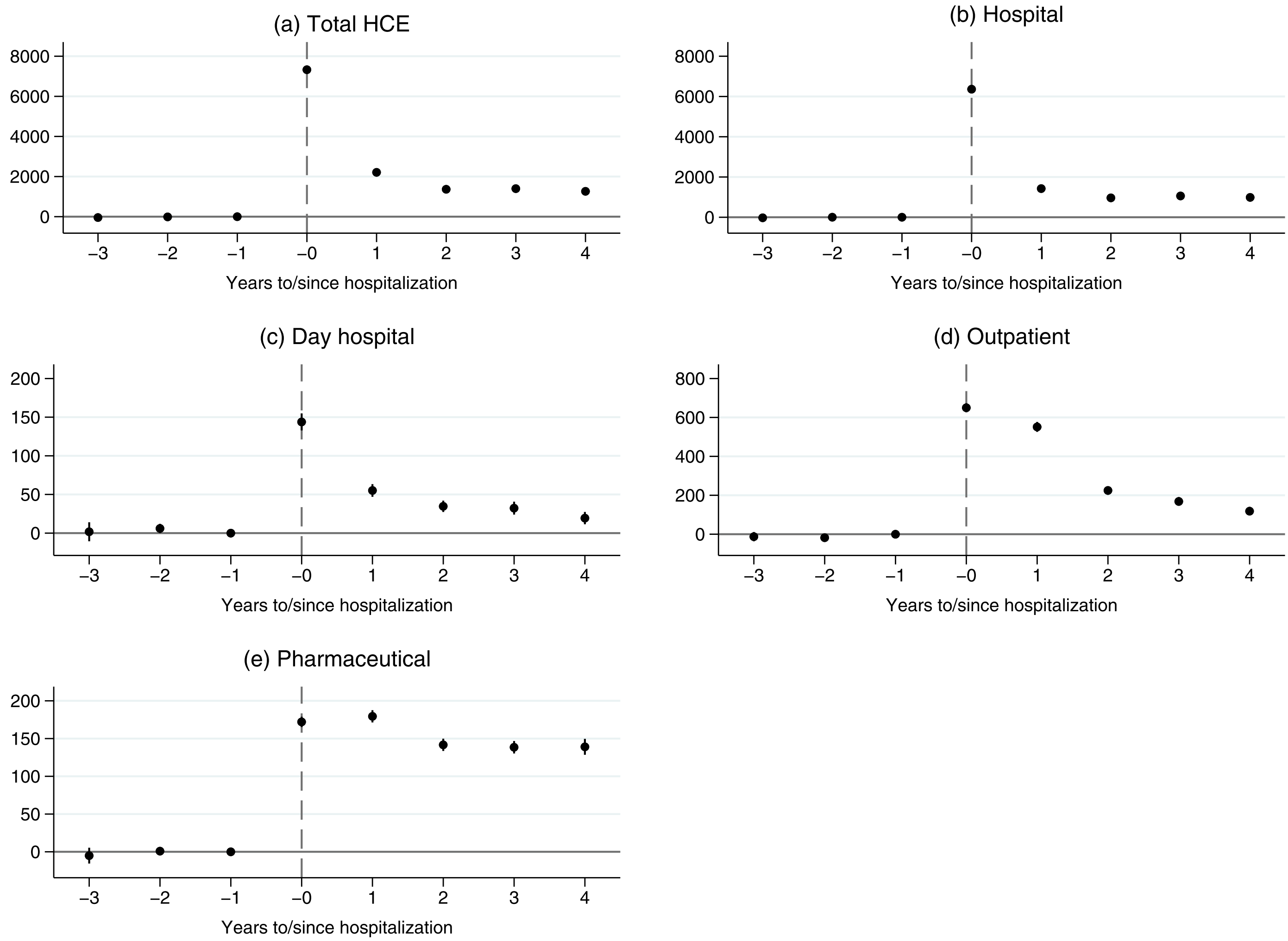

Fig. 1. Total HCE and expenses for health treatments by event time. The coefficients γs estimated from Eq. 1 (black dots) are plotted with their 95% confidence intervals (black vertical lines). The relative event time function s ranges from -3 years before the event to 4 years after, with the timing of first hospitalization plotted at $s = 0$ (dashed vertical gray lines). A high-resolution version of the image is available as eSlide: VM06784.

3.2. The effect of hospitalization by disease

We investigate the effect of first hospitalization for health conditions and selected diseases. In particular, we focus on chronically ill or disabled individuals and patients with cancer and cardiovascular disease (Fig. A1 in the Online Appendix A reports the findings from additional heterogeneity analyses). We analyze these subsamples for their relevance on health care spending: in OECD countries, major non-communicable disease groups account for nearly 60% of health spending, of which circulatory diseases absorb the largest share; together with cancer, the latter account for a substantial amount of expenses in the inpatient and pharmaceutical sector [35].

In Fig. 2, we compare HCE trends of individuals exempted for chronicity or disability (at or after admission) to those of non-chronic/non-disabled individuals, i.e. the never-exempted . Not surprisingly, the latter experience the lowest growth in HCE at admission and spend about 65% less than the exempted on inpatient care (panel a) and between 81% and 88% less on all other treatments (panels b-d). Moreover, the long-term effect of first hospitalization is small in magnitude, suggesting that admission is caused by temporary health shocks that required inpatient care can treat promptly and successfully, without the need for substantial post-discharge assistance. In contrast, HCE patterns of chronic and disabled individuals closely resemble those observed for the entire population. The effect of the first hospitalization is always large at the time of the admission and persistent in the following periods, a pattern also reported by other research [33]. Overall hospital-related costs for exempted individuals, about €21,600, are almost four times higher than those sustained by those who are never exempted.

Regarding the specific diseases, we find that CVD and cancer cause the highest increase in total HCE at the time of first hospitalization (Fig. A2 in the Online Appendix A). As shown in Fig. 3, for those admitted for CVD this is primarily due to a large increase in hospital expenditures in $s = 0$ (panel a), where the admitted spend roughly €10,900 more than those not yet hospitalized and about €3100 more than those hospitalized for cancer. For oncological patients, much of the increase in total HCE in $s = 0$ is also accounted for by outpatient expenses (panel c), which reach a level nearly €2400 higher than the expenditures of those not yet hospitalized and five times higher than those of CVD individuals. High expenditures are also observed in the post-discharge period. In particular, we note a large and persistent increase in outpatient expenses for oncological individuals, who spend almost three times as much as those with CVD even four years after first admission. CVD and cancer also account, together, for nearly 50% of overall post-discharge hospital costs, and cause 21% and 19% of all readmissions, respectively. We estimate that the predicted probabilities of being additionally hospitalized for these two diseases are the highest when readmissions are caused by the same disease as the first access (Table A1 in the Online Appendix A). This indicates the long-lasting nature of these conditions, as also demonstrated by the similarity of their HCE trends with those of chronic and disabled individuals. Overall

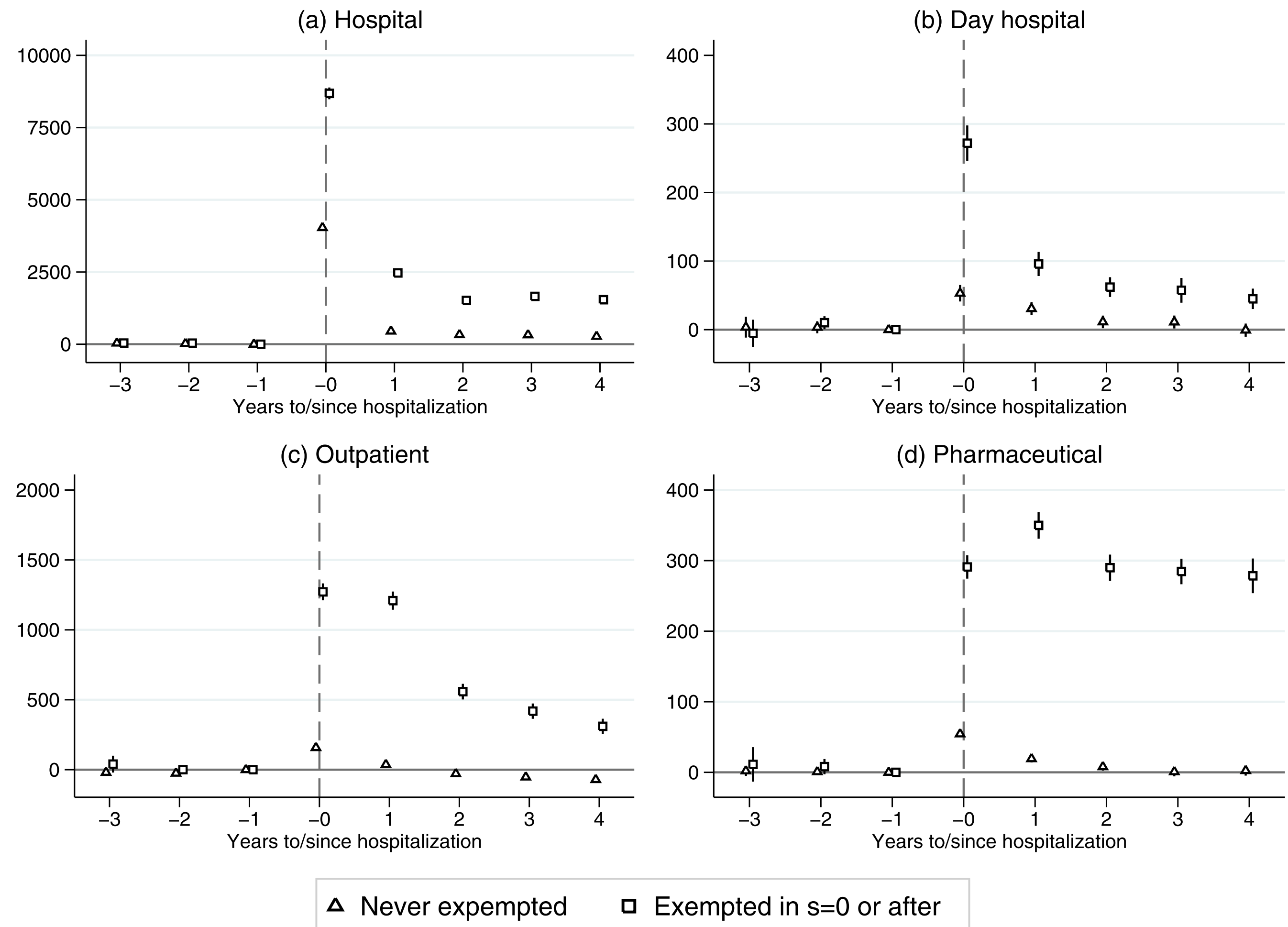

Fig. 2. Expenses for health treatments by event time for exempted and never-exempted individuals. The coefficients γs estimated from Eq. 1 are plotted with their 95% confidence intervals (black vertical lines) separately for never-exempted (hollow triangles) and exempted in $s = 0$ or after (hollow squares). The relative event time function s ranges from -3 years before the event to 4 years after, with the timing of first hospitalization plotted at $s = 0$ (dashed vertical gray lines). A high-resolution version of the image is available as eSlide: VM06785.

hospital-related expenses also are comparable, with oncological and CVD patients spending €22,700 and €19,800, respectively.

4. Discussion

The above results provide complete evidence that overall hospital-related costs extend far beyond the inpatient stay, amounting, on average, to nearly twice the expenses for a single admission. This finding is in line with other studies, of which the closest in spirit to our own are those of Fattore et al. (2012) [8] and Corrao et al. (2014) [6]. The former adopt a micro-costing procedure to calculate the cost of a stroke hospitalization in Italy, with the advantage of accurately identifying disease-specific expenditures associated with the admission. Estimated one-year health care expenditures amount to €11,747, with the major cost component being represented by the initial hospitalization (€5573). Follow-up expenses are €4877, of which €439 are due to readmissions. Similar to the study considered, we find that total HCE for cardiovascular patients in the year of first hospitalization amount to about €12, 000 (Fig. A2 in the Online Appendix A). In contrast, Fig. 3, panel a, shows that readmission costs are much higher (about €1750 in the year following the first hospitalization). One possible reason is that the sample used in Fattore et al. [8] is composed of selected individuals and has lower representativeness compared to the reference population. This issue is widely addressed by Corrao et al. [6], who generalize the findings at a regional level to measure the burden of new hospitalization for heart failure in Lombardy, Italy. As in our study, they find that the one-year average per capita expenses are €11,100, with the main cost being for subsequent admissions. Expenses for outpatient services amount to €400 and those for pharmaceuticals to €500. While the sample size and the availability of information on several health care services represent important strengths of the work of Corrao et al. [6], one drawback is the limited post-discharge time, which captures only partially the economic consequences of hospitalization. The DID approach allows us to handle this problem by estimating in a quasi-experimental way the differences in expenditures between the hospitalized and not-yet-hospitalized groups over a longer time period. In this way, we are able to provide a broader overview of the post-discharge HCE evolution over time and a more complete estimate of overall hospitalization-related cost.

The richness of our dataset allows us to bridge several gaps found in prior research. However, it also has some limitations compared to other studies [8–12,15,16,19,23,31,35], such as the lack of information on expenditures for long-term, rehabilitation and home care. Although these services account for only 10% of health spending in Italy [36], we would be able to analyze the post-discharge care pathway in more detail. We also do not have information about the hospital where individuals are admitted or the type of physician responsible for their care. These data would enable us to examine whether individuals treated by specific hospitals or types of specialists achieve better outcomes than other patients. Socio-economic information such as education level and marital

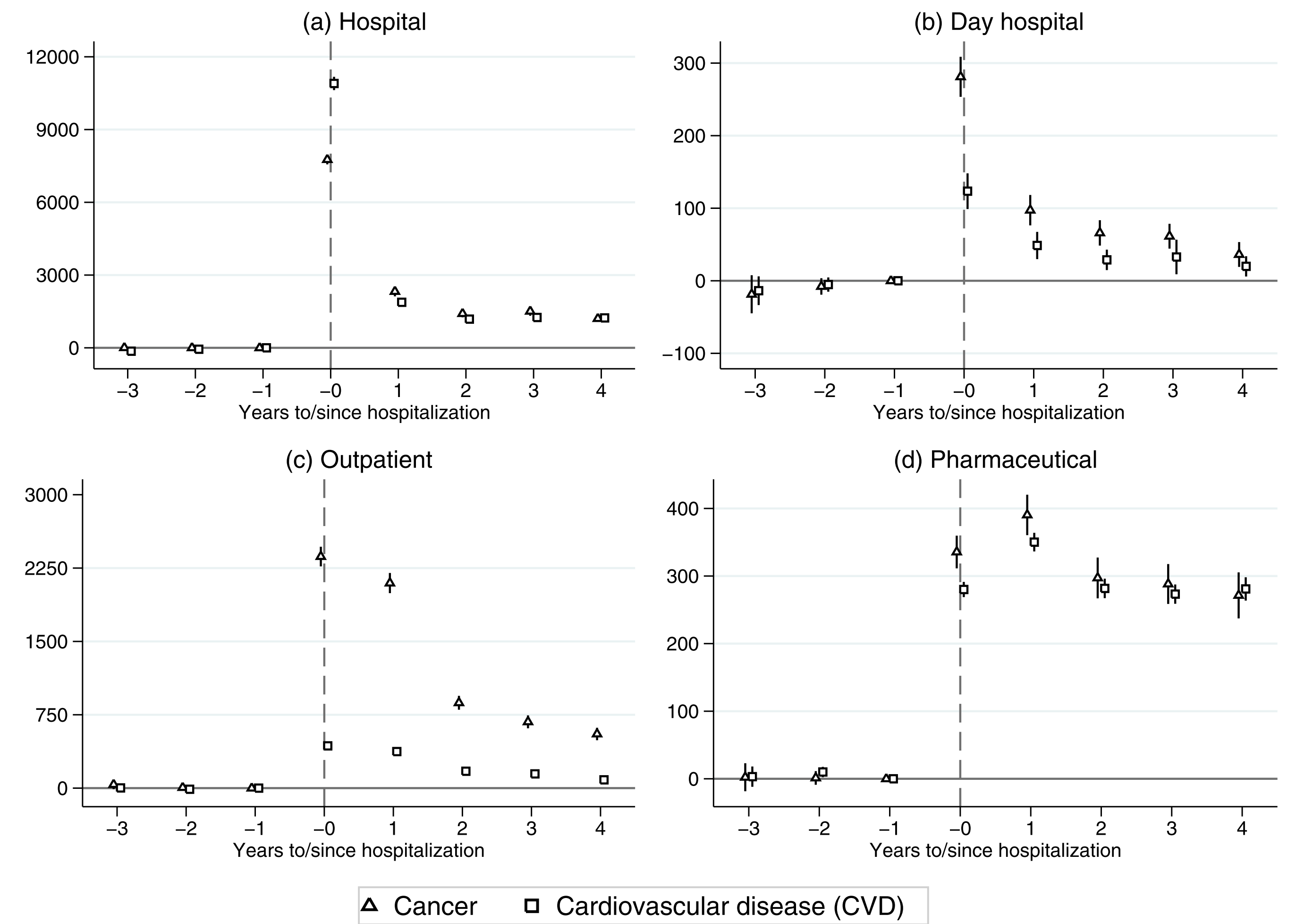

Fig. 3. Expenses for health treatments by event time for individuals admitted for cardiovascular disease (CVD) and cancer. The coefficients γs estimated from Eq. 1 are plotted with their 95% confidence intervals (black vertical lines) separately for individuals hospitalized for cancer (hollow triangles) and cardiovascular disease (CVD) (hollow squares). The relative event time function s ranges from −3 years before the event to 4 years after, with the timing of first hospitalization plotted at $s = 0$ (dashed vertical gray lines). A high-resolution version of the image is available as eSlide: VM06787.

status is also missing. To the extent that these variables are invariant over time, their effect on individual HCE is captured by individual fixed effects. However, with these data it would be possible to identify whether and what personal conditions are associated with higher or lower HCE levels at the time of admission and in subsequent periods.

Our study provides interesting insights from a policy perspective. The main finding is that post-discharge costs are primarily accounted for by additional hospitalizations. According to our estimates, for readmissions Lombardy Region spent nearly €220 million, almost three times more than the €79 million saved between 2011 and 2013 through the 'de-hospitalization' process described in Section 2.1 (the average unconditional hospital expenditures at the time of the admission, €6346, have been multiplied for the number of reduced accesses). While these figures clearly reveal their policy relevance, to draw accurate implications we show in Table 5 how the contribution of the different spending categories to total HCE varies between the time of first admission and following periods. We focus on four stylized individuals who best map a trajectory of exacerbation of initial health conditions representative for a younger (54–56 years of age) and an older (64–66 years of age) subpopulation. For all types we note that, although increases in the share of out-of-hospital treatments and reductions in the incidence of inpatient care are observed, four years after the first access hospital expenditures still cover 40.8%−60.3% of total HCE. The latter continue to be a major contributor to total HCE long after first admission, with the size of the differences $s_4 - s_0$ growing with increasing health condition severity especially for young types (from −46.1% to −27.2%). In these cases, the onset of chronicity and the presence of one or two co-morbidities plays probably the major role in shaping the care pathway. While this finding is not surprising, the change in the post-discharge care pathway when health conditions exacerbate for old types is less expected. Here, the difference $s_4 - s_0$ for hospital expenses remains fairly constant between the healthy and less healthy status, varying only from −27% to −25.7%. This result suggests room for intervention to reshape the follow- up pathway and reduce readmissions, especially for chronically ill elderly whose health condition is not severely compromised.

5. Conclusions

Estimates of overall hospitalization-related expenditures are of great importance for cost-containment policies to be effective in keeping the growth of health care spending under control. In this paper, we analyze the short- and long-term effect of hospitalization on individual HCE for the young-old population. We use a unique panel of individual records and estimate a dynamic two-way fixed-effects DID model with the first admission used as treatment and variation in treatment timing.

We show the existence of a substantial effect of hospitalization on individual HCE that persists over time for all treatments. The largest increase is observed for hospital costs, which, after a rapid decline in the year following the first access, remain remarkably high due to the occurrence of frequent readmissions. Expenses on day hospital and

Table 5
Share of total HCE covered by each treatment in $s = 0$ and $s = 4$, and difference.

	Total HCE (€)	Share of total HCE			
		Hospital (%)	Day hospital (%)	Outpatient (%)	Pharma. (%)
Young, no chronically ill, no co-morbidities					
s_0	3837	86.89	1.40	9.50	2.21
s_4	472	40.80	5.79	38.47	14.95
$s_4 - s_0$		−46.10	4.39	28.98	12.73
Young, chronically ill, 1–2 co-morbidities					
s_0	11,406	77.01	3.01	16.32	3.66
s_4	2459	49.74	2.05	30.40	17.81
$s_4 - s_0$		−27.27	−0.94	14.08	14.15
Old, chronically ill, no co-morbidities					
s_0	5223	87.33	1.00	8.95	2.72
s_4	2993	60.31	2.54	24.40	12.75
$s_4 - s_0$		−27.02	1.54	15.45	10.04
Old, chronically ill, 3–4 co-morbidities					
s_0	20,829	77.72	3.24	14.03	5.01
s_4	4339	52.01	1.42	24.08	22.49
$s_4 - s_0$		−25.72	−1.81	10.05	17.48

Note: The table shows the share of predicted total HCE covered by each health treatment at the time of the first admission (s_0) and four years later (s_4), along with the difference between the two periods ($s_4 - s_0$). Statistics are reported for four different stylized individuals.

outpatient services decline in the period following discharge without ever returning to the pre-admission value, while pharmaceutical expenditures remain stable slightly below the access level. For the average 50–70 year-old admitted individual, we estimate that overall hospital-related expenditures are approximately €13,500, nearly double the cost incurred for the single admission. Heterogeneity analyses show that the largest amount is borne by chronic and disabled individuals due to the long-lasting nature of their condition, and that cardiovascular disease and cancer are responsible for generating a greater need especially for post-discharge hospital treatments. Together, they account for nearly 50% of costs for readmissions.

From a policy perspective, our findings suggest that follow-up often fails to ensure effective rehabilitation to a health condition that can be successfully treated within out-of-hospital settings. Therefore, we believe that a different prioritization of policies is needed, with interventions strictly targeted at containing hospital costs that should be accompanied by those aimed at strengthening coordination at discharge between inpatient and community care. This requires i) investing in community and social care; ii) developing intermediated care services that bridge the gap between hospital and community care; iii) aligning financial incentives among providers to promote care coordination. All these measures can improve patient outcomes and experience while increasing value for money and reducing avoidable readmissions, without requiring fundamental restructuring of health care delivery [37].

CRediT authorship contribution statement

Irene Torrini: Data curation, Formal analysis, Investigation, Project administration, Software, Visualization, Writing – original draft. **Claudio Lucifora:** Conceptualization, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Supervision, Writing – review & editing. **Antonio Giampiero Russo:** Conceptualization, Resources, Project administration.

Declaration of Competing Interest

None.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.healthpol.2023.104803.

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