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Geographic variation in inpatient costs for Acute Myocardial Infarction care: Insights from Italy

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ABSTRACT

Geographic variations in healthcare expenditures have been widely reported within and between countries. Nevertheless, empirical evidence on the role of organizational factors and care systems in explaining these variations is still needed. This paper aims at assessing the regional differences in hospital spending for patients hospitalized for Acute Myocardial Infarction (AMI) in Tuscany and Lombardy regions (Italy), which rank high in terms of care quality and that have been, at least until 2016, characterized by quite different governance systems. Generalized linear models are performed to estimate index, 30-day and one-year hospitalization spending adjusted for baseline covariates. A two-part model is used to estimate 31–365 day expenditure. Adjusted hospital spending for AMI patients were significantly higher in Lombardy compared with Tuscany. In Lombardy, patients experienced higher re-hospitalizations in the 31–365 days and longer length of stays than in Tuscany. On the other hand, no significant regional differences in adjusted mortality rates at both acute and longer phases were found.

Comparing two regional healthcare systems which mainly differ in both the reimbursement systems and the level of integration between hospital and community services provides insights into factors potentially contributing to regional variations in spending and, therefore, in areas for efficiency improvement.

1. Introduction

The geographic variation in healthcare across and within countries is well documented, and at all levels such as between different healthcare services and between both large and small areas [1,2]. Part of this geographic variation is expected and often linked to differences in population health and needs (such demographics and health status). However, some of this variation may be unwarranted and driven by non-clinical factors, such as professional decision making, the availability and distribution of resources, physician incentives, financing and reimbursement models [2]. The main policy challenge is thus not to eliminate variation altogether but to identify areas of variation where population characteristics and health outcomes are comparable but higher- than-average costs suggest the potential for improved efficiency. Evidence from the Dartmouth research group suggested that even after adjusting for differences in population characteristics and in price levels, high-treatment intensity regions were generally not associated with better outcomes but with significantly higher spending. The results showed that if all these regions had reduced care volumes to the level observed in low- spending regions with a similar level of care quality, approximately 30% in spending could have been saved. Higher efficiency could thus be achieved by identifying and reducing unwarranted variation without producing worse outcomes, on average, or reductions in the quality of care [3–6].

Despite similar variations were corroborated by a large body of literature in US [7,8] and more recently in other advanced economies [9–13], there is still little agreement about the causes and the clinical implications of these reported variations. Numerous possible factors of varying impact could drive variations in spending, the majority of the studies found that the highest percentage of variations is due to supply-side factors including the types of services provided [8], payment differentials [14] physician behavior [15]. However, other studies shown that cost variations were not due to systemic inefficiencies but mostly to population health status [16,17].

Additionally, most findings in US confirmed that greater health care spending does not necessarily correlate with better care or better health [8,18–20]. However, in distinction to the Dartmouth

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research, other studies in US showed that more spending and utilization are likely to lead to better outcomes [21–25].

Other recent studies in Europe also reported mixed results. While some researches have shown that within country variations in health expenditures are mainly explained by medical need [26] and that expenditures are likely to be positively related to health outcomes [27], other studies, although confirming significant variations in costs and outcomes across and within countries and for different conditions, did not found any clear cost-quality trade off pattern [28,29,13,30].

Regardless the magnitude and direction of the association between healthcare costs and outcomes, it seems that there is a large proportion of variation in spending and utilization among and within countries which might reflect differences in inefficiencies. Further research is therefore needed to gain a better understanding of the underlying drivers of variations and to identify the related health policy implications.

In this context, the present study aims at analysing regional variation in hospital spending for patients with Acute Myocardial Infarction (AMI) in Italy. Using specific econometric models for healthcare costs, we compare one-year treatments and Diagnostic-Related Group (DRG)- based expenditures of patients hospitalized for AMI in Lombardy and Tuscany regions which are both characterized by similar high-performing healthcare systems but, however differ in terms of institutional settings. In particular, Tuscany healthcare system is based on a strong integration between the various healthcare providers to favour the efficient use of both acute and post-acute services, and on planning, target setting and competitive benchmarking on quality of care that play a crucial role in the regional governance. Lombardy has adopted until 2016 a quasi-market system made up of both public and private providers and based on a prospective payment system to reimburse hospitalizations [31–34]. The distinct differences between Lombardy's quasi market governance model and the integrated care model of Tuscany offer a valuable opportunity to explore regional variations in healthcare spending.

We focus on comparison of AMI care for several reasons supported by the scientific literature [35,36], including the fact that AMI is one of the most common hospital admission; that it is an acute condition which is not related to the patients' choice of providers, patients are in fact generally taken to the nearest hospital for immediate treatment, and, although there is a growing international consensus on which treatments should be administered to AMI patients, geographic variations in quality and treatment intensity are widely documented [13]. Moreover, the hospitalization for AMI is a well-defined index event, which is likely to be similarly defined across and within countries.

2. The healthcare systems of Lombardy and Tuscany Regions

The Italian National Healthcare System (NHS) follows the Beveridge model [37], providing universal healthcare coverage throughout the Italian State as a single payer. It entitles all citizens, regardless of their social status, to equal access to essential healthcare services. In 1992, a system reform transferred administrative and organizational responsibilities and tasks from the central government to the administrations of the 21 regions in Italy. These regions now have significant autonomy on the revenue side and in organizing services designed to meet the needs of their respective populations [38,34]. Across years, the decentralized structure of the Italian NHS has led to the emergence of a range of different governance models at the regional level [33], which offer rich opportunities for comparative study of the impact of different institutional settings on costs and outcomes (i.e. on the value creation process [39]).

Table 1
Description of the Tuscany and Lombardy healthcare systems.

	Tuscany Region	Lombardy Region
No. Inhabitants (million)	3,7	10
Population density (inh./km^2)	163.24	419,11
Life expectancy (years)	85	85
No. of public hospitals	40	98
No. of private hospitals	0	102

Among the 20 Italian regions, both Lombardy and Tuscany are among wealthiest regions in Italy and their population are similar in terms of health conditions and life styles. As shown in Table 1, Tuscany counts about 3,7 inhabitants while Lombardy about 10 millions. Life expectancy at birth is of 85 years in both regions and the percentage of people reporting of being in good health conditions are 71.5% and 71.2% in Tuscany and Lombardy respectively (Source: http://dati.istat.it). The two regions are both characterized by high quality healthcare systems [40,41] but with different approaches to the organisation of healthcare delivery and to the financing model.

The Lombardy healthcare system comprises approximately 200 hospitals generating 2 million discharges annually; 18 billion Euros are devoted to healthcare expenditures (80% of the regional budget) every year. The regional healthcare system was reformed in 1997 becoming a quasi-market characterized by a separation between health care purchasers and providers, and where private providers deliver the 30% of the hospitalizations per year and compete with the public providers. Patients, therefore, are free to choose where to be hospitalized whether in any private or public accredited providers Anessi-Pessina et al. [31,33,42,43].

Differently from Lombardy, the healthcare system in Tuscany is based on a strong integration between the various healthcare providers to favour the efficient use of both acute and post-acute services. Planning, target setting and competitive benchmarking play crucial roles in the regional governance [40] of Tuscany. The system comprises about 40 public providers and 34 health districts that are in charge of organize and deliver services of territorial health networks, social care and social integration. Starting from 2016, the Regional Healthcare System has been reformed by aggregating the existing 12 Local Health Authorities (LHAs) into three major new Local Health Authorities while keeping the existing four Teaching Hospitals. More than 95% of hospital beds are public and each of the LHAs are financed by the regional administration under a global budget with a weighted capitation system, that is, funds are allocated to providers through an administrative process not directly linked to patient volumes. On the other hand, budget cost control and quality care targets are applied to teaching hospitals. Even though patients have a free choice of health care provider, the absence of a clear link between volumes and reimbursement means that hospitals do not have the same incentive to compete for market share that they do in DRG-based financing systems. Indeed, hospitals in Tuscany, are more focused on outcome and appropriateness targets that are monitored through a benchmarking approach and through public disclosure of providers' performance levels (http://performance.sssup.it/netval).

With regard to the organization of care for AMI, in Italy there has been a rising in AMI care network coverage across the whole territory, with a growing number of Percutaneous Coronary Intervention (PCI) promptly delivered [44]. This holds also for both Tuscany and Lombardy regions, in which revascularization services are promptly accessed by the regional populations except for few municipalities which are more than 60 min distant from the nearest care network [44]. Moreover, in the last years, the healthcare system of Tuscany region has promoted the creation of an inte-

grated network of cardiac health services, following the logic of Hub & Spoke model [45], whereas access to treatment of AMI in Lombardy is assured through the coordination among hospitals and emergency services, especially for the treatment of STEMI patients [46,47].

3. Methods

3.1. Data sources

We conducted a retrospective cohort study using data from hospital discharge records from Tuscany and Lombardy. The analysis included all patients discharged with a primary diagnosis of AMI (International Classification of Deceases, 9th revision, Clinical Modification - ICD-9-CM codes: 410.xx) between January 1, 2012, and December 31, 2013, from all hospitals in Tuscany and Lombardy.

Admissions lasting less than two days were excluded, as well as hospitalizations of patients not resident in the two regions. The analysis concerned patients older than 18 years and younger than 100 years. Records with a diagnostic code 410.9 AMI of unspecified site, and a diagnostic code 410. × 2 subsequent episode of care for discharged patients were also excluded from the analysis.

If a patient had more than one admission for AMI during any study year, we randomly selected one of those admissions for each study year [48,49]. Starting with the AMI hospitalization (index admission), each patient was then followed for one year to measure variations in hospitalization volumes and spending across Tuscany and Lombardy, both at the initial AMI episode and during the post-hospitalization period.

The study observation was divided into four periods: index admission (1), all hospitalizations up to 30 days from the index admission (0–30) (2), from days 31 to 365 (3), and overall 1-year hospitalizations (4). The 0–30 days window can be considered as the acute phase of AMI management when patients should receive most of the guideline-based admission therapies (i.e. acute reperfusion therapy), and re-hospitalizations in this period may be strongly linked to the admission episode of care. On the other hand, re-hospitalization once the acute phase has passed (i.e. from day 31 to 365) should also depend on the primary care and community support provided to patients.

For each patient, hospitalization costs at index and post-index periods were identified using the DRG reimbursement registered in the HDRs. In order to take into account of the inter- regional differences in spending associated with differences in DRG tariffs, expenditures were calculated for the AMI patients of each region by applying the Lombardy DRG tariff system to the corresponding DRGs in Tuscany. Data had already been anonymized at the Regional Health Information System Office, where each patient was assigned a unique identifier. This identifier prevents the patient's identity and other sensitive data from being traced. The study was carried out in compliance with Italian law on privacy, and approval by an Ethics Committee was not required.

3.2. Methodological approach

The major methodological issues that arise when analysing healthcare costs are that these non-negative data often exhibit substantial positive skewness, "heavy" upper tail and a mass at zero for non-users, as in our study, for those patients who were not hospitalized in the 31–365 observation period [50–52].

The skewness of the cost distributions was approached using Generalized Linear Models (GLMs). In particular, to estimate hospitalization spending at the patient's index admission, at 30 days, and at 1 year follow up; three different GMLs were tested, specifying several families (Gamma, Poisson, Inverse Gaussian) and a link log function. The modified Park test [53] and Hosmer-Lemeshow test [54] were applied to choose the specification with the better model fitting. For the three dependent variables here considered, the tests indicated that the Gamma-Log link model was adequate compared to other types of distributions. Differently, a two-part model [50,55,56] was used to estimate hospitalization costs at 31–365 follow-up period (conditional on surviving the first 30 days). This allows to control for the zero-inflation affecting the hospitalization costs in this observation period. Two-part model is composed by two related equation: in the first part of the model (Eq. (2) in this paper) the probability to observe a patient in the period 31–365 days is modelled via probit regression. In the second part of the model (Eq. (3) in this paper), the level of hospital expenditure for the patients hospitalized in the period 31–365 days is modelled using a GLM with Gamma-Log link specification. All considered models are adjusted for age, sex, ST-segment AMI and selected comorbidities at baseline which were retrieved, for each patient, at both the index and in all hospitalizations one year prior to the index. A dummy variable indicating the patient's region of residence (1=Lombardy, 0=Tuscany) was also included as a covariate in the models, in order to measure the differences between the two regions.

This econometric approach can be formulated as follow:

Model 1: Dependent variables: cost at Index, 0–30 days post AMI, and at 1 year

$$E(Cos_i|X) = \exp(X/\boldsymbol{\theta})$$

Where i = 1, ..., n are the Lombardy and Tuscany patients, X is the matrix of the covariates and $\boldsymbol{\theta}$ is the vector of the coefficients. Using similar notation, Model 2 for the dependent variable expressing cost at 31–365 days post AMI can be formulated as follow:

$$E\left(Cost_i X\right) = \Pr\left(Cost_i > 0X\right) {}^{*} E\left(Cost_i > 0, X\right) \tag{2}$$

Which is composed by:

$$\Pr\left(Cost_i > 0X\right) = \frac{\exp(X\boldsymbol{\varphi})}{1 + \exp(X\boldsymbol{\varphi})} \tag{3}$$

$$E\left(Cost_i > 0, X\right) = \exp\left(X\boldsymbol{\phi}\right) \tag{4}$$

As anticipated, differently from Model 1, when we estimate the cost for 31–365 days, we need to control for the probability to be alive after 30 days. For this reason, the two-part model approach as described by Eq. (2) is adopted, where Eq. (3) estimates the probability to be alive at 30 days and Eq. (4) estimates the expenditure adjusted for the probability to be alive at 30 days.

Differences in adjusted costs between the two Italian regions were estimated using recycled predictions. This method avoids the problem of the covariates imbalance affecting nonlinear retransformations in GLM [56], and consists in 1000 bootstrap replications used to estimate 95%-bootstrap-percentile-intervals [56,57] of the difference between the expenditure in Tuscany and Lombardy.

Moreover, although the study was not designed to test the impact of spending on health outcomes, we compared mortality rates between the two regions after adjusting for age, sex, race, ST-segment AMI, and comorbidities at baseline by using a logistic regression. The available data did not allow us to analyse possible differences in non-clinical outcomes such as patients' reported outcomes or satisfaction.

Finally, a sensitive analysis was performed aimed at checking for potential selection bias due to the main confounders and to potential differences in coding practices between the two regions, we replicated the analysis by first matching the patients of the two regions on age, sex and comorbidities using a Coarsened Exact Matching (CEM) non-parametric approach [32,58,59]. The global balance between the patients belonging to the two regions was measured using the L1 index [58].

Table 2
Sample Characteristics Care Provided to patients admitted for Acute Myocardial Infarction.

Patients characteristics	Lombardy (N = 30,225)		Tuscany (N = 13,187)		P-value
	Mean (SD)		Mean (SD)		
Age	70.325	(13.404)	71.940	(13.329)	<0.001
Male	0.647	(0.478)	0.637	(0.4808)	0.068
Lipid metabolism disorder	0.093	(0.290)	0.212	(0.408)	<0.001
Cancer	0.031	(0.174)	0.036	(0.185)	0.027
Diabetes	0.132	(0.338)	0.212	(0.408)	<0.001
Hypertensive diseases	0.209	(0.406)	0.411	(0.4925)	<0.001
Other forms of ischemic heart diseases	0.248	(0.431)	0.350	(0.477)	<0.001
Previous Heart failure	0.173	(0.3773)	0.268	(0.442)	<0.001
Conduction disorders and cardiac dysrhythmias	0.182	(0.3857)	0.209	(0.406)	
Cerebrovascular diseases	0.054	(0.225	0.073	(0.260)	<0.001
Vascular diseases	0.039	(0.192)	0.060	(0.237)	<0.001
Chronic obstructive pulmonary disease	0.040	(0.195)	0.066	(0.249)	<0.001
Chronic nephropathies	0.070	(0.254)	0.116	(0.320)	<0.001
N-STEMI	0.513	(0.499)	0.557	(0.496)	<0.001
Treatments at index admission					
PCI	0.624	(0.484)	0.594	(0.491)	<0.001
CABG	0.019	(0.135)	0.009	(0.093)	<0.001
Patient outcomes [a]					
30 day mortality	0.077	(0.001)	0.075	(0.002)	0.753
1 year mortality	0.167	(0.001)	0.157	(0.002)	0.055
Patient spending in Euros(€) [b]					
Index	7,324	(4,336)	6,610	(3,204)	<0.001
30 day	9,033	(6.032)	8,037	(5,227)	<0.001
31-365 day [c]	3,668	(7,236)	3,044	(6,537)	<0.001
1 year	12,419	(9,908)	10,854	(8,682)	<0.001

[a] Represents risk-adjusted percentage (standard error).
[b] Spending is adjusted for regional differences in DRG-tariff systems.
[c] Conditional on surviving the first 30 days.

4. Results

We identified 13,187 patients in Tuscany and 30,225 in Lombardy who were hospitalized for AMI in the years 2012 and 2013.As shown in Table 2, Tuscan patients were significantly older and showed more comorbidities on average than the Lombardy patients ($p < 0.001$). These results could explain the higher significant percentage of NSTEMI (non-ST segment elevation myocardial infarction) patients in Tuscany compared to Lombardy, with 56% and 51% respectively ($p < 0.001$). Other studies have found that patients hospitalized for STEMI (ST segment elevation myocardial infarction) were more likely to be younger, male, and were less likely to have a prior history of several comorbidities [60].

Additionally, Lombardy patients were more likely to receive invasive treatments such as PCI or Coronary Artery Bypass Graft (CABG) at the index admission ($p < 0.001$). After controlling for patient characteristics, adjusted mortality rates at the acute phase (within 30 days of the AMI) was similar in the two regions (7.7% and 7.5% in Lombardy and Tuscany respectively) whereas, in the longer-term (one year), the mortality of AMI patients in Lombardy was about one percentage points higher than in Tuscany (adjusted 1 year mortality rates, 16.7% in Lombardy and 15.7% in Tuscany)

However, the adjusted rates at both observation periods did not differ significantly across the two regions.

Unadjusted mean hospital spending, standardized for the regional differences in the DRG tariff systems, were significantly higher in Lombardy compared to Tuscany across all the observation periods.

More specifically, total one-year spending per patient was 14% higher in Lombardy than Tuscany ($p < 0.001$). The regional gap in spending was lower in the acute phase of AMI with Lombardy exceeding Tuscany by 11% and 12% ($p < 0.001$) at the index and within 30 days respectively. On the other hand, the longer term post-admission period had the greatest interregional gap in the spending. That is, between 31 and 365 days, spending for hospital readmission was on average 20% higher in Lombardy compared with Tuscany ($p < 0.001$). Total expenditures in this post-acute care phase accounted for respectively 27% and 26% of the total 1 year spending in Lombardy and Tuscany.

A total of 41% of the Lombardy patients were readmitted at least once in the 31–365 days after the index admission compared with 37% of the Tuscany patients. In both regions, the highest volumes of hospitalizations were for cardiovascular interventions, although the rate of rehospitalization for revascularizations (either CABG or PCI) was higher in Lombardy compared to Tuscany (Fig. 1). Indeed, almost 9% and 2% of the readmissions in Lombardy were for percutaneous cardiovascular procedures with a drug-eluting stent and bare stent respectively, compared to 5% and 1% in Tuscany, whereas 1% of the readmissions were for CABG in Lombardy compared to 0.5% in Tuscany

Table 3 describes the regional trends in the Length of Stay (LOS) together with the percentage of hospitalization with LOS exceeding an established threshold (long-stay outliers). The average LOS at the index for Lombardy was two days longer than in Tuscany, whereas in the post-acute care (31–365 days post admission), the average length of stay was about 10 and 7 days for Lombardy and Tuscany, respectively. Besides having on average longer LOS compared with patients in Tuscany ($p < 0.001$), patients in Lombardy were also likely to experience greater lengths of stay than the DRG specific LOS threshold both at index and in the 1-year follow-up ($p < 0.001$). Indeed, the proportions of hospitalizations classified as long-stay outliers in Lombardy were almost twice those of Tuscany, thus leading to higher hospital spending for the same DRG in Lombardy compared to Tuscany.

The results presented above were confirmed by findings from the multiple regression of hospital spending for AMI (Fig. 2), which showed that also after adjusting for comorbidities and for differences in DRG tariffs, adjusted hospital spending was significantly higher in Lombardy than Tuscany across all observational periods. In particular, in the GLM models, the annual average cost for an AMI

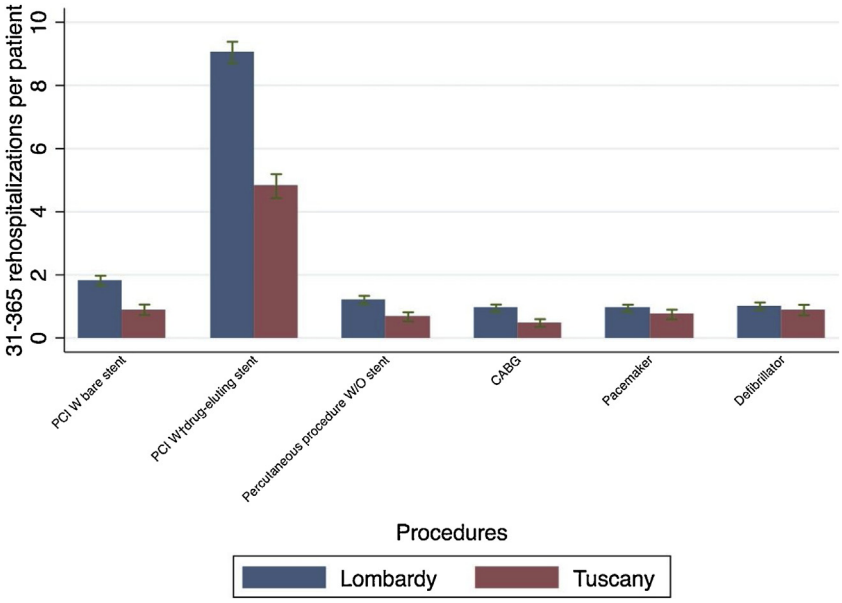

Fig. 1. Re-hospitalization in the 31–365 days following the index admission per patient with Acute Myocardial Infarction (AMI) for the most common surgical interventions.

Table 3
Analysis of the length of stay.

	Lombardy		Tuscany		P-value
Index					
Average Length of Stay (SD)	8.987	(6.979)	6.898	(5.239)	<0.001
% hospitalization over DRG threshold (SD)	20.206%	(40.154)	9.559%	(29.404)	
Up to 30 days after the index admission					
Average Length of Stay (SD)	10.356	(8.920)	7.471	(6.485)	<0.001
% hospitalization over DRG threshold (SD)	20.874%	(40.640)	9.584%	(29.437)	
31 to 365 days after the index admission					
Average Length of Stay (SD)	10.477	(12.134)	7.961	(10.729)	<0.001
% hospitalization over DRG threshold (SD)	13.625%	(34.306)	7.854%	(26.903)	
1 year after the index admission					
Average Length of Stay (SD)	10.396	(10.108)	7.629	(8.108)	<0.001
% hospitalization over DRG threshold (SD)	18.452%	(38.791)	9.024%	(28.653)	

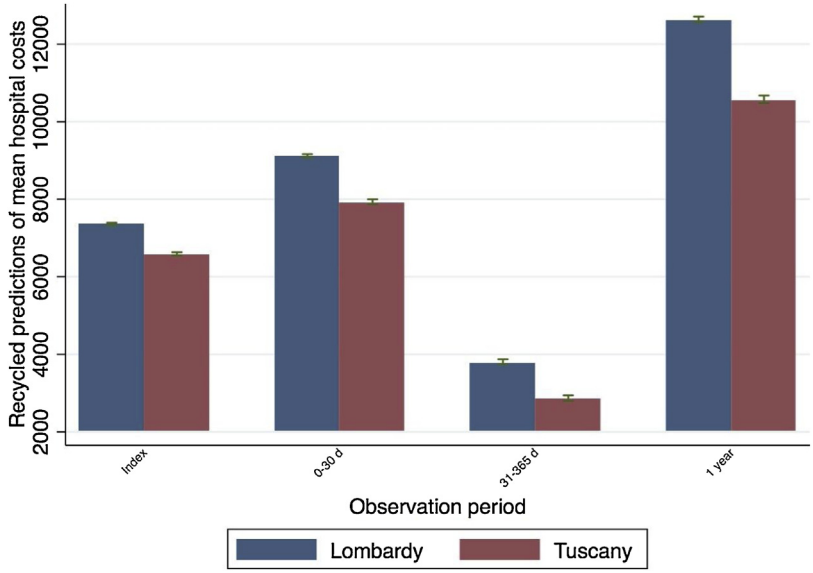

Fig. 2. Mean predicted hospital costs (95% confidence intervals) in Euros. Age, sex, selected comorbidities were controlled for in all regressions.

patient hospitalized in Lombardy was on average 2081 euros higher than that for AMI patients hospitalized in Tuscany ($p < 0.001$). On the other hand, the mean differences between Lombardy and Tuscany were 774 and 1197 euros for the hospitalization costs at index admission and in the first 30 days ($p < 0.001$) respectively. Moreover, in the two-part model, compared with Tuscany, Lombardy incurred on average 941 euros extra ($p < 0.001$) in hospitalization expenditure in the longer-term (31–365 days) post-admission period.

Results of the CEM analysis reported a lower post-matching L1 value which decreases from 0.51 to 0.28 indicating a high-quality match (a strong reduction in the unbalancing of the covariates). Average hospital spending of the matched samples of AMI patients of Lombardy and Tuscany were found to be significantly different. This means that even after removing potential selection bias due to different clinical and demographic characteristics of the two AMI cohorts, hospital spending remains significantly higher in Lombardy region compared to Tuscany across all the study observation periods ($p < 0.001$).

After matching the two cohorts, significant regional differences were also observed for both LOS and volume of revascularizations (either CABG or PCI) in the 31–365 observation, which remained higher for Lombardy patients ($p < 0.001$) compared to Tuscany ones. On the contrary, we did not observe any difference in terms of mortality between Tuscany and Lombardy in all the observation periods ($p > 0.10$)

5. Discussion

The literature on geographic variation has widely proved that there are a variety of factors that contribute to explain regional variations in healthcare spending and utilization. Some of these factors such as the different patients' needs and preferences are "warranted", whereas, the ultimate challenge for policy makers is reducing regionals variations due to "unwarranted" factors which ultimately reflect system inefficiencies.

In this study, we analyse the extent of regional variation in hospital spending for AMI patients across two Italian regions, Tuscany and Lombardy, both with high quality healthcare systems but with different regional governance models for financing and delivering healthcare.

In line with previous studies reporting that differences in prices and patient health status account for only a part of the variation in spending [6,17,61], we found that, compared with Tuscany, Lombardy presented significantly higher adjusted spending for AMI patients at both the acute phase (within 30 days of the AMI hospitalization) and in the longer-term (31–365 days) post-admission periods. More specifically, after adjusting for differences in patients' case-mix and regional DRG tariffs, the average annual hospital cost per AMI patient still significantly differed between the two regions and it was on average 2081 euros higher in Lombardy compared to Tuscany. On the other hand, after controlling for patients' characteristics, the mortality rates at acute (within 30 days of the AMI) and longer-term post admission period (1 year) of the AMI did not significantly differ between the two regions. Results were also reinforced by the CEM analysis which shows that the in matched samples Lombardy reported significantly higher AMI hospital spending compared to Tuscany whereas the two regions did not significantly differ in terms of AMI mortality across the study periods Beyond these observed differences in regional spending, the study attempts to contribute to the discussion on the potential drivers at system level of variations in hospital spending across regional healthcare systems with comparable health outcomes and populations.

We found that the average LOS was higher in Lombardy compared to Tuscany, with a percentage difference between Lombardy and Tuscany ranging between 30% at the index at 36% at 1 year follow-up. Moreover, the proportion of hospitalizations with longer than a stated LOS outlier threshold was almost double in Lombardy with respect to Tuscany across all the study periods and this was true also in the matched cohorts.

Lombardy's higher percentage of long-stay outliers, especially in the post-acute phase, could, for instance, suggest that this regional healthcare system might lack effective transitional programs between the acute hospital sector and community services for the AMI patients, especially for those who are more in need of coordinated discharge and ongoing support [62].

Furthermore, between 31 and 365 days, AMI patients in Lombardy were more likely to be readmitted compared to Tuscany. In particular, higher rates of repeated PCI were observed in the 31–365 days for the Lombardy patients with respect to the Tuscany ones in both the matched and not matched cohorts. In the literature, activity-related funding was found to provide incentives for greater volumes [63,64] and therefore to potentially lead to different local practice patterns. Indeed, in this context, we might hypothesize a different professionals' choice on revascularization modality in patients with multi-vessel disease. PCI Multi-vessel can in fact be performed either at the time of the index hospitalization or at separate subsequent hospitalizations. Although the identification of the optimal timing of a staged procedure in AMI patients still required further investigation, clearly the strategy of procedures performed in repeated hospitalizations leads to increased hospital costs with respect to treat other vessels at one stage [65,66].

Variations in procedures rates and in the use of resources (e.g. different LOS for similar patients) especially in the post-acute phase might be also explained by regional differences in other supply-side factors such as provider's capacity (e.g. hospital and long-term care beds per thousand, number of cardiac facilities) [67,3,68]. As an example, cardiac hospital beds in 2013 were 2.29 per 100,000 inhabitants in Lombardy region compared with 1.53 per 100,000 inhabitants in Tuscany (Source: Ministry of health - http://www.dati.salute.gov.it/dati/homeDataset.jsp). The available data did not allow us to analyse differences in out-of-hospital resource capacity.

Indeed, these results seem to confirm that, even between regional healthcare systems dominated by high standards of care, there can exist both different type of organizational structures within and between care settings and different levels of professionals' discretion over the care provided for similar patients.

We therefore hypothesize that system-level factors, such as the different reimbursement systems, and the different organization and level of integration between acute hospital providers and community care services in the two regions, might contribute to explain the supply-side of variation in expenditure and, more generally, the value for money that is produced.

Target policies which favour outcome goals and facilitate continuity of care between hospital and post-hospitalization settings can incentivize hospitals towards a more efficient use of their input resources (i.e. hospital beds), allow to efficiently reallocate the resources where services may provide more value for patients and to guaranteeing an appropriate support to patients from one health care setting to another [69].

The performance evaluation system adopted in Tuscany [40,70] allows physicians to be more aware of the impact of their choices on the use of resources thanks to the analysis of administrative data through the patients' clinical path perspective. Additionally, benchmarking and public disclosure of outcome results and the participation of physicians in meeting, strongly enhanced by the regional government, aimed at identifying and sharing best practice helping Tuscan clinicians to uniform behaviors at regional level putting reputation to work [71].

As matter of fact, in 2016 the Lombardy Region has started implementing a reform of the healthcare system aimed at overcom-

ing the quasi market governance system in favour of the integration between hospital and primary care, reducing readmissions and increasing the appropriateness. Moreover, Lombardy decided to be part of a network of 10 Italian Regions that adopt a unique performance evaluation system, based on target setting, competitive benchmarking, and public disclosure of data [75]. This is aimed at improving quality delivered and at containing the expenditure.

The study suffers from some relevant limitations many of which related to the data and design of the study. First, as with all observational data, we are unable to make inferences about causation, therefore, effect estimates should be cautiously interpreted. Second, as with other studies using administrative data [72,73], information was lacking on potential confounding variables such as AMI severity, lifestyle factors, treatment adherence, and procedural characteristics. Moreover, the type of data do not allow to carefully evaluate the appropriateness of strategies both adopted in the two regions for the AMI treatment both at the index and in the 31–365 hospitalizations. However, the use of administrative data has been widely adopted by healthcare agencies and other stakeholders to measure hospital performance. This is because such data, compared to clinical registries, are easily accessible, relatively inexpensive to use, and enable information to be collected on the entire population of concern [74].

Other variables that are important to the comparisons being made might have being omitted or unmeasured in this study such as information on AMI patients that may die before reaching the hospital, which could provide indication on whether hospital patient populations differ across the two regions.

Finally, at this stage of the analysis, we focused our study on the treatment of AMI only and we recognized that findings might not extend to the rest of healthcare. Also, we were only able to consider hospitalization spending and could not include non-clinical outcomes.

Despite these limitations, our study has several strengths. To the best of our knowledge, this is the first study that has analysed geographical differences in health care spending between two regional healthcare systems in Italy, in a longer time frame than the arbitrary 30 days of the acute care phase. In addition, compared to the other studies, the opportunity to compare the regional healthcare systems in Italy allows us to analyse geographic variation between two regions that are similar in terms of both socio-economic figures and citizens' standard of living but differ in terms of the governance and funding models of their healthcare systems. This might facilitate the identification of supply-side factors that could potentially explain system inefficiencies.

6. Conclusions

Health systems are looking for ways to shift to value-based healthcare. Our study suggests the importance of considering the impact of the governance system as one of the possible determinants of geographic variation when comparing different regional healthcare systems. Although the different regional organizational models may not lead alone to reductions in unwarranted variations in spending, the choice to introduce quasi-market mechanisms to promote both efficiency and efficacy seems to be less favorable then the introduction of governance based on planning, target setting and competitive benchmarking on quality of care, moreover if partnered with a strong integration between acute and post-acute services.

Conflict of interest

The authors do not have any conflicts of interest to declare

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