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The Long-Term Effects of Hospitalization on Health Care Expenditures: An Empirical Analysis for the Young-Old Population*

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Abstract

We investigate the short- and long-term effects of hospitalization on different types of health care expenditures (HCE). A dynamic DID model with variation in treatment timing is specified and estimated using register data of individuals aged 50-70 residing in Milan, Italy, and observed over the period 2008-2017. We analyze on the entire population and carry out heterogeneous analysis by leading cause of hospitalization and presence of chronicity or disability. We find evidence of a large and persistent effect of hospitalization on total HCE, with future medical expenses mostly accounted for by inpatient care. Considering all health treatments, the overall effect is sizable, accounting for approximately twice the cost for any single hospital admission. We show that chronic and disabled individuals require greater post-discharge medical assistance especially for inpatient care and that cardiovascular and oncological diseases account together for more than half of expenditures on future hospitalizations. Alternative out-of-hospital management practices are discussed as a post-admission cost-containment measure.

Keywords: Health Care Expenditures, Hospitalization Effect, Health Shocks, Chronic Disease, Cardiovascular Disease, Cancer

JEL classification: H510, I110, I180

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1. Introduction

Hospitalization expenditures account, on average, for 28% of health care spending among OECD countries (OECD, 2021). Given the significant incidence on public budgets, acute care 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 (Schwierz, 2016). As suggested by Chandra et al. (2013), 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 (Chandra et al., 2013) and geographic variation in health costs in the US (Newhouse & Garber, 2013); for some diseases, such expenses are comparable to those incurred for the initial hospitalization (Mechanic, 2014). 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) using administrative data of individuals aged 50-70. Previous evidence is mainly limited to the medical literature and, in particular, cost-of-illness studies. Examples include research focused on heart failure, stroke and heart attack (Fattore et al., 2012; Corrao et al., 2014; Korves et al., 2012), hip and knee fracture (Phillips et al., 2019; Urish et al., 2018), cancer (Li et al., 2021; Hyer et al., 2020), and infections (Manoukian et al., 2021; Touat et al., 2021). These works follow discharged individuals over a defined time period and calculate the costs of treating the condition that caused the hospitalization, with the potential advantage of accurately identifying disease-specific expenditures associated with admission. However, the sample is generally composed of a few non-randomly selected individuals and lacks representativeness for larger populations. In addition, most of these studies only cover a limited span of post-discharge time and a restricted number of treatments, only partially estimating the economic consequences of hospitalization. We address most of the above issues by exploiting a rich 10-year panel of the entire population aged 50-70 in the Milan metropolitan area and estimating a dynamic difference-in-difference (DID) model with both short- and long-term effects on health care expenditures.

We contribute to the existing literature in the following ways. First, we examine different types of care, namely hospital and day hospital admissions, outpatient services and pharmaceuticals, covering most post-discharge treatments. The remaining services, i.e. home and long-term care, account for only 10.04% of health spending in Italy (ISTAT, 2017b).

Second, we analyze hospital-related costs at the initial admission and for several years thereafter and investigate a large set of diseases. It allows us to identify the most costly diseases and get insights into post-discharge disease-specific care pathways. We are also able to consider readmissions for the same disease, increasingly used as hospital performance signals to promote improvement (OECD, 2021).

Third, by focusing on the young-old population[1], we explore a critical phase of individuals' lifespan in which the initial onset of health shocks may turn into chronic diseases. According to the existing literature, the first heart attack, stroke, and new onset of cancer occur in individuals between ages 50 and 64 (Cutler et al., 2011), and 86% of the burden of chronic diseases is

[1]Which is the age window that identifies the young-old population is unclear. For example, Neugarten (1975) places it within the age window 45-64, Forman et al. (1992) within 60-69, and Watanabe (2019) within 65-74. We define it as between 50 and 70 years of age.

among people under age 70 (WHO, 2005). 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, i.e., the complete recovery of the 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.

Fourth, we apply a novel empirical strategy based on a dynamic two-way fixed effects DID model with variation in treatment timing. We follow a recent econometric literature (Sun & Abraham, 2021; Goodman-Bacon, 2021; De Chaisemartin & d'Haultfoeuille, 2020; Callaway & Sant'Anna, 2021; Borusyak et al., 2021) and develop a quasi-experimental design in which we compare the expenditures of those who experience the hospital access to those of individuals who have not yet been admitted at the time of first hospitalization. In each period, the effect of hospitalization is the difference in estimated HCE between the two groups. Compared to the more traditional event study without a counterfactual group[2], this approach has the advantage of allowing the inclusion of individual and time fixed effects while preventing under-identification issues (Borusyak et al., 2021). The dynamic effect of hospitalization can thus be estimated net of time-specific factors, controlling at the same time for the permanent impact of previous health shocks, genetic traits, preferences, lifestyles and all other between-individual time-invariant differences.

Our main findings show a large and persistent effect of the first hospitalization on expenditures for all treatments. After following similar patterns before access, total HCE of the admitted increase substantially compared to those of not-yet-admitted individuals. In the year following the first hospitalization, expenditures decline rapidly but never return to the initial level. The primary driver of this evolution is the occurrence of additional admissions, which keep inpatient costs positive and stable after an initial reduction in the first post-discharge year. The expenses for the other types of treatment also contribute, but to a lesser extent. After a rapid increase in the year of the first hospitalization, day hospital and outpatient expenditures decline, while pharmaceutical costs settle at a level slightly below that of the first admission. We find that, for the average admitted 50-70 year-old individual, the overall four-year hospital-related expenditures are approximately €13,500, nearly twice the cost incurred for the single admission. The largest amount is borne by chronic and disabled inpatients, who spend almost four times as much as the healthiest individuals. As for specific diseases, cardiovascular disease and cancer are found to generate a greater need for post-admission assistance, and especially for inpatient care. They account together for nearly 50% of costs on future admissions.

From a policy point of view, our results open new perspective on health care management as a post-admission cost-containment measure. In particular, we believe that interventions strictly targeted at containing hospital costs should be accompanied by those aimed at strengthening integrated and transitional care. This is critical especially for the young-population, who need continuous care to prevent exacerbation of chronic conditions at their first onset and to reduce avoidable hospital readmissions.

The paper is organized as follows. Section 2 explains the institutional context. Section 3 describes data and descriptive statistics. Section 4 presents our empirical strategy. Section 5 shows the main results, while Section 6 illustrates different robustness checks. Finally, Section 7 discusses the findings and Section 8 concludes.

[2]For example, see Dobkin et al. (2018), who use a non-parametric event study with time fixed effects to estimate the effect of hospitalization in a sample of only admitted individuals.

2. Institutional setting

The Lombardy health care system is designed as a network of public and private actors with a complete separation of the territorial setting from the hospital one. The former provides day-to-day health care for non-acute conditions that can be managed and controlled through pharmaceutical and ambulatory treatments, diagnostic tests, and minor surgical procedures. The latter, conversely, is intended for individuals who need overnight care, either planned in advance or resulting from emergencies. In both settings, access is facilitated by the financial contribution of the Italian health care system. Hospital care is free of charge for acute cases and under the presentation of physicians' referrals, while territorial assistance requires patient contributions for prescribed pharmaceuticals and outpatient services, with exemptions from co-payment ensured for specific groups. Chronically ill and HIV-positive individuals, those with rare diseases, and pregnant women are exempted from paying for care related to their condition; total exemption is ensured, instead, to individuals with severe disabilities, low-income households, and prisoners.

This organization has contributed, over time, to the construction of an articulated and differentiated supply structure that excels especially in the treatment of acute cases. However, like any advanced system, the Lombardy health care system has to face the challenge of the exponential growth of the elderly cohort and the parallel expansion of the chronic population, often affected by co-morbidities and consequent frailty. In 2017, over-65 individuals were 23% of the more than 10 million residents in Lombardy, and those defined as chronic was 34%. Among the latter, 40% presented at least one chronic disease, while 19% at least two (ISTAT, 2017a). Altogether, in 2012 they accounted for almost 80% of health care spending for hospitalizations, outpatient services, and pharmaceuticals (Regione Lombardia, 2014).

In an attempt to address these demographic transitions and the changing needs and demands of the population, several interventions have been implemented, such as the rationalization of the inpatient setting to reduce unjustified and inappropriate admissions and consequent costs. It has resulted in a 'de-hospitalization' phenomenon, with a progressive shift from the hospital assistance to the territorial one, where continuity of care, essential for chronic and disabled individuals, can be provided more effectively and at lower costs (OECD, 2017). 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 were increased from 108 to 170 million (Regione Lombardia, 2014).

3. Data, sample and descriptive statistics

For our analysis we exploit a unique register drawn from the Health Information System of the Health Protection Agency (ATS according to the Italian acronym) of the metropolitan city of Milan. The dataset includes the whole population aged 50-70 residing in the area in 2008-2017, consisting of about 1,000,000 individuals for a total of roughly 8,000,000 observations. It provides information on individual volumes and expenditures for hospital and day hospital admissions, outpatient services and pharmaceuticals covered by the ATS[3], along with demographic and health-related traits. The latter cover gender, age, residence area, income-related exemptions,

[3]Out-of-pocket expenses are not included. As health care in Italy is largely free at the point of service, they represent a small share of individual total health expenditures (OECD/European Observatory on Health Systems and Policies, 2019).

year of demise, number of co-morbidities, as well as disease- and disability-related exemptions, used here as proxies for the onset of chronicity and disability.

To carry out our quasi-experimental design, we identify the first admission as the first year in which at least one access is observed[4] and divide our sample into a group of hospitalized and a group of not-yet-hospitalized. Individuals within the former are those who experience the first admission between 2011 and 2013, a time window ensuring a sufficiently long time span before and after the first hospitalization. To reduce the effect of previous health shocks that could bias our estimations, we restrict the group to those who have had no prior accesses and are observed at least three years before admission[5]. We also select only individuals who are observed for at least one year after being hospitalized to examine HCE trends in the post-discharge period[6]. The not-yet-hospitalized group is composed of individuals with hospital accesses after 2013. They are included up to the year prior to their hospitalization and are randomly assigned a 'placebo' admission in 2011-2013[7]. 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.

The total number of first accesses declines over time, from 20,884 in 2011 to 17,059 in 2012 and 11,999 in 2013, most likely as a result of the 'de-hospitalization' process described in the previous section[8]. Table 1 shows some summary statistics for the hospitalized at the time of the first admission. Average total HCE, calculated as the sum of the 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 the disease- and disability-related exemption, used here as proxies for the onset of chronic conditions or disabilities, respectively. In addition to the pathologies[9] included in the residual category 'Other'[10], the most common leading causes of hospitalization are cardiovascular disease (CVD) and cancer. Table 1 also reports statistics for the periods following the first admission and

[4]Because volumes data are recorded on an annual basis, when several hospitalizations occur in a year we know the total number of accesses but not how spaced they are over time and which one occurs first. Hence, the identification is independent of the number of multiple hospitalizations. While we could have restricted the sample to individuals with only one access in the first-hospitalization year, we decided not to in order to account for early readmissions.

[5]For the same reason, we also exclude individuals with day hospital, outpatient and pharmaceutical expenditures higher than the 95$^{\text{th}}$ percentile in the year before the admission.

[6]In a robustness check in Section 6, we remove such sample restrictions to test for selection bias.

[7]To the not-yet-hospitalized group we impose the same restrictions as the hospitalized group.

[8]The reduction of hospitalizations over time is also reported by the Lombardy Region Open Data, available at `https://www.dati.lombardia.it/Sanit-/Dataset-SDO-Regione-Lombardia/jv9t-c6q6` (last accessed on 03/24/2022).

[9]They are recorded in the dataset as Major Diagnostic Categories (MDC), aggregations of Diagnostic Related Groups representing epidemiologically relevant groups of patients with similar health problems and treatment patterns for which a hospital or day hospital admission is required. Since individuals may be hospitalized more than once during the year of the first admission, the leading cause of hospitalization is represented by the MDC related to the highest inpatient expenses in that year.

[10]It contains all MDC not identified in the dataset. They are: diagnosis related to ear, nose, mouth and throat; liver and pancreas; skin, subcutaneous tissue and udder; endocrine, nutritional and metabolic diseases; diagnosis related to kidney and urinary tract; diseases of male and female reproductive systems; birthing diagnosis and services for regular neonate; diseases of hematopoietic organs; disorders for alcohol, medicines abuse and other types of dependency; traumatisms, intoxications and toxic effect; other factors influencing the individual health status.

Table 1
Summary statistics, hospitalized group.

	First admission		
	N	**Mean**	**SD**
Expenditures (€)[a] :			
Total HCE		7847	10,230
Hospital		6346	9193
Day hospital		143	925
Outpatient		1017	2471
Pharmaceutical		341	633
Number of accesses: (%)			
One	12,452	71.35	44.65
More than one	5000	28.65	44.65
Age		61	5
Disease exemption (%)	2740	16.50	37.12
Disability exemption (%)	302	1.80	13.29
Leading cause of hospitalization (%):			
Infectious disease	138	0.86	9.19
Mental disorders	245	1.46	12.01
Nervous System	879	5.36	22.51
Cancer	2660	16.16	36.79
CVD	3095	18.65	38.95
COPD	791	4.69	21.14
Digestive System	2545	15.06	35.74
Musculoskeletal disease	1250	7.55	26.42
Other	5045	30.20	45.91
	Subsequent health events		
	N	**Mean**	**SD**
Number of accesses (%):			
Zero	22044	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.
[a] Expenditures data are deflated by dividing current expenditures by the Italian consumer price index for the health sector provided by the OECD (OECD, 2015); the reference year is 2015.

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.
We also analyze differences between the hospitalized group and the not-yet-hospitalized group before the first admission and find no major variations either in terms of individual characteristics or expenditures (Table A1 in Appendix A).

4. Empirical strategy

We analyze the effect of first hospitalization on individual HCE by using a dynamic two-way fixed effects DID design with variation in treatment timing. In practice, we estimate the change in HCE before and after the event 'first hospitalization' for admitted individuals as compared to the group of not-yet-hospitalized. In a setting with individual and time fixed effects, the inclusion of the comparison group allows us to separately identify the passing of calendar time t from the passing of relative time to the event s (Borusyak et al., 2021). We estimate the following model:

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

Y_{it} describes total HCE and expenditures for the health care treatments analyzed[11]; A_{it} is the set of age dummies included to estimate the effect of the first admission net of life-cycle patterns; c_{it} is a continuous variable capturing any unobserved linear trend prior to the hospitalization[12]; η_i and ν_t are individual and calendar time fixed effects, and ϵ_{it} is the unobserved error term. δ_s are event time dummies, while $Hosp_i$ is a dummy variable indicating individuals in the hospitalized group. We are interested in the coefficients γ_s of the leads $s_{<0}$ and lags $s_{\geq 0}$ of treatment, which indicate the number of periods the individual is distant from the true or placebo admission, occurring at $s = 0$. The γ_s estimate the difference in outcome change between admitted and not-yet-hospitalized 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. Errors are clustered at the individual level.

Given this set up, our identifying assumption is that, conditional on the included controls, the timing of the first hospitalization is as good as random. This implies both no anticipatory

[11] Health care expenditures are expressed in levels to keep observations with zero expenditures in the estimation sample. It is essential in order to include the not-yet-admitted group, whose observations included in the sample have zero hospital expenses.

[12] It is added following the works of Freyaldenhoven et al. (2019) and Borusyak and Jaravel (2017), with the choice of the functional form motivated by the results from a two-way fixed effects DID model without such a variable. The related findings suggest that a linear trend captures any pre-trends quite well. For not-yet-hospitalized individuals, c_{it} captures any linear trend before their true first admission, occurring after 2013 and excluded from the sample.
We test for multicollinearity between the variable c_{it} and the variable for the relative time to the event by calculating the centered Variance Inflation Factors (VIFs) and their reciprocals for the independent variables specified in a linear regression model for total HCE (Table A2 in Appendix A). Using the rule of thumb on which most analysis rely (Chatterjee et al., 1986), we do not observe strong evidence of multicollinearity in our model, as the mean of all VIFs is not considerably greater than 1 and no VIF is greater than 30. Overall, our model turns out to be quite parsimonious.

knowledge about future treatments for hospitalized individuals and parallel trends between the groups prior to the first admission. We control for anticipatory behaviors by including the term c_{it}, which captures pre-admission increases in HCE generated by the occurrence of planned admissions, usually preceded by several specialist visits or therapies to prepare the patient for hospitalization[13]. Once the potential discretion over the timing of access is taken into account and given the similarity between hospitalized and not-yet-hospitalized mentioned in the previous section, it is plausible to assume that individuals in the two groups would have followed the same HCE trend in the absence of the first admission. 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. Still, our estimates may be biased if readmissions occur in the post-discharge period independently of the first hospitalization and if not-yet-hospitalized individuals undergo out-of-hospital admission-related treatments before their true access. In the first case, the effect of interest would also capture the impact of unrelated accesses, while in the second it would be underestimated because of expenses incurred in preparation for hospitalization. We further explore these issues in Section 6, where we also verify whether our results are biased due to attrition and selection and whether our estimates are robust to different samples.

5. Results

5.1. Main results

Figure 1, panel (a), shows the long-term effect of first hospitalization on total HCE. We observe that the estimated coefficients on the pre-admission period are not statistically significant. The absence of pre-trends indicates that the HCE of admitted and not-yet-admitted evolve in parallel before the access and that the timing of the first hospitalization is as good as random, conditional on the included controls. At the time of the first hospitalization, total HCE of the admitted rise by about €7300 with respect to HCE of not-yet-hospitalized. Then, they rapidly decrease by 69% one year after the access and by 82% four years after, without ever returning to the pre-admission level[14]. The primary driver of this evolution is the occurrence of readmissions, which keep inpatient costs positive and stable after an initial reduction in the first post-discharge year. As shown in Figure 1, panel (b), in $s = 0$ hospital expenditures increase by about €6400 and then remain considerably high[15] (about €1000 in $s = 4$).

By looking at the other panels of Figure 1, we see that the other treatments also contribute,

[13]The dataset does not provide information on the type of hospital access, i.e., planned or emergency admission, making it impossible to exclude hospitalizations that can be expected in advance. With c_{it}, each γ_s represents the deviation of y_{it} from the pre-admission linear trend and the identifying assumption is that, conditional on the included controls and individual fixed effects, the timing of the hospitalization has to be uncorrelated with deviations of the outcome from the linear trend. Hence, while individuals may be on a secular trend before the admission, they are not able to anticipate or have discretion over the exact timing of the access (Borusyak & Jaravel, 2017).

[14]To give an idea of the magnitude of the effect in absolute terms, we calculate the unconditional total HCE for not-yet-admitted individuals in $s = -1$, which amount to about €310. It follows that total HCE of the admitted amount to almost €7600 in $s = 0$ and €1500 four years after the admission.

[15]Since the individuals in the not-yet-admitted group have zero inpatient expenses during the observed period, the estimated coefficients reported in Figure 1, panel (b), represent the absolute means for the individuals in the admitted group.

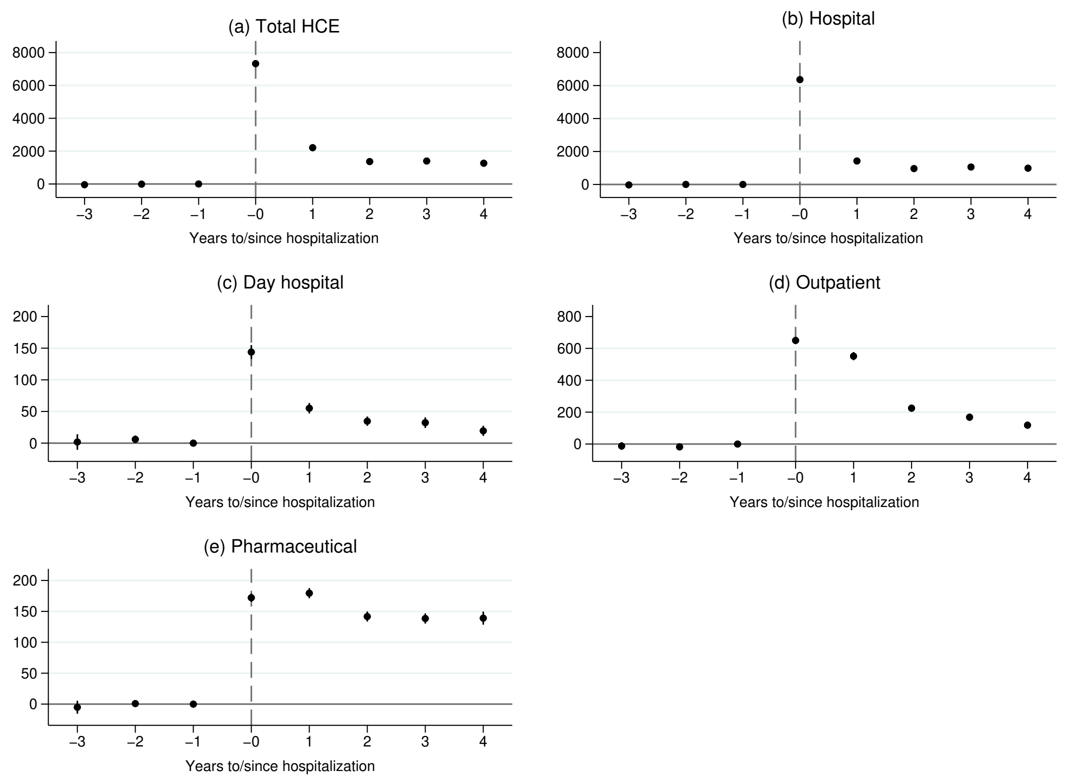

Fig. 1. Total HCE by event time. Coefficients estimated from Equation 1 (black dots) are plotted with their 95% confidence intervals (black vertical lines). The relative event time function s ranges from -3 years before the event to 4 years after, with the timing of first hospitalization plotted at $s = 0$ (dashed vertical grey lines).

but to a less 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[16]. Finally, pharmaceuticals expenses (panel (e)) rise by about €170 in $s = 0$, increase in the year after hospitalization, and then settle slightly below the admission level[17]. This last result is in line with previous evidence, which documents much higher persistence for pharmaceutical expenses than for other types of health care costs (Coulson & Stuart, 1992; Longden et al., 2018).

Adding together 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 €13500, nearly twice the cost incurred for a single hospitalization.

5.2. *The effect of hospitalization by disease*

We now carry out heterogeneity analyses to investigate the effect of first hospitalization for different health conditions[18]. To examine the impact of long-lasting diseases, in Figure 2 we compare the HCE trend of never-exempted with those of individuals exempted for chronicity or disability at the time of the admission or after. Not surprisingly, never-exempted individuals experience the lowest growth in HCE at the admission and spend about 65% less than the exempted on inpatient care (panel (a)), and between 81% and 88% less on all other treatments. Also, the long-term effect of first hospitalization is small in magnitude, indicating that we are facing temporary health shocks that the required admission can promptly and successfully treat, with no substantial need for post-discharge care. In contrast, HCE patterns of chronic and

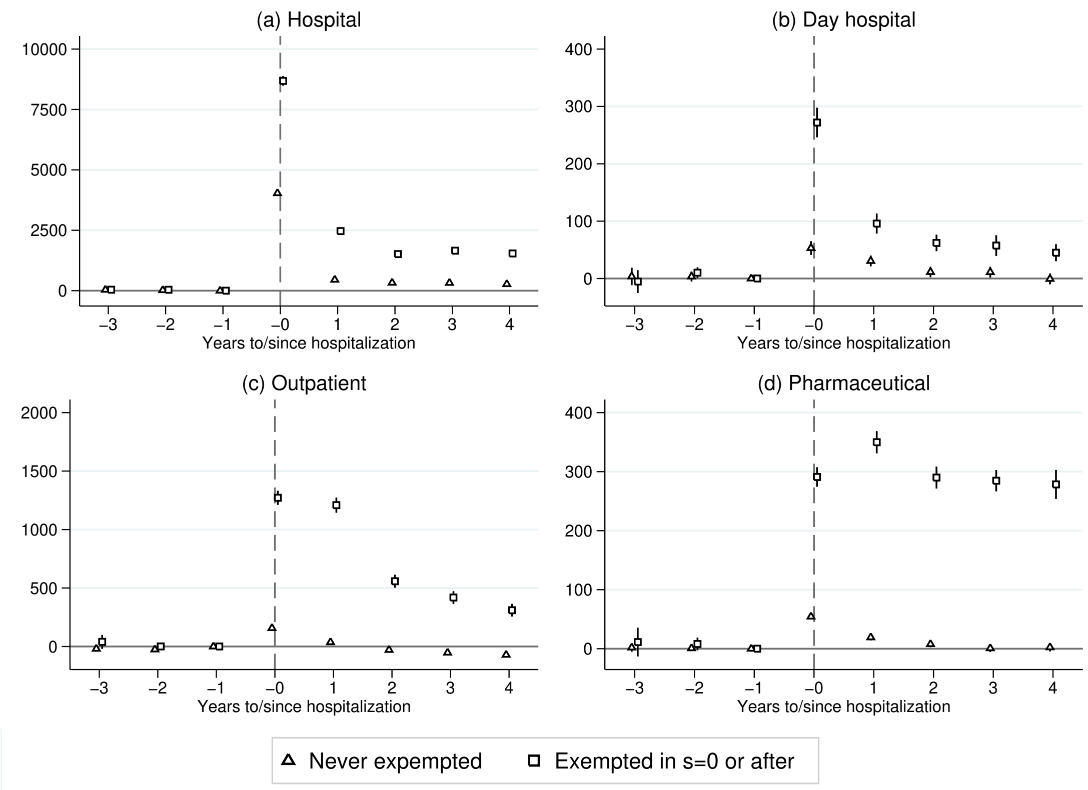

Fig. 2. Expenses for health treatments by event time for exempted and never-exempted individuals. Coefficients estimated from Equation 1 are plotted with their 95% confidence intervals (black vertical lines) separately for never-exempted (hollow triangles) and exempted in $s = 0$ or after (hollow squares). 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 grey lines).

[16]Although small and very close to zero, the coefficient on relative time $s = -2$ is statistically significant, indicating the presence of pre-trends. It is due to the fact that outpatient expenses present a non-linear pre-admission trend that the linear term c_{it} is not completely able to capture.

[17]In $s = -1$, the unconditional day hospital, outpatient and pharmaceutical expenses for those not yet hospitalized are about €0, €180, and €130, respectively. It follows that, in $s = 0$, hospitalized individuals spend in absolute terms approximately €145 and €830 for day hospital and outpatient services, respectively, and €300 for pharmaceuticals.

[18]In Figure A1 in Appendix A, we also report and discuss the findings by age class, time to death, number of co-morbidities and number of accesses at the admission, gender and number of subsequent years with readmissions.

disabled individuals closely resemble those observed for the whole population. The effect of the first admission, in fact, is always large at the time of the admission and persistent in the following periods. This finding is consistent with research on the persistence of high cost of care for long-lasting conditions (Longden et al., 2018). Overall hospital-related costs for the exempted, about €21,600, is almost four times higher than those sustained by never-exempted individuals.

We further decompose our sample to examine the HCE trend for the leading causes of hospitalization listed in Table 1, except for the residual category 'Other'. In line with previous evidence (OECD, 2016), we find that CVD and cancer cause the highest increase in total HCE at the time of first hospitalization (Figure A2 in Appendix A). As shown in Figure 3, for those admitted for CVD this is primarily due to a large increase in hospital expenditures in $s = 0$ (panel (a)), where admitted spend roughly €10,900 more than those not yet hospitalized and about €3100 more than those hospitalized for cancer. For oncological patients, a large share 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 expenditures of not-yet-admitted and five times higher than those of CVD individuals[19]. High expenditures are also observed in the post-discharge

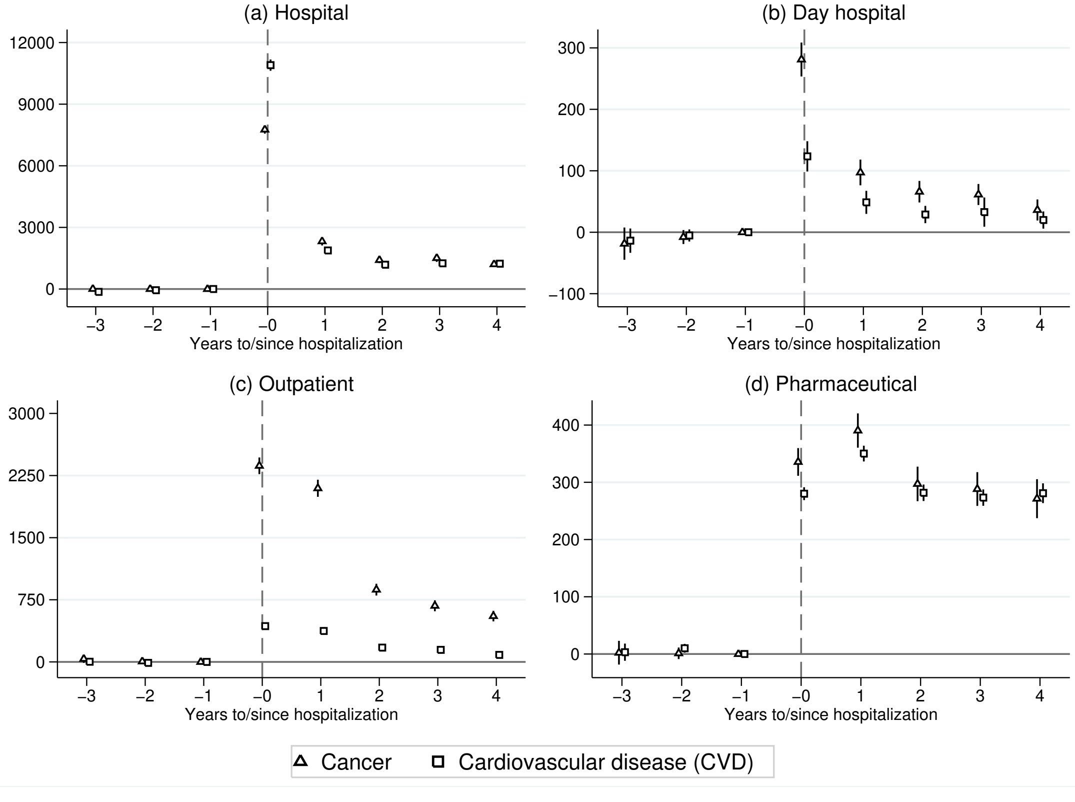

Fig. 3. Expenses for health treatments by event time for individuals admitted for cardiovascular disease (CVD) and cancer. Coefficients estimated from Equation 1 are plotted with their 95% confidence intervals (black vertical lines) separately for individuals hospitalized for cancer (hollow triangles) 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 grey lines).

[19]These results highlight some distinctive features of the diseases analyzed or the way they are diagnosed and treated. First, CVD, often called the 'silent killer', develops slowly over time and rarely shows early symptoms, leading to emergency admissions for untreated acute cases frequently associated

period. We observe 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 their first hospitalization. CVD and cancer also account, together, for nearly 50% of overall post-discharge hospital costs, and cause 21% and 19% of all readmissions, respectively. As shown in Table A3 in Appendix A, the predicted probabilities of being additionally hospitalized for these two diseases are the highest when the readmissions are caused by the same disease as the first access. It indicates the long-lasting nature of these diseases, which is demonstrated by the high percentage of chronic and disabled individuals among those admitted for CDV (42%) and cancer[20] (55%) and by the similarity of HCE trends of the latter with those of chronic and disabled individuals. Overall hospital-related expenses are also comparable, with oncological and CVD patients spending €22,700 and €19,800, respectively.

6. Robustness checks

We conduct several robustness checks on our main findings for total HCE and present the results in Figure 4. First, our estimates may be biased due to attrition if individuals leave the sample after the first hospitalization because of non-random mortality or other causes related to the admission. In our sample, the share of individuals who exit the sample for non-construction reasons[21] is 7.66% among those not yet admitted and 9.23% among those hospitalized (Table A4 in Appendix A). Out of the latter, 5.40% die, while 3.83% drop the sample for unknown reasons. We also calculate the predicted probability of leaving the sample at calendar time t for non-construction reasons, conditional on the time since first access, and find that it is always statistically significant and decreasing as the time since first admission increases (Table A5 in Appendix A). To verify how and to what extent attrition bias influences our baseline results, we drop individual fixed effects and the comparison group and balance the sample around the first hospitalization[22]. In this way, we are able to examine the time pattern of total HCE without concerns about the potential effects of compositional changes. Results are reported in Figure 4, panel (a), and confirm our baseline findings: the effect of the first admission on total HCE is large in magnitude at the time of the access and persistent in the following years.

Another issue for our estimates is selection bias, which may be generated by the restrictions explained in Section 3 on the minimum number of years individuals are observed around the first admission. We replicate our DID design on the original sample without any constraints

with diagnosis- and treatment-related high costs (WHO, 2013). Second, screening tests, chemotherapy regimens and supportive care can be delivered in outpatient settings for several types of cancer (Sarfaty & Yuen, 2008).

[20]These are the highest percentages among all causes of hospitalization analyzed. The reason is that those who survive an acute form of CVD, such as acute myocardial infarction and angina pectoris, naturally become chronically ill (Ministero della Salute, 2014); in addition, immunotherapy is often used to convert a tumor that has not been completely eliminated into a chronic disease (Phillips & Currow, 2010).

[21]The dataset consists of individuals who are 50-70 years old between 2008 and 2017. This means that those who enter in 2008 at age 70 remain only one year in the sample, as well as those who turn 50 in 2017.

[22]A standard solution to attrition bias is the inclusion of individual fixed effects, as within-individual estimates should not be affected by individuals exiting the sample. However, if the treatment effect is heterogeneous across individuals, results may still be affected by compositional changes within the group of individuals used to identify a given relative time coefficient (Dobkin et al., 2018).

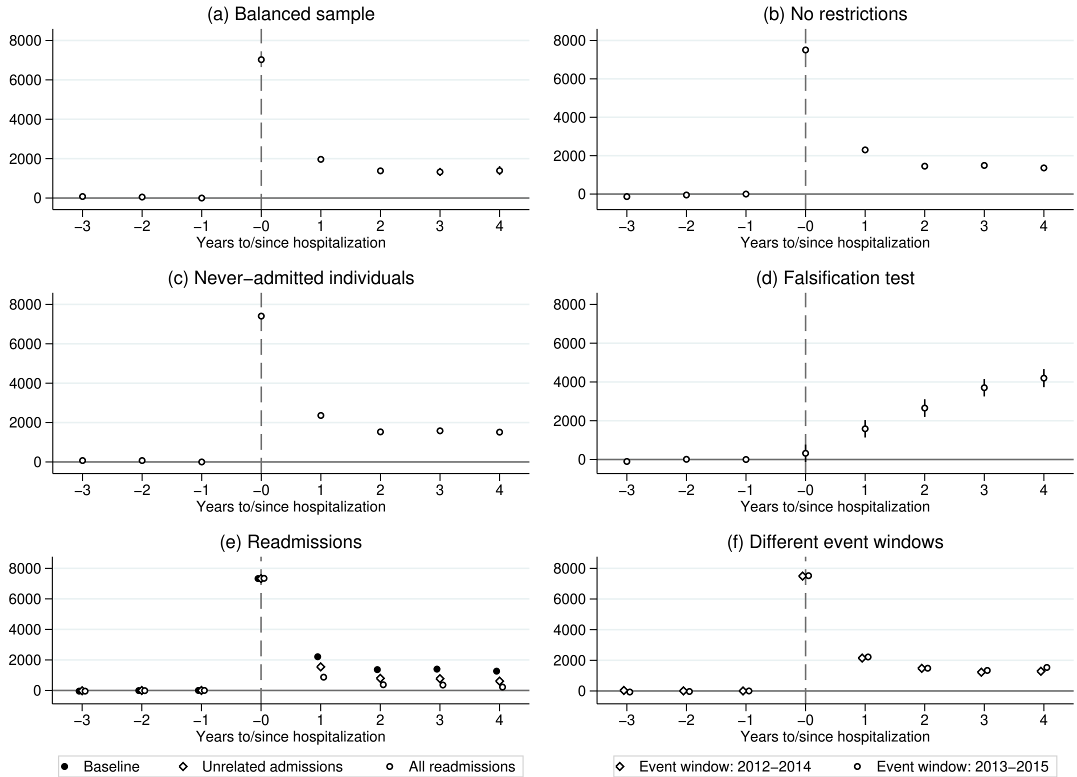

Fig. 4. Total HCE by event time, robustness checks. (a): Coefficients from a specification without individual fixed effects estimated on a balanced sample of only hospitalized individuals. (b): Coefficients estimated on a sample with no restrictions on the minimum number of years individuals must be observed around the admission. (c): Coefficients estimated on a sample in which the comparison group is composed of never-admitted individuals with a randomly-assigned first admission within the 2011-2013 time window. (d): Coefficients estimated on a sample of individuals hospitalized for the first time in the years 2014-2017 with a randomly-assigned first admission within the 2011-2013 time window. (e): Baseline coefficients (black dots), coefficients from a specification where unrelated hospitalizations are controlled for (hollow triangles), coefficients from a specification where all readmissions are controlled for (hollow diamonds). (f): Coefficients estimated on a sample of individuals who experience the first hospitalization within the time windows 2012-2014 (hollow triangles) and 2013-2015 (hollow diamonds).

and report the coefficients estimates in Figure 4, panel (b). The results are extremely close to those from our baseline empirical strategy, indicating that our main findings are not biased by selection into treatment.

Then, our post-discharge baseline estimates may be downward biased if not-yet-hospitalized individuals incur hospital-related expenditures before their true access. The inclusion of the linear term c_{it} allows us to control for potential increases in out-of-hospital expenditures due to preparatory treatments. However, it is possible to check for downward bias by using as a counterfactual the group of individuals never hospitalized during the observation period, to whom we randomly assign a first access in 2011-2013. In this way, we minimize the magnitude and likelihood of out-of-hospital expenditures occurring before the true admission of the counterfactual group, which may only occur after 2017. The results are shown in Figure 4, panel (c), and are robust to our main findings, with the coefficients on each post-discharge relative time being only slightly higher than the baseline estimates.

On the contrary, we may face upward bias in the post-discharge estimates if hospitalized individuals undergo readmissions that are independent of first access[23]. To explore the size of this bias, we replicate the DID analysis by including separately in our regression a dummy variable for all readmissions and one for unrelated readmissions only. As we lack more detailed information, we define the latter as those occurring for a disease other than the one that caused the first hospitalization. Results are shown in Figure 4, panel (e), which illustrates the effect of both unrelated and related readmissions. While the former is described by the hollow triangles, the latter is shown by the distance between the hollow triangles and the black dots, representing the coefficients from the baseline specification. Both types of access seem to contribute to the post-admission increase in total HCE for nearly the same extent. If so, about half of the effect estimated according to Equation 1 would represent overestimation. However, our definition of unrelated hospitalizations does not take into account that such admissions may be required for complications of the first access which give rise to, or are represented by, diseases other than those leading to the first hospitalization[24]. Given such an over-representativeness of the group of unreleted accesses, we expect the true pattern of total HCE to lie between the baseline estimation and the specification in which unrelated readmissions are controlled for. Unfortunately, the extent to which it approximates the baseline estimate is a measure that we cannot determine here.

Finally, we conduct a falsification test and carry out our estimation on different event windows to verify the external validity of our analysis. For the first exercise, we select individuals hospitalized for the first time in the years 2014-2016, to whom we randomly assign a first admission within the 2011-2013 time window. The comparison group is composed of individuals admitted in 2017 who are followed up to 2016 and randomly assigned a first admission between 2011 and 2013. The results are shown in Figure 4, panel (d). As expected, the coefficient on the event time $s = 0$ is not statistically significant, with the upward increase in HCE observed in the following periods reflecting the impact of the true first accesses. For the second exercise, we select individuals who experience the first hospitalization in the years 2012-2014 and 2013-2015. Results are shown in Figure 4, panel (f), and confirm the patterns found in our main DID design, with the effect of the first admission being positive, large, and persistent over time.

7. Discussion

The above results provide complete evidence that overall hospital-related costs extend well beyond the inpatient stay, amounting, on average, to nearly twice the expenses of the single admission. Post-discharge costs are primarily accounted for by additional hospitalizations, which continue to be a major contributor to total HCE long after the first admission. As shown in Table 2, 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 78% of total HCE. According to our estimates, for such additional admissions

[23]The inclusion of a comparison group prevents the expenditures for out-of-hospital admission-unrelated services from biasing post-discharge estimates, as the impact of such treatments cancels out when comparing the two groups. Issues arise, however, for post-admission hospital costs, as not-yet-admitted individuals have zero inpatient expenditures during the period of analysis.

[24]For example, Table A3 in Appendix A shows that individuals admitted the first time for infectious diseases present a high predicted probability of being further hospitalized for CVD. Despite this, according to our definition, future accesses for CVD cannot be considered readmissions when they occur as a consequence of infections.

Table 2
Share of total HCE covered by each treatment.

	(1) $S_{s=0}$	(2) $S_{s=4}$	(3) $S_{s=4} - S_{s=0}$
Hospital	85.81	78.09	-7.72
Day Hospital	2.97	1.50	-1.47
Outpatient services	8.87	11.56	2.69
Pharmaceuticals	2.35	11	8.65

Note: The table shows the share of predicted total HCE, estimated from Equation 1, covered by each health treatment. Columns (1) and (2) report the shares of predicted total HCE covered by each treatment at the time of the first admission ($S_{s=0}$) and four years later ($S_{s=4}$), respectively. Column (3) shows the difference between the two periods ($S_{s=4} - S_{s=0}$).

Lombardy Region spent nearly 220 million euros, almost three times more than the €79 million saved between 2011 and 2013[25] through the 'de-hospitalization' process described in Section 2.

How can readmissions be reduced? To answer this question, it is worth pointing out that they represent an indicator not only of the quality of the first admission (Dahl & Kongstad, 2017), but also of the quality of integration and transition between inpatient and community care (OECD, 2021; Picone et al., 2003). Integrated and transitional care is aimed at patients with major health care needs transitioning from the acute hospital phase to the post-acute phase, and is intended to create hospital discharge processes and early planning of post-admission outpatient and primary care services. It also provides reverse flows to manage re-acute episodes occurring in the territory to avoid improper hospitalization. This type of care can improve patient outcomes and experience, while increasing value for money by improving co-ordination and reducing duplicative and unnecessary care (Gunning-Schepers et al., 1984; Crawford et al., 2021; Bakx et al., 2020). In particular, integrated and transitional care is found to have positive effects on measures related to hospital readmissions. Konetzka et al. (2018) estimate that hospitals that are vertically integrated with skilled nursing facilities have a decline in their rate of 30-day readmission by 17%. Also, Rose (2020) finds that post-acute care in skilled nursing facilities reduces the probability of readmission to the hospital within 30 days by 33 percent. Lastly, Jackson et al. (2013) show that patients receiving transitional care are 20% less likely to experience a readmission during the year after hospitalization.

In Italy, several innovative projects for the management of patient transition between hospital and territory have been developed (Ferrara et al., 2017). Still, ample room for improvement is documented. First, to the extent that additional accesses evidenced in this work are required for unplanned readmissions rather than for adherence to defined care paths, 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. Second, international comparisons show high frequencies of readmissions, although in line with OECD averages. Among patients who suffered an ischemic stroke in 2018, 17% were readmitted in the year after admission, compared with 2% in Costa Rica. For patients admitted for congestive heart failure, 1-year readmission rate was 27%, as opposed to 9% in Costa Rica (OECD, 2021). To reduce overall hospital-related expenditures, we believe that a different prioritization of policies is needed, with interventions strictly targeted at containing hospital costs that should

[25] The unconditional average hospital expenditures at the time of the admission, €6346, have been multiplied for the number of reduced accesses.

be accompanied by those aimed at strengthening integrated and transitional care. This is even more relevant when it concerns the young-old population, which experiences the first onset of chronic diseases.

8. Conclusions

Estimates of overall hospital-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 variation in treatment timing. In practice, we develop a quasi-experimental design in which we compare the expenditures of the admitted to those of not-yet-hospitalized individuals.

We show the existence of a large effect of hospitalization on individual HCE that persists over time for all treatments. The highest 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 outpatient services decline in the post-discharge period without ever returning to the pre-admission level, while pharmaceutical expenditures remain stable slightly below the access level. For the average admitted 50-70 year-old individual, we calculate that the overall hospital-related expenditures are approximately €13,500, nearly twice 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. Regarding specific illnesses, cardiovascular disease and cancer are responsible to generate a greater need especially for post-discharge hospital treatments. They account together for nearly 50% of costs for readmissions.

From a policy perspective, our findings suggest that overall hospital-related costs can be reduced by implementing policies aimed at improving integrated and transitional care, necessary to reduce avoidable readmissions, along with those targeting inpatient expenditures.

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