The relationship between health care expenditures and time to death: focus on myocardial infarction patients

La relazione tra spesa assistenziale e prossimità al decesso: studio dei pazienti affetti da infarto al miocardio

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Abstract This study focuses on the relationship between health care expenditures (HCE) and time to death (TTD). This is a central theme of regional and national healthcare systems, given the current ageing of the population and the increasing expenditures. This study is aimed to investigate in-depth the causal-effect relationship between TTD and HCE. Existing regional health administrative archives have been used to build a cohort of patients with new-onset myocardial infarctions observed between 2003 and 2007. All patients are residents in the Italian region Friuli Venezia Giulia. Data on individual HCEs, socio-demographic and health status characteristics are included in the analysis, together with TTD. The econometric analysis is based on a sample selection approach necessary to account for the inflation patterns in the distributions of HCE and TTD. The main results suggest that the causal effect of TTD on HCEs ("red herring" hypothesis) is confirmed, while the reversal relationship is only partially revealed in the selection equation.

Abstract *Il presente studio analizza la relazione tra spese assistenziali e prossimità al decesso. Questo è un ambito di interesse primario dei sistemi sanitari pubblici regionali e nazionali che si trovano ad affrontare il fenomeno dell'invecchiamento della popolazione e dei trend crescenti delle spese assistenziale. L'obiettivo principale perseguito è lo studio della relazione biunivoca tra spese assistenziali e prossimità al decesso. L'analisi si basa su una coorte di pazienti affetti da infarto al miocardio, residenti nella regione italiana del Friuli Venezia Giulia, osservati nel periodo 2003-2007. La costruzione del database è derivata dai database amministrativi sanitari regionali. Il database include i dati individuali relativi alle spese sanitarie, alle caratteristiche socio-demografiche, alle proxy dello stato di salute e alla prossimità al decesso. Per l'analisi econometrica è stato adottato un approccio*

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di sample selection, data la presenza di punti di massa nelle distribuzioni di probabilità delle spese sanitarie e del tempo al decesso. I risultati confermano il rilevante effetto della prossimità al decesso sulle spese assistenziali (nota come ipotesi "red herring"), mentre la relazione di causalità inversa risulta confermata solo in relazione al modello di selezione.

Key words: Administrative Data, Health Care Expenditures, Health Econometrics, Sample Selection Models, Time To Death

1 Aim and context of analysis

The aim and the context of this study are tied to central themes of modern health care policy (*Health, demographic change, and wellbeing is one of the societal challenges in the European programme Horizon 2020*) such as increasing trends of health care expenditures (HCE); the role of time to death (TTD) and the ageing of the population on HCE patterns; and the increasing burden of healthcare profiles due to medical innovations. In particular, we focus on a relevant challenge: the relationship between TTD and HCE, focusing on whether TTD affects HCE (TTD as a determinant of budget growth) or if the reciprocal relationship holds (care profiles affecting health outcomes).

The health economics literature presents different approaches to HCE: some studies consider HCE dynamics within the macro-econometric framework (see, for instance, [11]), while a wide range of works is devoted to assessing the determinants of HCE both at micro and macro-level (a review on the topic can be found in [6] and [12]). These kinds of studies focus on the analysis of the relationship between diseases and health care utilization, or on the distribution of HCE across individuals and cohorts. Moreover, HCEs are often considered in the analysis of the relationship between the ageing of the population and TTD, which has driven the *Red Herring* literature on the significant effect of TTD on the increase of HCEs ([4], [5], [8], [13] and [15] are some examples of these works). The literature devoted to the assessment of TTD determinants is mainly characterized by epidemiological (survival) analyses, while studies on the effect of HCE on TTD are rare (see [4] again). Given the differences in these existing research approaches, the following competing hypotheses are evaluated in this study: compression of morbidity (TTD causal effect hypothesis) according to which health care expenditures are determined by proximity to death; expansion-of-morbidity hypothesis based on the assumption that prolonging life means prolonging morbidity and increasing costs. We wish to explore both given hypotheses separately for different sources of HCE, by considering administrative datasets and trying to measure TTD more accurately.

The phenomena of interest of this study present the so-called inflation issue. In particular, HCEs are often zero-inflated measures, while the TTD presents a double inflated distribution (determined by sudden deaths and by survivals). In order to deal with these issues, the econometric literature has developed some "alternative" approaches (in particular, for the HCEs analysis): latent class models ([3]); sample selection models ([7]); two-part models ([1], [2] and [9]); copula probit models (as in [14]). Finally, to deal with TTD double inflated distribution it is possible to apply the solution proposed in [10].

2 Study design

Many empirical analyses on the relationship between HCE and TTD are classified as population-based studies. A specifically structured administrative database has been developed for this research. In particular, we consider a cohort type dataset of all the patients with an incident case of acute myocardial infarctions (AMI) observed in the period 2003-2007 in Friuli Venezia Giulia (Italy).

2.1 Cohort and variables

To determine the final cohort, four steps have been followed: first 11530 patients are identified selecting all the hospital admissions with a diagnosis of AMI (ICD-9 code 410*) in the Hospital Discharge Register in the period 2003-2007; within the selected cases 10700 patients are admitted with incident AMI; the size of the dataset is reduced to 9962 to consider patients who are resident in FVG at admission date. In order to deal with homogeneous patients, cases with the first intervention of AMI (no previous PTCA[1] or bypass surgery) are selected, thus identifying 9897 cases. The HCE and TTD of these patients are observed in a 5 years period (follow-up); HCEs (regarding inpatient cares, outpatient cares, and drugs) are measured by semesters while TTD is computed in days and truncated at 1825 for the survivors at the end of the 5th year.

The data are derived from the regional health data-warehouse. Data regarding HCEs are collected also for the two years before the entering event. An important role in the model specification is played by the TTD covariate definition and, given the peculiar double truncated TTD variable distribution, we considered both a factor variable identifying: sudden deaths (SD), patients died during the observational period (DDOP) and survivors (SURV), and a numerical variable (*days to death*), interacting with DDOP dummy only. The age and gender of the patients are collected, together with proxies of individual health status as dummies for pathology exemptions, dummies for PTCA or bypass surgery and a dummy for deceased. Finally, information on the area of residence (such as local health agency - LHA - and municipality) and the deprivation index (at the municipality level) are considered.

The cohort is characterized by 5766 males (58.3% of the total) with 68.2% of survivors. 45.5% of patients are more than 75 years old at the entering time and the

[1] Percutaneous transluminal coronary angioplasty

percentage of survivors is 97.8% for patients aged less than 45 decreasing to 36.6% in the oldest age class. The proportion of survivors decreases also by deprivation class (from 63.3% in the "very rich" to 56.9% in the "very deprived" class). Median values of all types of individual HCE are lower in the group of 6151 survivors and this is particularly clear for the median values of drugs expenditures (1010.9 and 1185.8 for dead patients, while 543.4 for the survivors).

3 HCE and TTD models and results

In the following sections, the HCE model is introduced and the main results on the determinants of health care expenditures are briefly discussed. The TTD model is then introduced and the main results, reported in Table 1, are discussed.

3.1 The HCE model

In the analyses, we adopted the sample selection paradigm. In particular, the Heckman-style selection model is applied separately to three kinds of health expenditures. The model for the HCEs can be defined as:

$$y_i^O = \begin{cases} 0 & \text{if } y_i^S = 0 \\ y_i^{O*} = X_i^O \beta^O + \varepsilon_i^O & \text{otherwise} \end{cases} \quad (1)$$

where y_i^O denotes the observed level of health expenditure, y_i^S is the variable defining the selection process (which can be estimated by considering a probit generalised linear model - selection equation) and y_i^{O*} represents the observed level of positive expenditures, modeled as a linear function of the explanatory variables X_i^O.

The results of this first step can be summarised as follows. The selection equations in the models for health expenditures present a significant relationship between age and outpatient and drug expenditures, while for inpatient care expenditures the "red herring" hypothesis is fully supported. Exemptions have positive effects on the probability of positive HCEs for all kinds of expenditures. The model estimation is developed separately for the different kinds of the health expenditures.

Going into greater details, males have a higher probability of HCE for inpatient care and being a male affects positively the expenditure for outpatient services. The age over TTD effect on the probability of HCE is clear for all age classes over 65 years, with an increasing effect on the amount of outpatient and drug expenditures. Survivors generally show a low probability of inpatient care and a larger probability of outpatient care. The same pattern is pointed out in expenditure model. Proxies of health conditions, represented by pathology exemptions, are, as expected, positively correlated with the probability of all types of expenditures but with greater effects on the amount of outpatient and drug demand. Moreover, strong positive relationships between types of HCEs are revealed, as expected. The HCE models point out further expected results in terms of factors affecting both the HCE likelihood and its amount. However, the TTD effect is not relevant as it is probably absorbed by the dummies included to account for sudden deaths and survivors, whose coefficients confirm the "red herring" proposition.

3.2 The TTD model

The Heckman-style selection model has also been applied in the estimation of TTD. The distribution of TTD presents two mass points generated by sudden deaths (0 days) and 5 years survivals (1825 days). For this reason, the selection model has been specified by considering an ordinal probit model (as in [10]). The bias-corrected linear model has been estimated by considering the specific inverse Mills ratios (for the ordinal model) on the patients who died during the observational period. In order to obtain better estimation results, we considered a Box-Cox transformation of the days to death.

Table 1 shows the TTD model estimation results. TTD is only partially connected to health expenditures. In particular, in the selection equation, all the coefficients of expenditure sources are significant. The HCEs affect survival status in the selection step. Notwithstanding, in the outcome equation only the logarithm of inpatient care expenditure is significant. The significance of the coefficient of the inverse Mills ratio confirms the necessity to adopt the sample selection model.

Selection Model		Estimate	p-value
Gender	*Female*	-	
	Male	-0.1770	< 0.001
Age classes	*Less than 45*	-	
	(45,55]	-0.6124	0.001
	(55,65]	-0.8933	< 0.001
	(65,75]	-1.0236	< 0.001
	More than 75	-1.6459	< 0.001
	Intervention Dummy	0.7906	< 0.001
	Bypass Dummy	-0.1367	0.010
LHA	*101*	-	
	102	0.0333	0.479
	103	0.0424	0.531
	104	0.0992	0.011
	105	-0.0030	0.952
	106	0.1096	0.008
	Emergency Dummy	-0.0729	0.084
Exemptions	*Cardiology*	0.7681	< 0.001
	Invalidity	-0.1563	< 0.001
	Cholesterol	0.2332	< 0.001
Log-HCEs	*Inpatient*	-0.0338	< 0.001
	Drugs	-0.0335	< 0.001
	Outpatient	0.0314	< 0.001
Thresholds	z_1	-2.5915	< 0.001
	z_2	-1.2976	< 0.001

Outcome Model		Estimate	p-value
	Intercept	8.4914	0.141
Gender	*Female*	-	
	Male	1.3225	0.014
Age classes	*Less than 45*	-	
	(45,55]	4.3047	0.448
	(55,65]	8.9082	0.105
	(65,75]	11.6086	0.035
	More than 75	15.2522	0.007
	Intervention Dummy	-2.3245	0.024
LHA	*101*	-	
	102	-1.4371	0.093
	103	-2.3241	0.073
	104	-2.6228	< 0.001
	105	-2.3982	0.009
	106	-2.3000	0.003
Exemption	*Invalidity*	4.0841	< 0.001
Log-HCEs	*Inpatient*	0.1516	0.015
	InvMillsRatio	9.2201	< 0.001
R^2	0.0627		

Table 1 The results of the TTD model estimation. The selection ordinal logit model results are reported in the left panel. The right panel shows the results of the outcome model.

4 Conclusions

This study has assessed the role of TTD on HCE and has confirmed, in general, the "red herring" hypothesis. Moreover, this hypothesis has not always been confirmed in our framework. The role of HCE has been studied to verify the simultaneity between HCE and TTD. This last analysis involved a non-standard econometric approach and it has been developed by using a suitable measure of TTD (presenting a double inflated distribution). The adoption of ordinal selectivity in the analysis of the role of HCE on TTD allows us to study the peculiar behaviour of the phenomenon. The results of the empirical analyses show that the role of HCE on TTD (reversal relationship) is significant, in particular for the selection equation.

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