Health policy 164 (2026) 105483

Contents lists available at ScienceDirect

Health policy

journal homepage: www.elsevier.com/locate/healthpol

The impact of pre-admission care on hospital mortality: Results of an instrumental variable analysis from Italy

Francesco Moscone [a,b], Elisa Tosetti [c,*], Giorgio Vittadini [d]

[a] Brunel Business School, Brunel University of London, Kingston Lane, Uxbridge, Middlesex UB8 3PH, United Kingdom
[b] Department of Economics, Ca' Foscari University of Venice, Dorsoduro 3246, 30123 Venice, Italy
[c] Department of Economics, University of Padova Via del Santo 33, 35123 Padua, Italy
[d] Department of Statistics, University of Milan Bicocca Piazza dell'Ateneo Nuovo 1, 20126, Milan, Italy

ARTICLE INFO

JEL classification:
C55
D14
R11

Keywords:
Hospital productivity
Health expenditure
Hospital quality
Instrumental variables

ABSTRACT

Background: With healthcare spending projected to increase in the coming decades, the relationship between expenditure and health outcomes demands urgent attention.
Objective: This paper investigates the impact of health care spending on hospital mortality. We use data on 96,778 patients admitted for acute myocardial infarction (AMI) in the Lombardy region, Italy, in the years from 2007 to 2022 and combine them with information on expenditure on pharmaceuticals and outpatient visits made in the 12 months prior to hospital admission.
Methods: We adopt an instrumental variables approach to evaluate the causal impact of the total cost for pre-admission prescriptions and outpatient visits on hospital patient's mortality.
Results: We find that pre-admission healthcare, particularly pharmaceutical spending, has a significant impact on reducing mortality rates within hospitals, with a 10 % increase in pharmaceutical spending leading to a reduction in mortality by around 3.0 percentage points, although this result varies depending on the age group and the type of infarction.
Conclusions: The findings suggest that prioritizing pharmaceutical management can significantly reduce hospital mortality, highlighting a key area for healthcare optimization.

Research in context

1. What is already known about the topic?

Existing literature extensively debates the relationship between healthcare spending and patient outcomes, with mixed evidence on whether higher expenditure consistently improves health. Research has highlighted the variability in the cost-effectiveness of different healthcare inputs, such as pharmaceuticals, inpatient care, and outpatient services. While studies on hospital-based and post-admission care dominate the field, the role of pre-admission spending, particularly on pharmaceuticals and outpatient visits, remains unexplored. Previous findings suggest that how resources are allocated - focusing on preventive care and cost-effective treatments - often matters more than the total expenditure.

2. What does this study add to the literature?

This study contributes to the literature by addressing the gap in understanding the impact of pre- admission healthcare spending on mortality outcomes for acute myocardial infarction patients. Using a robust instrumental variables approach, it reveals that pharmaceutical spending before hospital admission significantly reduces both 30-day and 1-year mortality, with effects stronger for older patients and less severe infarctions. Outpatient spending, in contrast, has no substantial impact after accounting for endogeneity.

3. What are the policy implications?

The findings have key policy implications. To enhance patient outcomes and optimize healthcare resources, policymakers should prioritise investments in pharmaceutical management and preventive care. Additionally, healthcare systems should evaluate the effectiveness of outpatient services and explore ways to improve their quality and relevance, particularly in managing chronic conditions.

* Corresponding author.
E-mail address: Elisa.tosetti@unipd.it (E. Tosetti).

https://doi.org/10.1016/j.healthpol.2025.105483
Received 15 January 2025; Received in revised form 7 August 2025; Accepted 8 September 2025
Available online 20 November 2025
0168-8510/

1. Background

The ageing of populations across the OECD countries is placing unprecedented pressure on health systems, as the proportion of elderly individuals rises sharply while the working-age population declines, raising concerns about the sustainability of these systems. Over the past several decades, the percentage of people aged 65 and over in the OECD countries has doubled, increasing from <9 % in 1960 to 18 % in 2021, although this trend varies significantly across countries. In Italy, where the elderly population has reached 23.6 %, the strain on health care resources is particularly severe (OECD [7]). As life expectancy increases and birth rates remain low, OECD countries face growing demands for healthcare services for ageing populations, who often require more frequent and complex medical care. Ageing is often associated with chronic conditions, such as heart disease, diabetes, and dementia, which are resource-intensive and demand long-term management. The burden of care intensifies not only in terms of direct healthcare needs but also in terms of care-giving and social support systems, which add to the costs borne by public healthcare providers. This demographic shift, coupled with economic challenges such as inflation, has intensified competition for public funds, making it difficult to balance quality care with financial sustainability. In 2019, prior to the COVID-19 pandemic, OECD countries spent an average of 8.8 % of their GDP on health care, a figure that remained stable since 2013. By 2021, this percentage had risen to 9.7 %, reflecting the increased demands due to the pandemic. However, projections for 2022 suggest a decline to 9.2 %, driven by reduced pandemic- related expenditures and inflationary pressures (OECD [8]). As health care spending is expected to rise in the coming decades, understanding the link between expenditure levels and health outcomes has become a pressing issue. Policymakers need data-driven insights to determine whether increased spending translates into improved health outcomes or if other structural reforms might yield better returns on investment. For instance, shifting the focus toward preventive care, managing chronic conditions effectively, and improving healthcare delivery efficiency may play a role in maintaining sustainable healthcare systems in an ageing world.

Many studies have investigated whether, ceteris paribus, higher health care spending leads to better health outcomes. Despite extensive research, there remains little consensus on whether higher health care spending leads to better outcomes. Estimates of this relationship vary widely, ranging from significantly positive to zero, or even negative impacts (see Skinner et al. [10], Fisher et al. [3], Skinner [9], Newhouse and Garber [6], Doyle et al. [2], Skinner and Staiger [11], Moscone et al. [5], and Chandra et al. [1], among others). A number of empirical studies support the hypothesis of a flat curve of health care expenditure, namely that more spending has little or insignificant impact on health improvements. Focusing on a sample of patients entering the hospital on an emergency basis to avoid selection bias, Doyle et al. [2] investigated the relationship between hospital spending over the three months following a health emergency and patient outcomes. The authors found that hospitals with higher *inpatient* spending have only modestly better survival outcomes compared to those with lower spending levels. Further, they found higher survival for patients assigned to hospitals with high levels of inpatient spending, lower survival for patients assigned to hospitals with high levels of *outpatient* spending. Similar findings were reported by Likosky et al. [4], who examined the relationship between Medicare expenditure growth and reductions in mortality from 1999 to 2014. Their study found that improvements in health outcomes for patients with acute myocardial infarction varied across hospitals and were more closely linked to the adoption of cost- effective treatments, such as early percutaneous coronary intervention (PCI), than to overall increases in spending. To a lesser extent, post-acute care also contributed to improved outcomes. The authors suggested that interventions aimed at encouraging hospitals to implement cost-effective care practices could enhance patient outcomes. Furthermore, if these interventions were accompanied by a reduction in cost-ineffective treatments both within and outside hospital settings, they could help lower overall healthcare expenditures. Chandra et al. [1] argued that how the money is spent, rather than how much money is spent, is central to understanding productivity differences in health care. The authors investigated the health returns of three types of inputs, a set of cost-effective inputs such as drug treatments effective for nearly all AMI patients, such as beta blocker, statin, and ACE/ARB prescription during the 6 months after discharge from the hospital and the use of same day percutaneous coronary interventions (category I), inputs that are recognised to have heterogeneous effects, for example, the number of intensive-care unit or cardiology-care unit days (ICU plus CCU), and the number of MRI and CT scans (category II), and a set of treatments that are both costly and lack evidence of effectiveness, such as post-acute home health care spending (Category III). The authors found that, conditional on expenditures, hospitals more likely to use Category I treatments are associated with substantially higher survival, while Category II and III treatments are associated generally with lower survival. Much research has emphasized the important role played by medical technology when considering the relationship between health spending and health outcomes. Skinner and Staiger [11] developed a macroeconomic model of health care productivity and technology diffusion to explain persistent productivity differences across US hospitals. Focusing on US Medicare data, they found that cost-effective medical innovations, such as aspirin, beta blockers, and reperfusion or PCI within 12 h of the heart attack, explain a large fraction of persistent variability in hospital productivity which impact upon traditional factor inputs. A similar result is found by Moscone et al. [5] using US data on patients admitted for acute myocardial infarction. The authors, after risk-adjusting mortality and health expenditure, and controlling for unobserved spatial correlation found that treatments with proven effectiveness, such as PCI positively predict survival, while spending in home health care received after admission does not.

Although it is widely recognised that not all health care spending is cost-effective, the majority of studies have focused on the impact of expenditures related to inpatient care or health care services provided after hospital admission. These studies typically examine how hospital-based interventions or post-admission outpatient care influence patient outcomes. However, far less attention has been given to the role of health care expenditures incurred before hospitalisation, which may be crucial for early detection, prevention, and management of chronic conditions that could significantly affect health outcomes. In this paper, we aim to investigate the impact of health care spending prior to hospital admission, particularly focusing on expenditures for outpatient visits and pharmaceutical prescriptions. Pre-admission spending represents investments in preventative care and chronic disease management, which may mitigate the severity of conditions upon hospitalisation and, consequently, improve patient outcomes. We hypothesise that pre-admission spending on pharmaceuticals and outpatient visits, which are key components of early detection and treatment of heart diseases, plays a critical role in reducing mortality. By analysing these pre-admission health care inputs, we seek to understand their role in reducing hospital mortality and identify whether earlier, targeted spending can lead to more effective use of health care resources. Our analysis draws on data from 96,778 patients admitted for acute myocardial infarction (AMI) between 2007 and 2022 in the Lombardy region (Italy), alongside detailed information on pharmaceutical prescriptions, outpatient visits, and associated costs incurred in the 12 months before admission. Using patient-level data, we calculate risk-adjusted mortality rates and health care expenditures aggregated at the hospital and yearly level. We then adopt a hospital-level regression framework to estimate the marginal impact of incremental spending on hospital care, pre-admission pharmaceuticals and outpatient visits on risk-adjusted mortality. A major challenge in this analysis is the potential for reverse causation, where unobserved severity of illness could drive higher spending and higher mortality, thus leading to biased estimates. By restricting our analysis to AMI patients, we aim to reduce this endogeneity, as hospitals with generally poorer health may encounter more AMI cases. However, conditional on having an AMI with specific co-morbidities, the risk of bias from unrelated health factors is diminished. This approach has been employed in several studies (see, among others, Moscone et al. [5]). Another approach, that we will take in this paper, is to risk-adjust mortality and inpatient health spending, taking into account of a set of admission-level co-morbidities and risk factors that may affect both mortality and spending. However, we observe that pharmaceutical spending as well as outpatient expenditure before hospital admission may still be correlated with pre-admission unobserved individual characteristics, such as underlying health conditions that could also influence mortality. To address this issue, we employ an instrumental variables approach, using the average annual cost of all cardiovascular pharmaceuticals or outpatient visits prescribed by the patient's general practitioner (GP) to other patients admitted to different hospitals as instruments for the potentially endogenous variables of pharmaceutical and outpatient expenditures.

Our findings show substantial differences in the marginal productivity of various health inputs. Consistent with Moscone et al. [5], we find only a modest impact of risk-adjusted hospital spending on mortality. We find that pre-admission health care, particularly pharmaceutical interventions, has a more significant impact on health outcomes than acute in-hospital care. A 10 % increase in pharmaceutical spending is associated with a 2.9 percentage point reduction in 30-day mortality, and a 3.0 per cent decrease in 1-year mortality. We also find consistent heterogeneity in the effect of various sources of spending on health outcomes across age groups and type of infarction. Specifically, the gains in pharmaceutical spending are higher for older patients, particularly when looking at 1-year mortality, as well as for patients with a less severe type of infarction. Through this analysis, we aim to provide insights that can inform more effective strategies for improving patient outcomes, particularly for those suffering from cardiovascular diseases, while optimising resource allocation within health care systems. Our findings suggest that shifting focus toward enhancing primary care and pharmaceutical management could help reduce the financial and operational burdens on hospitals.

The remainder of this paper is organised as follows. Section 2 describes the data and illustrates the econometric approach. Section 3 and 4 comment on the empirical results, while Section 5 concludes with some concluding remarks (Table 1).

Table 1
Summary of patients' characteristics used in the risk-adjustment model.

Variable	Definition	Proportion
Emergency	if admitted via emergency room	0.2949
NSTEMI	if non-ST-elevation myocardial infarction	0.6345
Demographics		
Male	if male	0.5188
Age 65–69	if age between 65 and 69	0.0795
Age 70–74	if age between 70 and 74	0.1060
Age 75–79	if age between 75 and 79	0.1429
Age 80–84	if age between 80 and 84	0.1769
Age 85–89	if age between 85 and 89	0.1813
Age≥90	if age is 90 or above	0.1331
Comorbid conditions		
COPD	if patient has chronic obstructive pulmonary disease	0.0381
Dementia	if patient has dementia	0.0122
HIV	if patient has HIV	0.0034
Cancer	if patient has cancer	0.0240
Diabetes	if patient has diabetes	0.1193
Injury	if patient has an injury (fall, etc.)	0.0432
Anterior	if AMI location is anterolateral	0.0868
Inferior	if AMI location is inferolateral	0.0758
Lateral	if AMI location is anterolateral	0.1109
Posterior	if AMI location is anterolateral	0.0021
Sub	if AMI location is subendocardial	0.6345

Notes: Data cover the period from 2007 to 2022.

2. Data and methods

2.1. Data

The primary source of data is the administrative data set from the Italian region Lombardy obtained under the ministerial project NETWORK (NET-2016 02,363,853). This data set contains information on all individuals resident in the Lombardy region (Italy) and the health care services they received from the region. We first collected information from the hospital discharge chart (HDC) of all patients aged 18 and over admitted for the first time with a Diagnoses Related Group (DRG) between 121 and 125 (Acute Miocardyal Infaction) in the years from 2007 to 2022. Information from the HDC includes socio-demographic characteristics of the patient, such as age, gender, and place of residence (the municipality); clinical information like principal diagnosis, the interventions, length of stay, the type of admission (planned or via the emergency room) the ward of admission, type of discharge (e.g. death); financial information such as the Diagnosis Related Group (DRG), and the HDC reimbursement. Using information on the diagnosis, we differentiate between NSTEMI (non-ST-elevation myocardial infarction) and STEMI (ST-elevation myocardial infarction). NSTEMI typically involves a subendocardial infarction, whereas STEMI is associated with locations such as anterolateral, anterior wall, inferolateral, inferior wall, infero-posterolateral, true posterior, or unspecified regions. This distinction is important for assessing the severity of acute myocardial infarction, with STEMI generally indicating a significantly more severe condition (see Likosky et al. [4]) for further information). Table 2 summarises the characteristics of patients in our sample.

Following existing literature, for each patient we measure her inpatient hospital spending as the total amount of reimbursement linked to her admission. We gather information on mortality of these patients and the General Practitioner with whom they are registered over time. Finally, for these patients we collect data on the prescriptions made by GPs for pharmaceuticals that are used to treat heart diseases. Specifically, using the ATC classification, we restrict to pharmaceuticals for treating conditions related to the cardiovascular system (ATC code C), and Antithrombotic agents (B01). Further, for each patient in the sample we take all outpatient cardiovascular visits prescribed by her/his GP in the 12 months before her/his hospital admission. Outpatient cardiovascular visits are usually carried at an outpatient clinic, or an ambulatory and typically include a range of non-emergency, non-hospitalised services that allow cardiologists to assess and manage patients with heart-related issues. Examples of outpatient services are initial assessment and history review, diagnostic tests and monitoring, adjusting medications. Outpatient visits are designed to provide ongoing care and management of cardiovascular health, focusing on early detection, prevention, and monitoring of heart diseases. We observe that in Italy, for a specific pharmaceutical treatment or medical examination to be

Table 2
Definition and summary statistics on patients' outcomes and costs.

Variable	Definition	Average	std. dev.	Min	Max
30-day mortality	Death within 30 days from discharge	0.169	0.375	0	1
1-year mortality	Death within 1 year from discharge	0.3112	0.463	0	1
Inpatient	Cost of hospital admission (Euro)	4673	2084	113	40,123
Pharmaceutical	12-months pre-admission cost of pharmaceutical prescr. (Euro)	511.5	481.2	0	6028
Outpatient	12-months pre-admission cost of outpatient visits (Euro).	76.6	228.6	0	8821

Notes: Data cover the period from 2007 to 2022.

eligible for coverage under the National Health System, it must be prescribed by a General Practitioner. A summary of the patients' health outcomes and spending categories is provided in Table 2. We observe that there is a very small number of patients for which hospital expenditure is 0.

2.2. Methods

In this paper we adopt a risk-adjustment approach to account for differences across hospitals in mortality and inpatient expenditure due to differences in risk factors. To risk-adjust, we estimate a linear probability model where we regress either 30-day or 1-year mortality on admission-level co-morbidities such as cancer, diabetes, HIV, dementia, COPD, the clinical location of the AMI (e.g., inferior, anterior, lateral, sub-endocardial), whether the patient has been admitted via the emergency room, gender and age groups, year fixed effects, and then calculated mean residuals by hospital and year to create the risk-adjusted mortality measures. The same approach has been adopted to calculate risk-adjusted, individual-level hospital spending. The output of the regressions used for calculating risk-adjusted mortality and expenditure is reported in Table 1 in the online Appendix. Hence, in our main regression specification presented in Tables 3–5, risk-adjusted mortality is regressed on risk-adjusted hospital spending (*Inpatient*), as well as the average patient expenditures on pharmaceutical prescriptions (*Pharma*) and outpatient visits (*Outpatient*) made by their GPs during the 12 months preceding admission, as well as hospital fixed effects.

To address the potential skewness caused by outliers in our main regression specification, all expenditure variables are log-transformed. We also account for potential heteroscedasticity by clustering the standard errors at the hospital level. While mortality rates and inpatient spending are adjusted for admission-level controls, this form of risk adjustment cannot be applied to pharmaceutical and outpatient spending, which occurs prior to hospital admission. However, the probability of receiving a pharmaceutical or outpatient visit prescription is likely to be correlated with unobserved patient characteristics, such as their underlying health conditions or their propensity for preventive care, both of which may influence the dependent variable. To address the endogeneity of pharmaceutical and outpatient spending we adopt an instrumental variables approach. As instrument for *j*th hospital endogenous variable, $Pharma_{jt}$, we use the average yearly cost of pharmaceuticals prescribed by hospital *j* patients' GPs for cardiovascular treatments of patients admitted to hospitals other than the *j*th hospital. This approach helps to account for the unobserved factors that might otherwise bias the relationship between pharmaceutical spending and hospital quality outcomes. Similarly, as instrument for the endogenous variable, $Outpatient_{jt}$, we use the average yearly cost of outpatient visits prescribed by the GP of hospital *j*th patients' GPs for cardiovascular treatments of patients admitted in hospitals other than the *j*th hospital.

We observe that GP prescribing behaviour is largely driven by local medical practice norms, patient health characteristics, and peer effects that are consistent across patients within a geographic area but are not directly influenced by the specific hospital a patient ultimately visits. Patients' pre-hospital pharmaceutical consumption is shaped by their GPs' typical prescribing patterns, and these patterns reflect treatment norms or tendencies that are plausibly independent of the specific unobserved severity of a patient's acute condition at the time of AMI admission. In addition, by excluding hospital *j*'s own patients, we remove any direct mechanical correlation between the instrument and the outcome, ensuring that the variation in the instrument is exogenous to unobserved hospital-specific quality or treatment intensity. This design ensures that the variation used for identification is exogenous to unobserved hospital-specific quality or treatment intensity. Taken together, these considerations support the validity of the exclusion restriction by justifying that the instrument affects mortality only through its impact on pre-admission pharmaceutical use.

Fig. 1 presents a plot of the variables $Pharma_{jt}$ and $Outpatient_{jt}$ against their respective instruments. The graph indicates a positive relationship between these key variables and their instruments, with statistically significant correlation coefficients of approximately 0.28 and 0.15, respectively. These correlations suggest that the instruments are relevant, providing preliminary evidence for their validity in the context of our instrumental variables approach.

3. Results

Fig. 2 illustrates the relationship between 30-day mortality rates and different types of healthcare expenditures, averaged over the period 2020–2022. Each plot shares the same y-axis, showing risk-adjusted 30-day mortality rates, but differs in the type of expenditure shown on the x-axis. The first plot looks at inpatient expenditure, showing virtually no correlation, as indicated by the nearly horizontal trend line. This suggests that changes in inpatient spending had little to no systematic relationship with changes in mortality rates during this period. The middle plot examines pharmaceutical expenditure, displaying a negative correlation (around 0.40), suggesting that increased spending is associated with lower mortality rates. In the third plot, focusing on outpatient expenditure, the relationship appears negative although milder in magnitude relative to that of pharmaceutical spending. The ranges of spending across the three graphs is quite different, with inpatient expenditures showing the widest range of variation. This comparison raises interesting questions about the relative effectiveness of different types of healthcare spending in improving patient outcomes, though the weak correlations suggest that simply increasing spending in any category may not directly translate to better mortality rates.

Table 3 provides regression results for 30-day mortality and 1-year mortality, comparing estimates from Ordinary Least Squares (OLS) and Instrumental Variables (IV) methods. For 30-day mortality, both OLS and IV results show a negative and statistically significant relationship between inpatient spending and mortality. The effect is stronger in the IV specification, indicating that after addressing endogeneity concerns, the impact of inpatient spending on reducing mortality is greater than initially estimated using OLS. Similarly, for 1-year mortality, the OLS results suggest no significant effect of inpatient spending, but the IV estimation reveals a significant negative effect, reinforcing the need to correct for potential biases. In the case of pharmaceutical expenditure, both OLS and IV results show a strong negative association with mortality, meaning that higher pharmaceutical spending reduces mortality. The IV results exhibit a much larger magnitude, especially for 1-year mortality, suggesting that OLS may underestimate the effect of pharmaceutical spending on mortality reduction. Specifically, according

Table 3
Regression results.

	(A) 30-day mortality OLS IV	(B) 1-year mortality OLS IV
Inpatient	−0.0665*** −0.0988***	−0.0299* −0.0651*
Pharma	(0.0153) (0.0269)	(0.0142) (0.0304)
	−0.0655*** −0.2882***	−0.0578*** −0.3033***
Outpatient	(0.0098) (0.0799)	(0.0099) (0.0711)
	−0.0123*** −0.0223	−0.0148*** −0.0333
	(0.0027) (0.0395)	(0.0030) (0.0405)
adj.R^2	0.41	0.39
1-Stage F-stat:		
Pharma	76.0	76.0
	[0.00]	[0.00]
Outpatient	33.3	33.3
	[0.00]	[0.00]
Wu-Hausman	88.9	104.5
	[0.00]	[0.00]

Notes: */**/*** indicate significance at 10 %/5 %/1 %, respectively. Standard errors in parentheses are clustered at the hospital level. p-values are reported in square brackets.

Table 4
IV regression results by age group.

	(A) 30-day mortality			(B) 1-year mortality		
	40 – 64	64 – 84	≥ 85	40 – 64	64 – 84	≥ 85
Inpatient	−0.0020	−0.0465**	−0.0759*	0.0106	−0.0523**	−0.0042
	(0.0171)	(0.0205)	(0.0389)	(0.0238)	(0.0260)	(0.0440)
Pharma	−0.1319**	−0.2566***	−0.3081**	−0.1848**	−0.3181***	−0.3865***
	(0.0558)	(0.0522)	(0.1402)	(0.0720)	(0.0640)	(0.1462)
Outpatient	−0.0434	−0.0240	−0.0113	−0.0412	−0.0450	0.0225
	(0.0328)	(0.0345)	(0.0876)	(0.0413)	(0.0444)	(0.0927)
1-Stage F-stat:						
Pharma	10.9	82.7	67.9	10.9	82.7	67.9
	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]
Outpatient	8.1	22.7	32.3	8.1	22.7	32.3
	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]
Wu-Hausman	27.4	97.9	63.5	25.7	131.6	80.1
	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]

Notes: */**/*** indicate significance at 10 %/5 %/1 %, respectively. Standard errors in parentheses are clustered at the hospital level. p-values are reported in square brackets.

Table 5
Regression results by type of AMI.

	(A) 30-day mortality		(B) 1-year mortality	
	NSTEMI	STEMI	NSTEMI	STEMI
Inpatient	−0.0124	−0.0749***	0.0163	−0.0397
	(0.0379)	(0.02487)	(0.0354)	(0.0299)
Pharma	−0.2501***	−0.1519	−0.3456***	−0.0517
	80.0844)	(0.1112)	(0.1044)	(0.1335)
Outpatient	−0.0198	−0.0949	−0.0248	−0.1742*
	(0.0398)	(0.0676)	(0.0514)	(0.0356)
1-Stage F-stat:				
Pharma	46.7	92.6	46.7	92.6
	[0.00]	[0.00]	[0.00]	[0.00]
Outpatient	18.6	49.6	18.6	49.6
	[0.00]	[0.00]	[0.00]	[0.00]
Wu-Hausman	50.7	130.5	61.7	160.4
	[0.00]	[0.00]	[0.00]	[0.00]

Notes: */**/*** indicate significance at 10 %/5 %/1 %, respectively. Standard errors in parentheses are clustered at the hospital level. p-values are reported in square brackets.

to IV results, 10 per cent increase in pharmaceutical spending implies a rise in 30-day and 1-year mortality rate by 2.7 and 3.0 percentage points, respectively. As for outpatient expenditure, while OLS indicates a significant negative effect on mortality for both short- and long-term outcomes, the IV results show no significant relationship. This suggests that outpatient spending might not have as strong an influence on mortality as initially indicated by OLS, as it is subject to endogeneity issues which are corrected by the IV method. The diagnostic statistics, particularly the first-stage F-statistics for the instruments, indicate strong instrument relevance, with values of 68.4 for pharmaceutical spending and 40.7 for outpatient spending. The significant Wu-Hausman test results confirm that the IV approach is preferable to OLS. Overall, the IV estimates suggest that pharmaceutical expenditure plays a crucial role in reducing both short-term and long-term mortality, while outpatient care appears less impactful after controlling for endogeneity.

Table 4 presents the results of IV estimation, examining the relationship between different categories of healthcare services and mortality outcomes across three age groups: 40–64, 65–84, and 85 and above. For 30- day mortality, pharmaceutical care appears to have a statistically significant and substantial negative effect on mortality across all age groups, with the strongest effect seen in the oldest group (85 and above). This suggests that pharmaceutical interventions may be particularly effective in reducing short-term mortality in older populations. Inpatient care shows a smaller, often insignificant effect for younger age groups but achieves statistical significance in the middle and oldest groups, indicating that inpatient care might be more critical for older patients in the short term. Outpatient care does not show

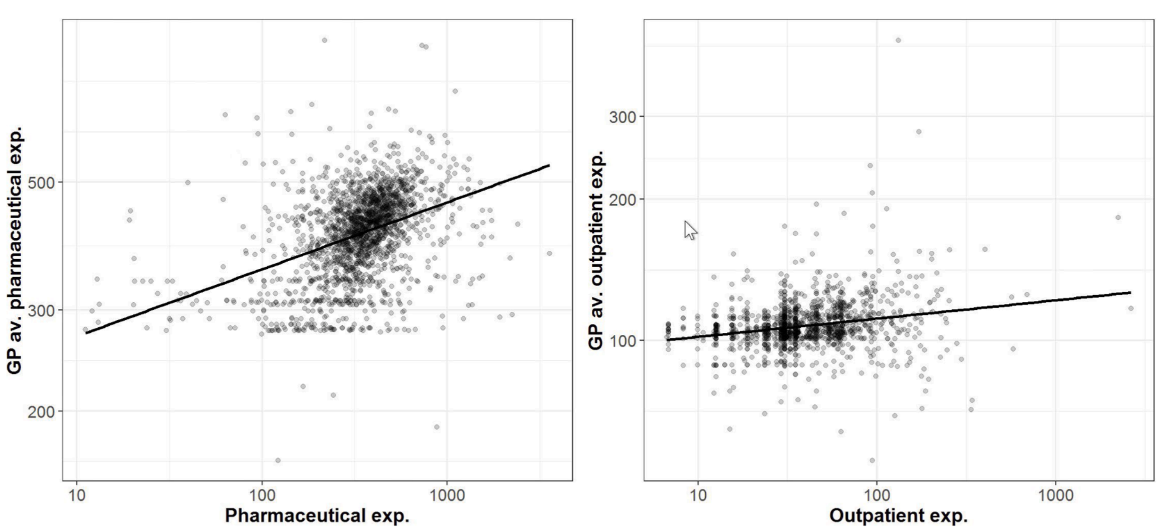

Fig. 1. Plot of the variables *Pharma* (left) and *Outpatient* (right) against their respective instruments.

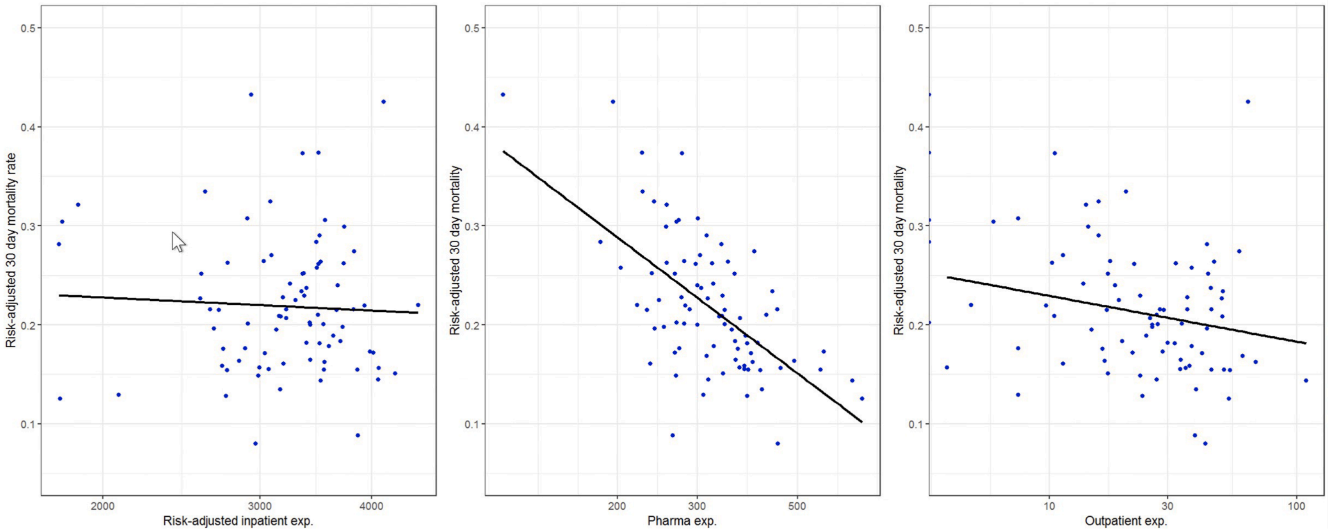

Fig. 2. Risk-adjusted mortality vs risk-adjusted inpatient spending (average over 2020–2022).

statistically significant effects on 30-day mortality for any age group.

For 1-year mortality, the results for pharmaceutical care remain strongly significant across all age groups, with notable differences in magnitude. Interestingly, while it reduces mortality in the youngest and oldest groups, it shows the strongest reduction in the oldest age group. Inpatient care has a significant impact in the middle group, while its effect in other age groups is minimal or insignificant. Outpatient care again demonstrates no statistically significant influence. The first-stage F-statistics indicate strong instrument relevance for pharmaceutical and outpatient care in the middle age and older age groups. Overall, the pharmaceutical care coefficients remain particularly robust across the analyses, underscoring the importance of pharmaceuticals in reducing mortality, especially in the short term and for older individuals.

Table 5 provides further insight into the heterogeneity of treatment effectiveness by differentiating between types of acute myocardial infarction (AMI): NSTEMI (non-ST-elevation myocardial infarction) and STEMI (ST-elevation myocardial infarction). The results clearly demonstrate that pharmaceutical spending is significantly associated with lower 30-day and 1-year mortality in NSTEMI patients, with coefficients of –0.2501 and –0.3456, respectively, both statistically significant at the 1 % level. These effects are not only large in magnitude but also robust, as supported by the high first-stage F-statistics (46.7 and 92.6), well above conventional thresholds for instrument strength, and significant Wu-Hausman tests confirming the relevance of using instrumental variables. In contrast, the effect of pharmaceutical spending is not statistically significant for STEMI patients. This likely reflects the fact that STEMI is a more acute and rapidly evolving condition that requires immediate invasive interventions (e.g., angioplasty or thrombolysis), with less scope for pharmaceutical intervention prior to hospitalisation. These findings align with the notion that pharmaceutical care is more effective at managing chronic cardiovascular risks and stabilizing patients in the sub-acute phase (i.e., NSTEMI). In addition, inpatient expenditure is significant in reducing short-term mortality for STEMI infarction, highlighting that immediate and intensive care may play a more critical role for patients with more severe conditions. This finding contrasts with Likosky et al. [4], which reports that hospital spending is consistently statistically insignificant both overall and across different types of infarction among patients in the United States. Interestingly, outpatient spending does not show a consistent or significant effect across most specifications, except for a statistically significant negative effect on 1-year mortality among STEMI patients (–0.1742, $p < 0.1$). This further supports the view that cost-effective cardiovascular care must consider the nature and timing of interventions, and that upstream investment in pharmaceuticals may help reduce the burden on acute inpatient services.

4. Discussion

The findings of this study underscore the important role of pre-admission healthcare expenditures, particularly pharmaceutical spending, in improving patient outcomes for AMI. A 10 % increase in pharmaceutical expenditure was associated with a 2.9 to 3.0 percentage point reduction in mortality rates, highlighting the efficacy of targeted pharmacological interventions. This contrasts with the modest effect of inpatient spending, which showed smaller but statistically significant reductions in mortality, especially for less severe cases such as STEMI infarctions. Given the average baseline pharmaceutical expenditure per patient (see Table 2) our estimates suggest that relatively modest increases in outpatient drug expenditures are linked to meaningful improvements in survival outcomes. Interestingly, outpatient care spending showed no significant impact on mortality after controlling for endogeneity, suggesting its limited role in influencing critical outcomes for AMI patients. These results align with prior research emphasising the importance of cost-effective interventions, such as pharmaceuticals and early detection, in enhancing healthcare productivity. The study contributes to the literature by focusing on pre-admission spending, an area often overlooked in discussions of healthcare efficiency. By demonstrating the differential impacts of healthcare inputs, the findings suggest that reallocating resources to preventive care and pharmaceutical management could yield substantial benefits in terms of mortality reduction. The heterogeneity in the effects across age groups and infarction types further highlights the need for tailored healthcare strategies. Older patients appeared to benefit the most from pharmaceutical interventions. The greater benefit from pharmaceutical spending for older patients may be due to a combination of clinical, behavioural, and systemic factors. First, disease progression tends to be more advanced in older populations, increasing the marginal impact of appropriate pharmacological treatment. Medications targeting chronic conditions such as hypertension, diabetes, or heart failure may yield more pronounced improvements in health outcomes for older individuals with more severe or long-standing disease. Second, treatment protocols for older patients often emphasize pharmacological management over surgical or invasive interventions, particularly in the presence of co-morbidities. As a result, medication adherence and access to effective drug regimens become central to managing health risks in this group. Third, medication adherence may improve with age in some contexts, especially when older patients have more frequent contact with healthcare providers or caregivers who help reinforce treatment routines. Higher pharmaceutical spending may reflect greater access to or compliance with appropriate drug therapies, which can translate into better clinical outcomes. Together, these factors suggest that pharmaceutical spending may have a more direct and substantial effect on the health outcomes of older patients compared to younger populations, for whom the same level of spending may be either less necessary or less effectively absorbed. This discussion emphasizes the importance of proactive chronic disease management in elderly populations, who are more likely to face complex co-morbidities. The limited impact of outpatient spending, despite its focus on preventive care, calls for further investigation into the quality and appropriateness of these services.

Policy implications from this study are significant. Healthcare systems should prioritise investments in pre-admission care, particularly pharmaceuticals, to enhance patient outcomes while managing resource constraints. Policymakers should also consider strategies to optimize outpatient services to ensure their effectiveness. Additionally, the findings reinforce the importance of addressing the endogeneity in healthcare spending analyses, as demonstrated by the substantial differences between OLS and IV results. Overall, the study provides valuable insights into the allocation of healthcare resources and their implications for patient outcomes, particularly in the context of aging populations and rising healthcare costs. Future research should explore the long-term sustainability of these interventions and investigate their broader implications across different health care systems and population groups.

5. Conclusion

This study has highlighted the complex relationship between healthcare expenditures and patient outcomes. Although the broader literature has not yet reached a consensus on whether increased spending consistently improves health outcomes, our findings indicate that allocation of resources plays a critical role. Specifically, we find that pre-admission health care, particularly pharmaceutical spending, has a significant impact on reducing mortality rates in patients admitted for acute myocardial infarction, with a 10 % increase in pharmaceutical spending leading to a reduction in mortality by 2.9 to 3.0 percentage points. In contrast, hospital care shows a milder effect, reducing mortality by 0.6 to 0.9 percentage points, although this becomes very significant for severe forms of infarction. Finally, outpatient visits do not show a significant impact on mortality. In conclusion, achieving sustainable health care requires a careful balance and efficient allocation of spending across key categories such as hospital care, pharmaceuticals, and outpatient services. This approach is essential to providing accessible high-quality care to ageing populations while maintaining financial resilience. Beyond reallocating resources, success will depend on innovative approaches to care delivery, strengthened social support for elderly citizens, and proactive policy measures that encourage healthier lifestyles and reduce the prevalence of chronic diseases. Together, these efforts will ensure that healthcare systems remain robust, equitable, and capable of meeting the challenges of demographic change.

CRediT authorship contribution statement

Francesco Moscone: Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Software, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Elisa Tosetti:** Writing – original draft, Visualization, Supervision, Resources, Project administration, Methodology, Writing – review & editing, Validation, Software, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Giorgio Vittadini:** Validation, Software, Project administration, Formal analysis, Conceptualization, Writing – review & editing, Visualization, Investigation, Data curation, Writing – original draft, Supervision, Resources, Methodology, Funding acquisition.

Declaration of competing interest

None.

Funding

Elisa Tosetti acknowledges funding from the PRIN project n. 2022CZKPMY 002 entitled “Health and Wellbeing of the Elderly”. Francesco Moscone acknowleges funding from the Next Generation EU project entitled - “Age-It - Ageing well in an ageing society” project (PE0000015), National Recovery and Resilience Plan (NRRP) - PE8 - Mission 4, C2, Intervention 1.3.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.healthpol.2025.105483.

References

[1] Chandra A, Colla C, Skinner J. Productivity variation and input misallocation: evidence from hospitals. working paper 31569. National Bureau of Economic Research; 2023.

[2] Doyle JJ, Graves JA, Gruber J. Uncovering waste in us healthcare: evidence from ambulance referral patterns. J Health Econ 2017;54:25–39.

[3] Fisher, E., D. Goodman, J. Skinner, and K. Bronner (2009, 01). Health care spending, quality, and outcomes.

[4] Likosky D, Van Parys J, Zhou W, Borden W, Weinstein M, S JS. Association between medicare expenditure growth and mortality rates in patients with acute myocardial infarction: a comparison from 1999 through 2014. JAMA Cardiol 2018;3:114–22.

[5] Moscone F, Skinner J, Tosetti E, Yasaitis L. The association between medical care utilization and health outcomes: a spatial analysis. Reg Sci Urban Econ 2019;77: 306–14.

[6] Newhouse JP, Garber AM. Geographic variation in health care spending in the united states: insights from an institute of medicine report. JAMA 2013;310(12): 1227–8.

[7] OECD. Health at a glance 2021: oecd indicators. oecd publishing, paris: OECD Publishing; 2021. https://doi.org/10.1787/ae3016b9-en. Technical report.

[8] OECD. Fiscal sustainability of health systems. OECD Report; 2024. Technical report.

[9] Skinner, J. (2011). Chapter two - causes and consequences of regional variations in health care11this chapter was written for the handbook of health economics (vol. 2). My greatest debt is to john e. wennberg for introducing me to the study of regional variations. I am also grateful to handbook authors elliott fisher, joseph newhouse, douglas staiger, amitabh chandra, and especially mark pauly for insightful comments, and to the national institute on aging (po1 ag19783) for financial support. In M. V. Pauly, T. G. Mcguire, and P. P. Barros (editors), *Handbook of health economics*, volume 2 of *handbook of health economics*, pp. 45–93.

[10] Skinner J, Chandra A, Goodman D, Fisher E. The elusive connection between health care spending and quality. Health Aff (Millwood) 2009;28:w119–23.

[11] Skinner J, Staiger D. Technology diffusion and productivity growth in health care. Rev Econ Stat 2015;97:951–64.