CSP CADERNOS DE SAÚDE PÚBLICA
REPORTS IN PUBLIC HEALTH

ARTIGO
ARTICLE

Health expenditures and causa mortis: an investigation on municipalities of the State of Paraná, Brazil

Gastos com saúde e *causa mortis*: uma investigação dos municípios do Estado do Paraná, Brasil

Gastos en salud y causa mortis: una investigación para los municipios del Estado de Paraná, Brasil

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doi: 10.1590/0102-311XEN272421

Abstract

The Brazilian government shares the responsibility of financing public health among federal, state, and municipal levels. Health expenditures are thus uneven across the country and cannot contribute equally to health outcomes across disease categories. This study aims to identify how the health expenditures of municipalities affect the mortality rate in the state of Paraná by causa mortis. We considered years of life lost for each municipality, the chapters of the International Classification of Diseases (10th revision), and the elasticity of this measure in relation to public health expenditure. Considering the possibility of endogeneity, this study follows the instrumental variable approach in a panel of generalized method of moments – instrumental variable (GMM-IV) with fixed effects. Our results show that a 1% increase in health expenditure could decrease the average number of years lost specifically for some causes from 0.176% to 1.56% at the municipal level. These findings could elucidate policy perspective within state finance.

Healthcare Financing; Budgets; Years of Life Lost; ICD-10; Health Resources

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Introduction

According to the Grossman model [1], health is a capital that increasingly devalues with time. We are born with a health stock that inevitably decreases over time, requiring individual gross investments such as healthcare, health treatments, and healthy behaviors. Individuals who invest in their health obtain great health capital and more time for productive activities. The approach of Nixon & Ulmann [2], in turn, conceptualizes health as an outcome, as the output of a health system which is influenced by the inputs that are injected there. Both points of view consider health as a dynamic process of investment and depreciation. According to them [1,2], since Brazil relies on a public and universal healthcare system, the government would effectively be the main health investor in the country.

In 1988, the *Brazilian Constitution* created the Brazilian Unified National Health System (SUS), stating that health is a right of every citizen and a duty of the government. Universalization, equity, and comprehensiveness are the three principles that rule patient care in SUS. These responsibilities are shared among the municipalities, states, and the Federal Government [3], who, considering the shortage of public resources, must sufficiently attend to the population while minimizing costs.

Tax collected by the municipalities, states, and the federal government supports the functioning of SUS. In each of these spheres, a minimum percentage of resources is allocated to healthcare, as defined by law [4,5,6] (Federal Government: see Santos et al. [6]; States: 12%; Municipalities: 15%). The Municipality sphere manages most activities, including the basic health units (UBS), immunization initiatives, regulation and supervision of sanitation, and epidemiological surveillance, among others. As the gatekeeper of the country, SUS offers primary care services, represented by the UBS, whereas more specific needs are directed to other complexity levels of care [3]. Municipalities are therefore essential to help the population maintain their health.

Despite embracing the integral nature of healthcare, SUS does not fulfill every healthcare need equally. The equity principle aims to reduce health inequalities by taking an individualized approach to healthcare [3]. Since health funding is distributed by expenditure, i.e. primary care, pharmaceutical support, epidemiological surveillance, among others, assessing the expenditure elasticity for each healthcare need or disease is significant.

Theoretically, according to Nixon & Ullman's model, investments on healthcare could affect health outcomes. Most of the empirical research on health outcomes rely on mortality measures such as child mortality, life expectancy, or both to understand the elasticity of health expenditures [2,7,8,9,10,11,12,13]. The literature has consistently indicated these measurements as feasible proxies for the population's health status despite their limitations [2].

The literature on health elasticity is recurring. The pioneering paper of Cochrane et al. [14] identified that health expenditure elasticity affects mortality rates; however, the outcomes were counterintuitive. Using a sample of developed countries and ordinary least squares (OLS) estimation, the authors sought to find effects on mortality rates considering the expenditures, GDP per capita, demographic features, behavioral and social aspects, and the number of physicians available, among others, as control variables. However, the results indicated striking and unexpected effects: income, population density, and public health expenditures are in fact negatively related to mortality rates, but the number of physicians is positively related to mortality for some age groups. The literature exhaustively reviewed this association of mortality with health professionals, considering it as a "persistent anomaly". Those results attracted the interest of researchers, who later identified a possible endogeneity within this research issue. That is, mortality guides the efforts needed in health whilst responding to them.

In the 1980s, the studies of Gravelle & Backhouse [7] tried to correct the econometric frailties of Cochrane et al. [14], mainly attributing the presence of endogeneity to health expenditure measures. From the 1990s on, with the rise of social themes in economics, more studies indicated that other socioeconomic variables could also affect health outcomes – sometimes even more than health expenditures [13,15,16]. On the other hand, some studies found no relationship among these variables [8,10,11,16,17].

Associated with the discussion that started in the 2000s about allocative efficiency, government quality, and differences between developed and developing countries, this theme is continually adapting itself to further understand the health outcomes which health investment can effectively

achieve [17,18,19], allowing the heteroskedasticity of the error term [9,18,20,21] and separating the analysis by cause of death [13,22,23].

Brazilian studies on health expenditures are strongly related to the literature on SUS funding. Since SUS is funded by taxes, the source and availability of resources are subject to scrutiny. The discussions inquire how much of the investment contributes to the access, equity, and comprehensiveness of treatment, which are the principles of SUS [3]. Overall, criticisms are aimed at the funding model, which was based on fixed proportions defined by the Tax Liability Law [4] up until 2015, when it started to suffer the effects of the *Constitutional Amendment n. 85/2015*. This law changed the rules of funding in the federal sphere, decreasing the investments in health care and resulting in the upward trend of municipalities injecting more of their own resources while the limitation of resources incentives the privatization of health services [5,6,24,25,26,27,28,29,30,31].

The discussions on the health system also approaches the clear priority given to primary care compared to second and tertiary care [25]. The role of each level of care is examined within the principle of universality and the criticisms of its social design. As an example, Mendes & Marques [26] analyzed the Family Health Program (FHP), which is increasingly dependent on the municipality's health resources and therefore a liability for sustainable funding.

This study aimed to assess how the mortality rates in each group of diseases (according to the International Classification of Diseases, 10th revision – ICD-10) respond to the health expenditure applied by each municipality. This study considers the most recent publications on this research area, bringing theoretical and empirical novel methods of analysis [13,22,23]. To our knowledge, this is the first study to use this approach for Brazilian data, with important implications for local policymakers and policymakers from other similar developing countries. To approach the endogeneity issue, panel data was used from the GMM-IV method (generalized method of moments – instrumental variable). Data were analyzed from 2014 to 2018, collected from the Brazilian Ministry of Health [32] and from the Brazilian Information System for the Public Budgets in Health (SIOPS) [33].

In this study, we follow the regional approach, choosing the state of Paraná as a case. The state has four macroregions and is subdivided into 22 health management regions [32]. Among Brazilian states, Paraná has one of the highest life expectancy, lowest infant mortality, and lowest poverty rate [32,34], but still ranks the lowest within its region. The state's health expenditures per capita (BRL 373.73) are similar to the national average (BRL 376.85 per capita – USD 69.78, considering the exchange rate of USD 1.00 to BRL 5.40 on Nov 12, 2021), varying significantly across 399 municipalities. This indicates that other states perform better with almost the same budget and Paraná should further improve its health financing and achievement of health outcomes.

Methodology

Following Martin et al. [22,23] and Claxton et al. [12], health outcomes could be expressed from mortality rates, classified by cause of death considering the public health expenditures. Similarly to the authors who studied the British NHS (National Health Service), we analyzed a public health system funded by citizens' taxes – the SUS – using the dependent variable years of life lost (YLL) for each chapter of ICD-10.

Data were obtained from 2014 to 2018 for the 399 municipalities of the state of Paraná. In the Mortality Monitoring Panels, the Brazilian Ministry of Health [32] provides the number of deaths by location, cause of death (based on chapters of ICD-10), time, and age range. This classification groups death causes which have different mortality rates among each other. Regarding representativity, the causes of death that represented less than 1% of the total were excluded from the sample. Table 1 summarizes the occurrences and names of the classifications and the YLL for each cause.

The number of expected YLL was estimated considering the life expectancy at birth in each location as informed by the 2010 Population Census [34]. Marshall's [35] approach was used considering the population of a location i, where M deaths have occurred in a period of t years due to a particular cause j in a population of age group a; in which e is the measure of expected YLL for an individual that passes away at the age a. The number of expected YLL due to cause j in the location i and time t, summed by groups of age ranges, is then given by A_{ijt}.

Table 1

Mortality in the State of Paraná, Brazil, 2014-2018, accordign the chaprtes of the International Classification of Diseases, 10th revision (ICD-10).

ICD-10 (chapter)	Deaths		YLL (mean)	YLL (sum)
	n	%		
I. Certain infectious and parasitic diseases	11,663	3	433.27	864,381.28
II. Neoplasms	69,241	19	730.91	1,458,158.14
III. Diseases of the blood and blood-forming organs and certain disorders involving the immune mechanism	1,441	0	52.55	104,832.39
IV. Endocrine, nutritional, and metabolic diseases	21,800	6	218.96	436,825.75
V. Mental and behavioral disorders	4,064	1	68.58	136,822.37
VI. Diseases of the nervous system	13,156	4	96.22	191,965.02
VII. Diseases of the eye and adnexa	0	0	0.00	0.00
VIII. Diseases of the ear and mastoid process	34	0	172.00	343,139.62
IX. Diseases of the circulatory system	102,624	28	727.63	1,451,612.77
X. Diseases of the respiratory system	43,720	12	301.01	600,509.99
XI. Diseases of the digestive system	19,412	5	160.95	321,092.73
XII. Diseases of the skin and subcutaneous tissue	793	0	9.09	18,128.37
XIII. Diseases of the musculoskeletal system and connective tissue	1,617	0	29.00	57,849.54
XIV. Diseases of the genitourinary system	8,909	2	58.11	115,927.75
XV. Pregnancy, childbirth, and the puerperium	393	0	43.61	86,997.24
XVI. Certain conditions originating in the perinatal period	4,926	1	172.22	343,574.97
XVII. Congenital malformations, deformations, and chromosomal abnormalities	3,084	1	109.73	218,905.33
XVIII. Symptoms, signs, and abnormal clinical and laboratory findings, not elsewhere classified	10,799	3	258.71	516,123.69
XIX. Injury, poisoning, and certain other consequences of external causes	0	0	0.00	0.00
XX. External causes of morbidity and mortality	43,518	12	574.44	1,146,012.90
Total	361,194	100	4,216.97	8,412,859.85

YLL: years of life lost.

Source: prepared by the authors based on data from the Brazilian Health Informatics Department (DATASUS) [32].

$$A_{ijt} = \sum_{a} e_a M_{ajit}$$

The empirical findings on this subject indicate a possible reverse causality between health expenditures and health outcomes such as life expectancy or YLL, resulting in endogeneity. According to Grossman [1] and Nixon & Ullman [2], if a public health system helps reduce the burden of the diseases in a locality, more resources should be applied in this system to reduce YLL to these illnesses. However, health outcomes would also affect the direction of the resources in a particular area; that is, they affect and are affected by health expenditures. Instrumental variables were thus used while acknowledging the possibility of endogeneity between these two variables.

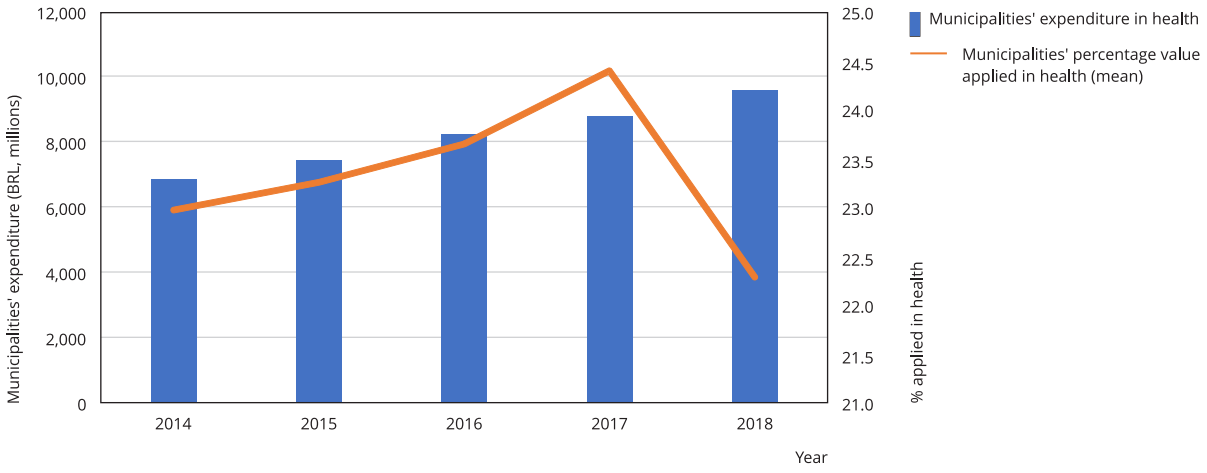
The dataset is constructed in the form of panel data, where constant non-observable or non-available characteristics are captured using fixed effects by locality.

According to the Tax Liability Law [4], every Brazilian municipality must apply 15% of collected taxes on healthcare. Considering the recent trend of increased municipality funding in health activities [6,25,26], municipalities have engaged in operational responsibilities and are using more of their own resources besides the mandatory 15%. Figure 1 shows municipalities' expenditures on the left axis and the amount applied in health care in 2014-2018 on the right. Health expenditure steadily increased for the whole period while the percentage applied dropped from 2017 onwards.

The data show that in 99.7% of all the annual investments within the considered period, municipalities of Paraná applied variable portions above 15% on healthcare. The variances of the percentage

Figure 1

Municipalities' health expenditures and % applied in health (2014-2018).



Source: prepared by the authors based on information from Brazilian Information System for the Public Budgets in Health (SIOPS) [33].

applied and its deviation are close to 21 whereas the standard deviations are around 4.5%, showing that the investments of the municipalities vary considerably. As a result, the percentages applied and their deviation from the minimum required express a proxy of the healthcare needs considered essential by the government of each municipality.

Andrews et al. [36] and Claxton et al. [12] have previously used, in the United Kingdom, funding rules that determine the volume of resources each geographical area receives. The authors argue that these rules alone can influence the expenditures but not mortality rates. In Brazil, the revenue of municipalities is a complex combination of resources including taxes and transfers from other sources, such as the federal and state governments. Our parallel instrument would thus be the percentage applied in health and the deviation from the minimum stipulated by law, which are also possibly related to expenditure but not to mortality.

If the instrument was related to municipality revenue, it could result in endogeneity. However, since the linear correlation between the two variables is low (0.0033), these variables may be considered exogenous, kept as candidates for instrumental variables, and submitted to the appropriate tests.

Some studies [9,18,20,21] have indicated that the method of two-stage least squares (2SLS) with instrumental variables leads to biased results in the presence of heteroskedasticity [37]. We therefore tested the presence of heteroskedasticity in our estimations to verify this problem. Using the Pagan-Hall test, all causes of death returned heteroskedastic errors when regressed with our 2SLS instrumental variable method. We thus chose the GMM-IV method, robust for heteroskedasticity.

To control variables that may be indicators of the supply of health services and human capital, vaccinal coverage [19] and the number of health professionals for each 10,000 inhabitants were considered as proxies for SUS attendance in municipalities. The literature on the persistent anomaly [7] shows that the mortality-expenditure relationship could be affected by the number of health workers and lead to endogeneity. In Brazil, the expenditure of salaries and personnel costs might also be a large part of health expenditures, but the SIOPS data did not display those costs separately. The variable of health professionals was thus maintained as a control considering that if human capital leads to endogeneity, this variable must be significant. This information was obtained from the Brazilian Ministry of Health [32].

To consider development variation among the municipalities, the included explanatory variables were demographic density, the gross value (GV) of agriculture, industry, services, public administra-

tion, and GDP per capita. The population variable was obtained from the 2010 Population Census [34] estimations for 2014-2018. We tried to consider differences in education that may be related to health outcomes according to the literature [10,18,19,20]. The IDEB (Basic Education Development Index) score was used as a proxy for education outcomes by municipality.

Moreover, a dummy variable was included from 2016 onwards for two reasons. Firstly, this period comprises the possible effects of the *Constitutional Amendment n. 85/2015* on the health funding of municipalities. Secondly, since a general election for mayors occurred in 2016, the changes in public expenditure and political scenarios could have affected our analysis.

Formally, the model is estimated using fixed effects, with every variable in logarithmic form:

$$A_{itj} = G_{it} + X_{it} + d_t + t$$

Where: A_{ij} are the YLL in year t, municipality i, and cause of death j, while G_{it} is the health expenditure of the municipality i, X_{it} is a vector of covariates, d_t is our dummy from 2016 onwards, and t is a time trend.

To test the validity of the instruments, the estimations were submitted to underidentification tests, weak instruments tests, and overidentification tests (respectively Kleibergen-Paap rk LM, Kleibergen-Paap rk Wald F, and Hansen J). In every estimation, the outputs were within the values that allow accepting both instruments (expenditure percentage of tax collection and the difference to the minimum). The output of the tests is available under request. Furthermore, each estimation was submitted to the Hausman test for endogeneity robust to heteroskedasticity. The health expenditures were considered endogenous to mortality for some diseases.

Results

Overall, the results suggest significant and negative elasticities, indicating that health investments can reduce the mortality rates of some diseases. In turn, population density was almost unanimously positively related to mortality and YLL but significant only in some specifications – possibly because of its association with urbanization, industrialization, and population growth. These phenomena are also related to higher exposure to pollution, lack of access to sanitation, and other factors which may be negatively affecting mortality rates.

The results of immunization efforts may seem contradictory: in most cases, better vaccine coverage seems to increase mortality rates instead of decreasing them. However, using ICD chapters directly related to immunization (i.e., those which contains diseases preventable by vaccines), the relation between vaccine coverage and mortality is negative, as expected, and more significant with higher magnitudes, indicating the fitness of the model. The number of health professionals variable was not statistically significant in any specification.

Variables aimed at measuring the degree of development conditions and education were not considered significant in the model. We hypothesized that, in the short term, their variation might not directly affect health outcomes. The gross value of public administration, however, was found significant and had high coefficients in many specifications.

Interestingly, the dummy variable for 2016 onwards showed different patterns among the causes of death, being negatively related to YLL in most cases. This could indicate that, overall, health investments were relatively more effective for some diseases during this period.

Tables 2 and 3 present results by ICD-10 chapters. The analysis for Diseases of the blood (Chapter III), Mental and behavioral disorders (Chapter V), Diseases of the nervous system (Chapter VI), Diseases of the circulatory system (Chapter IX), Diseases of the respiratory system (Chapter X), Diseases of the skin and subcutaneous tissue (Chapter XII), Diseases of the genitourinary system (Chapter XIV), Pregnancy, childbirth and the puerperium (Chapter XV), Symptoms, signs and abnormal clinical and laboratory findings (Chapter XVIII), and External causes of morbidity and mortality (Chapter XX) were not found endogenous and are statistically insignificant. These analyses therefore were not analyzed in the text.

The results for the remaining causa mortis are detailed as follows.

Table 2

Results according the International Classification of Diseases, 10th revision (ICD-10) – chapters I to X.

Variables	ICD-10 chapter								
	I	II	III	IV	V	VI	VIII	IX	X
logdesp	-0.176 *	-0.520 **	-0.108	-0.234 *	-0.172	-0.0763 ***	-0.00795	-0.0470	-0.0424 ***
	(0.0849)	(0.147)	(0.0686)	(0.106)	(0.135)	(0.0395)	(0.0182)	(0.108)	(0.0251)
logdens	0.119 ***	0.537 *	0.0411	0.216	0.0257	0.0177	0.0264	0.147 ***	0.00770
	(0.0608)	(0.216)	(0.0669)	(0.132)	(0.143)	(0.0368)	(0.0237)	(0.0846)	(0.0229)
logimuni	0.00169	-0.065 **	0.0236 ***	0.0412 ***	-0.0445 ***	0.00888	-0.00267	-0.0128	-0.00268
	(0.0138)	(0.0206)	(0.0132)	(0.0219)	(0.0227)	(0.0101)	(0.0112)	(0.0141)	(0.00740)
logprofi	0.0143	-0.0119	-0.0392	-0.0237	0.0514	-0.00417	0.00484	-0.0192	-0.00833
	(0.0484)	(0.0561)	(0.0300)	(0.0434)	(0.0560)	(0.0184)	(0.0156)	(0.0334)	(0.0121)
GV_A	-0.00699	0.0917	-0.0730 *	-0.0357	-0.0293	-0.0509	-0.0515 *	0.0141	0.00658
	(0.0330)	(0.0563)	(0.0332)	(0.0443)	(0.0544)	(0.0316)	(0.0235)	(0.0334)	(0.0137)
GV_I	0.0215	0.0342	-0.0143	-0.0263	0.0187	-0.0151	-0.0145 ***	-0.000225	0.00755
	(0.0198)	(0.0384)	(0.0149)	(0.0251)	(0.0312)	(0.0107)	(0.00798)	(0.0216)	(0.00733)
GV_S	-0.00596	-0.0281	-0.0295	-0.0226	0.0677	-0.0288	-0.0345 ***	-0.0546	-0.00366
	(0.0374)	(0.0846)	(0.0362)	(0.0561)	(0.0823)	(0.0246)	(0.0204)	(0.0423)	(0.0129)
GV_pub	-0.174 *	-0.855 **	-0.0293	0.0365	-0.0456	0.0172	0.0230	-0.195 *	-0.0218
	(0.0817)	(0.165)	(0.0772)	(0.123)	(0.144)	(0.0590)	(0.0375)	(0.0860)	(0.0296)
GDP_pc	0.0454	-0.193	0.0918	0.0984	-0.0495	0.124 ***	0.105 ***	0.0852	-0.0226
	(0.0728)	(0.153)	(0.0777)	(0.106)	(0.138)	(0.0718)	(0.0539)	(0.0770)	(0.0428)
ideb	-6.37e-05	-0.000427	-0.000106	0.000661	-0.000879	-0.000220	-0.000262	0.000904	-0.000103
	(0.00055)	(0.00208)	(0.00040)	(0.00072)	(0.00078)	(0.00037)	(0.00025)	(0.00064)	(0.00015)
2016_on	0.0167	-0.0708 *	0.0216	-0.0359	-0.00314	0.00918	-0.00387	-0.0327 *	0.0111
	(0.0190)	(0.0282)	(0.0144)	(0.0229)	(0.0261)	(0.0140)	(0.00812)	(0.0160)	(0.0117)
t_id	0.024 **	0.190 **	0.00840	0.032 **	0.0152	-0.00136	-0.000766	0.032 **	0.00340
	(0.00779)	(0.0153)	(0.00769)	(0.0115)	(0.0152)	(0.00562)	(0.00268)	(0.0111)	(0.00302)
Observations	1,990	1,990	1,990	1,990	1,990	1,990	1,990	1,990	1,990
Municipalities	399	399	399	399	399	399	399	399	399
R-squared	-0.087	-0.033	-0.031	-0.064	-0.008	-0.030	0.006	0.013	-0.004

2016_on: dummy for years 2016 on; GDP_pc: Gross Domestic Product per capita; GV_A: Gross Value – agriculture; GV_I: Gross Value – industry; GV_pub: Gross Value – public administration; GV_S: Gross Value – services; logdens: log of demographic density; logdesp: log of health expenditures; logimuni: log of immunization coverage (%); logprofi: log of health professionals per capita; ideb: IDEB score (Basic Education Development Index); t_id: time trend.
Note: robust standard errors in parentheses.
* p < 0.05;
** p < 0.01;
*** p < 0.1.

Certain infectious and parasitic diseases (Chapter I)

About 38% of deaths in this chapter were caused by bacterial diseases and 25% were caused by HIV [32]. Expenditure was found endogenous to mortality and its elasticity was negative and significant at around -0.176. This implies that for every 1% increase in health expenditure YLL are expected to decrease in 0.176% for this cause of death. Population density was significant only at 10% while immunization and health professionals were not statistically significant. The gross value of public administration is highly significant at 1% significance.

Table 3

Results according the International Classification of Diseases, 10th revision (ICD-10) – chapters XI to XX.

Variables	ICD-10 chapter								
	XI	XII	XIII	XIV	XV	XVI	XVII	XVIII	XX
logdesp	-0.272 *	-0.0686 **	0.0545	-0.0487 **	-0.164	-1.563 ***	-0.702 ***	0.0825	-0.0600
	(0.105)	(0.0354)	(0.0504)	(0.0271)	(0.263)	(0.618)	(0.275)	(0.0846)	(0.178)
logdens	0.0850	0.121	-0.0220	-0.00695	0.573	1.338 **	0.617 **	-0.0281	0.0702
	(0.134)	(0.0854)	(0.0317)	(0.0353)	(0.357)	(0.734)	(0.321)	(0.0729)	(0.149)
logimuni	-0.00742	0.00380	-0.00870	0.000518	-0.0128	-0.577 *	-0.0540	0.00146	-0.0307
	(0.0164)	(0.00772)	(0.00655)	(0.00782)	(0.0510)	(0.101)	(0.0370)	(0.0152)	(0.0330)
logprofi	-0.0608	-0.00575	0.00320	-0.00648	0.107	0.372	0.0705	-0.00428	-0.0895
	(0.0437)	(0.0123)	(0.00592)	(0.0106)	(0.109)	(0.237)	(0.0959)	(0.0314)	(0.0685)
GV_A	0.0130	-0.0563 ***	0.0498	-0.0226	0.0393	0.424 **	0.133	0.0818 ***	0.0120
	(0.0388)	(0.0245)	(0.0401)	(0.0271)	(0.145)	(0.234)	(0.0954)	(0.0377)	(0.0606)
GV_I	0.0258	-0.0179 ***	0.0115	-0.00651	0.0341	-0.105	0.0811	0.0182	0.00444
	(0.0239)	(0.00825)	(0.00966)	(0.00794)	(0.0643)	(0.152)	(0.0596)	(0.0195)	(0.0545)
GV_S	-0.0963 **	-0.0194	0.0329	-0.0226	0.221	0.251	-0.0402	0.0586	-0.00896
	(0.0545)	(0.0196)	(0.0268)	(0.0172)	(0.209)	(0.342)	(0.141)	(0.0371)	(0.114)
GV_pub	-0.251 ***	-0.00346	-0.0283	0.0982 ***	-0.261	-4.148 *	-1.259 *	-0.117	-0.490 ***
	(0.109)	(0.0495)	(0.0638)	(0.0426)	(0.276)	(0.651)	(0.268)	(0.0855)	(0.229)
GDP_pc	0.104	0.117 ***	-0.125	0.0933	-0.414	-0.236	-0.0543	-0.147 ***	0.00902
	(0.0957)	(0.0574)	(0.101)	(0.0611)	(0.335)	(0.619)	(0.252)	(0.0740)	(0.165)
ideb	0.00166	5.16e-05	2.30e-05	1.82e-05	0.000577	-0.00407	0.00116	0.000378	0.00449
	(0.00186)	(0.00016)	(0.00011)	(0.00019)	(0.00155)	(0.00980)	(0.00268)	(0.00036)	(0.00503)
2016_on	-0.0294	0.00908	0.000106	-0.0212 **	-0.0118	0.625 *	-0.0935 ***	-0.0203	0.0265
	(0.0192)	(0.0102)	(0.00576)	(0.0119)	(0.0576)	(0.123)	(0.0445)	(0.0138)	(0.0400)
t_id	0.059 *	-0.000378	0.00203	-0.00244	0.0520 **	0.381 *	0.234 *	0.0144 **	0.0437 ***
	(0.0113)	(0.00472)	(0.00391)	(0.00451)	(0.0291)	(0.0641)	(0.0281)	(0.00797)	(0.0190)
Observstions	1,990	1,990	1,990	1,990	1,990	1,990	1,990	1,990	1,990
Municipalities	399	399	399	399	399	399	399	399	399
R-squared	-0.107	-0.026	-0.009	0.001	-0.000	0.007	-0.056	0.000	0.007

2016_on: dummy for years 2016 on; GDP_pc: Gross Domestic Product per capita; GV_A: Gross Value – agriculture; GV_I: Gross Value – industry; GV_pub: Gross Value – public administration; GV_S: Gross Value – services; logdens: log of demographic density; logdesp: log of health expenditures; logimuni: log of immunization coverage (%); logprofi: log of health professionals per capita; ideb: IDEB score (Basic Education Development Index); t_id: time trend.

Note: robust standard errors in parentheses.

* p < 0.01;

** p < 0.1;

*** p < 0.05.

Neoplasms (Chapter II)

Almost all (98%) deaths from neoplasms are caused by localized malignant tumors [32]. Expenditure was found endogenous to mortality and its elasticity was negative and significant at around -0.520. This implies that for each 1% increase in health expenditures, YLL are expected to decrease in 0.520% for this cause of death. Population density was positively related to mortality at a 5% level of statistical significance. Immunization showed a statistically significant and negative coefficient, but with no obvious reasons. The dummy variable for 2016 was found negatively related to YLL for this cause of death. The number of health professionals and GDP are not significant in this setting. GV of the public administration was found to be negative and statistically significant.

Endocrine, nutritional, and metabolic diseases (Chapter IV)

More than 80% of the victims of this ICD-10 chapter were diagnosed with diabetes mellitus [32]. Expenditure was found endogenous to mortality and its elasticity was negative and significant around -0.234 at the 5% level. This implies that for each 1% increase in health expenditures, YLL to this cause of death are expected to decrease in 0.234%. Population density was not significant in this setting. This could be positively related to mortality since diabetes is prevalent in more industrialized or urbanized regions [38]. Other variables considered proxies for regional development – such as GDP or GV of services/industry/public administration – and immunization were also not significant.

Diseases of the digestive system (Chapter XI)

The victims of this ICD-10 chapter were, in 75% of the cases, patients with diseases of the liver, gallbladder, pancreas, or intestine [32]. Expenditure found endogenous and significant, with an elasticity of -0.272. This implies that for each 1% increase in health expenditures, YLL due to this cause of death are expected to decrease in 0.272%. Both immunization and the number of health professionals are not statistically significant. GV of public investment was statistically significant and negatively related to this cause of death at the 5% level of significance.

Certain conditions originating in the perinatal period (Chapter XVI)

In 51% of the cases, the victims of this condition underwent complications of pregnancy and delivery [32]. Expenditure was found endogenous to mortality and significant, reaching an elasticity of -1.563 to 1% of significance. That is, for each 1% increase in health expenditure, YLL to this cause of death are expected to decrease in 1.563%. Immunization was significant at the 1% level and negative around -0.577. Although this result cannot be verified directly from the database used, it may be related to the application of BCG and hepatitis B vaccines, which must be applied in infants within the first month of their life. GV of public administration was found statistically significant, having a negative relationship with our dependent variable, while our dummy variable for 2016 was significant and positive. This positive relationship is an exception, suggesting that the changes in public funding and political environment that occurred in 2016 onwards somehow positively affected the numbers of this ICD-10 chapter. The coefficient of health professionals was not statistically significant for this cause of death.

Congenital malformations, deformations, and chromosomal abnormalities (Chapter XVII)

Out of the victims of this chapter, 52% are patients with malformations in the circulatory or nervous systems [32]. Expenditure was found endogenous and significant at 1%, with a negative coefficient of -0.702. This implies that for each 1% increase in health expenditure, YLL due to this cause of death are expected to decrease in 0.702%. This result may be surprising at first since many malformations are fatal and cannot be mitigated by the health system. However, since 1993, the European community has classified the mortality of this chapter as deaths preventable by the health system via surgery and medication [39]. The health professionals and immunization variables had no statistically significant coefficients. GV of public administration was significant and negatively related to YLL. Our dummy for 2016 was found statistically significant at 5%, being negatively related to our dependent variable.

Discussion and conclusion

The studies by Martin et al. [22,23] and Claxton et al. [12] used data on specific health expenditures per health care program, that is, the financing earmarked for that disease or group of diseases. This study did not use this approach due to data unavailability. Health expenditure aggregates all expenses recorded for health at SIOPS, including elements of the intensive margin (such as the payment for surgeries and treatments) and the extensive margin (such as the performance of health surveillance). Our results may also differ from the international literature for several other reasons. As an example,

our data allowed estimating expenditure with different controls and our dependent variable was estimated by age ranges and not by the exact age of death. Moreover, we used a specific life expectancy for each municipality based on the 2010 Population Census while the international literature fixed life expectancy at 75 years. Life expectancy surpasses this age only in 30% of Paraná's municipalities, which may affect result interpretation. Finally, international literature used standardized mortality rates for their population. Considering these limitations, Box 1 summarizes the comparison between our results and the researched literature.

Some of our results corroborate those found in the British literature for cancer, diabetes, neurological diseases, and gastrointestinal diseases, but our coefficients are considerably different in magnitude. The most diverse results concern cardiovascular diseases, which were not significant in this analysis despite the previous evidence from other countries. Moreover, respiratory diseases were not significant for expenditure despite the impact of immunization. This group was found to be negatively elastic with expenditure and significant in Claxton et al. [12]. In Martin et al. [22,23], the same diseases were also found negatively related and significant, but since they did not pass the test of weak instruments, the authors recommended caution in using this estimate.

To our knowledge, Martin et al. [23] is the only other study in the literature which also mentions the analysis of diseases of the genitourinary system. The authors, however, did not report the analysis results since they considered them contradictory and counterintuitive. Since we found no significance for this ICD-10 chapter, overall, this classification may not react as expected to health expenditure.

Comparison of the other variables used in the model is less direct since most studies which adopted the fixed-effects panel regression conducted investigations between countries and therefore adopted different variables [2,17,18,20]. Regarding provincial data [9], the lag of time was greater in our study. In Bilgel & Tran [21], the dynamic panel considers lags of time not directly comparable with our results. Martin et al. [22,23] and Claxton et al. [12] do not use other control variables for British provinces.

Regarding human capital proxy, the number of health professionals was not significant in any of our specifications, indicating that the persistent anomaly presented by Cochrane et al. [14] may not occur for the state of Paraná.

The elasticity of public health expenditure for each cause reaches a magnitude below one, which is expected considering the context of whole-budget elasticities instead of by-program. That is, for per cent increases in health expenditures, the accompanying per cent decreases in YLL are proportion-

Box 1

Comparison between our results and the international literature.

DISEASE	THIS STUDY	MARTIN ET AL. [22]	MARTIN ET AL. [23]	CLAXTON ET AL. [12]
Cancer	Significant and negative (-0.520)	Significant and negative (-0.378)	Significant and negative (-0.393)	Significant and negative (-0.282)
Diabetes	Significant and negative (-0.234)	N/C	Significant and negative (-1.427)	N/C
Neurological diseases	Not significant	N/C	Not Significant	N/C
Cardiovascular diseases	Not significant	Significant and negative (-1.427)	Significant and negative (-1.585)	Significant and negative (-2.450)
Respiratory diseases	Not significant	N/C	Significant and negative, with caveats	Significant and negative (-2.194)
Gastrointestinal diseases	Significant and negative (-0.272)	N/C	Significant and negative (-2.018)	Significant and negative (-2.888)
Genitourinary diseases	Not significant	N/C	Contradictory results	N/C

N/C: not considered in this work.

Source: prepared by the authors.

ally lower. Among causes of death, the conditions originating in the perinatal period stand out. In this setting, elasticity above one indicates that the YLL for this cause is elastic and improvements in health expenditure may decrease the average YLL proportionally more. This information is significant to improve public policies related to the care of mothers and infants. However, this cause of mortality represents only 1% of deaths in Paraná in the analyzed period.

Neoplasms are the second most elastic death, in which YLL decrease in 0.502% for every 1% increase in expenditure in a municipality. They cause 19% of deaths in Paraná, indicating a potential to offer better treatment to numerous patients and thus effectively extend longevity.

Our results indicate reformulating funding by budget programs which allocate funding by diseases or group of diseases could offer better adjust each need according to each elasticity.

In fact, chronic diseases that increase mortality (i.e., cancer, diabetes) respond well to health expenditure. As expected, the same care, however, is not effective with chronic incurable diseases with historic lower mortality, such as neurological diseases, which do not achieve a similar result to other diseases despite relying on palliative care.

Death caused by cardiovascular diseases, the major cause of death, was not considered elastic to health expenditure. This result indicates at least two perspectives. On one hand, this suggests that patients affected by a heart attack or stroke could inevitably die despite medical care. In turn, it indicates that the population suffering from this these diseases may not be receiving or seeking adequate medical treatment in time or before the attack occurs. Unfortunately, the data available do not allow further assessment in this regard.

Overall, acute and deadly conditions such as violence, suicide, disorders caused by psychoactive substances, and death from undefined causes are not statistically significant relationship to health expenditure. This result indicates how the health system often cannot achieve comprehensive needs since, in many cases, nothing can be done.

This study has several limitations. Considering that life expectancy cannot increase unlimitedly, it may be associated with diminishing marginal returns. Unfortunately, due to multicollinearity in the endogenous variable, a square coefficient could not be tested for health expenditures. Another limitation is the absence of individual-level data for our population since many other factors, such as health behavior, may have influenced mortality rates.

Some diseases which can be treated and mitigated by the health system showed relevant results. Further studies should contribute to expand information to promote equity in health considering this evidence on how SUS financing has affected health outcomes.

Contributors

T. K. Feldens and K. B. Souza conceptualized the study and contributed to the literature search. T. K. Feldens compiled and analyzed data, produced the figures and tables, and wrote the original draft of the manuscript. K. B. Souza provided statistical guidance and input on the analysis and edited early drafts of the manuscript. All authors contributed to subsequent drafts of the manuscript, provided critical interpretation of the results, and approved the manuscript for publication.

Additional informations

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Conflict of interests

None.

References

1. Grossman M. On the concept of health capital and the demand. J Polit Econ 1972; 80:223-55.
2. Nixon J, Ulmann P. The relationship between healthcare expenditure and health outcomes: evidence and caveats for a causal link. Eur J Health Econ 2006; 7:7-18.
3. Brasil. Lei nº 8.080, de 19 de setembro de 1990. Dispõe sobre as condições para a promoção, proteção e recuperação da saúde, a organização e o funcionamento dos serviços correspondentes e dá outras providências. Diário Oficial da União 1990; 20 sep.
4. Brasil. Lei complementar nº 101, de 4 de maio de 2000. Estabelece normas de finanças públicas voltadas para a responsabilidade na gestão fiscal e dá outras providências. Diário Oficial da União 2000; 5 may.
5. Carvalho M, Paulus Júnior A, Cordoni Jr. L. Financiamento público da saúde pelo governo do Estado do Paraná, Brasil, 1991-2006. Cad Saúde Pública 2008; 24:2532-40.
6. Santos AO, Delduque MC, Alves SMC. Os três poderes do Estado e o financiamento do SUS: o ano de 2015. Cad Saúde Pública 2016; 32:e00194815.
7. Gravelle H, Backhouse M. International cross-section analysis of the determination of mortality. Soc Sci Med 1987; 25:424-41.
8. Hitiris T, Posnett J. The determinants and effects of health expenditure in developed countries. J Health Econ 1992; 11:173-81.
9. Crémieux P, Ouelette P, Pilon C. Health care spending as determinants of health outcomes. Health Econ 1999; 8:627-39.
10. Filmer D, Pritchett L. The impact of public spending on health: does money matter? Soc Sci Med 1999; 49:1309-23.
11. Gallet C, Doucoliagos H. The impact of healthcare spending on health outcomes: a meta-regression analysis. Soc Sci Med 2017; 179:9-17.
12. Claxton K, Lomas J, Martin S. The impact of NHS expenditure on health outcomes in England: alternative approaches to identification in all-cause and disease specific models of mortality. Health Econ 2018; 27:1017-23.
13. Martini CJ, Allan GH, Davison J, Backett EM. Health indexes sensitive to medical care variation. Int J Health Serv 1977; 7:293-9.
14. Cochrane AL, St Leger AS, Moore F. Health service 'input' and mortality 'output' in developed countries. J Epidemiol Community Health 1978; 32:200-5.
15. Mackenbach J, Bouvier-Colle M, Jougla E. "Avoidable" mortality and health services: a review of aggregate data studies. J Epidemiol Community Health 1990; 44:106-11.
16. Babazono A, Hillman A. A comparison of international health outcomes and health care spending. Int J Technol Assess Health Care 1994; 10:376-81.
17. Berger M, Messer J. Public financing of health expenditures, insurance, and health outcomes. Appl Econ 2002; 34:2105-13.
18. Farag M, Nandakumar A, Wallack S, Hodgkin D, Gaumer G, Erbil C. Health expenditures, health outcomes and the role of good governance. Int J Health Care Finance Econ 2013; 13:33-52.
19. Makuta I, O'Hare B. Quality of governance, public spending on health and health status in Sub Saharan Africa: a panel data regression analysis. BMC Public Health 2015; 15:932.
20. Bokhari F, Gai Y, Gottret P. Government health expenditures and health outcomes. Health Econ 2007; 16:257-73.
21. Bilgel F, Tran K. The determinants of Canadian provincial health expenditures: evidence from a dynamic panel. Appl Econ 2013; 45:201-12.
22. Martin S, Rice N, Smith P. Does health care spending improve health outcomes? Evidence from English programme budgeting data. J Health Econ 2008; 27:826-42.
23. Martin S, Rice N, Smith P. Comparing costs and outcomes across programmes of health care. Health Econ 2012; 21:316-37.
24. Cordeiro HA. Descentralização, universalidade e equidade nas reformas de saúde. Ciênc Saúde Colet 2001; 6:319-28.
25. Marques R, Mendes A. A política de incentivos do Ministério da Saúde para a atenção básica: uma ameaça à autonomia dos gestores municipais e ao princípio da integralidade? Cad Saúde Pública 2002; 18:163-71.
26. Mendes A, Marques R. O financiamento da atenção básica e da Estratégia Saúde da Família no Sistema Único de Saúde. Saúde Debate 2014; 38:900-16.
27. Medeiros K. Lei de Responsabilidade Fiscal e despesas com pessoal da saúde: um estudo dos municípios brasileiros [Doctoral Dissertation]. Recife: Centro de Pesquisas Aggeu Magalhães, Fundação Oswaldo Cruz; 2011.
28. Leite V, Lima K, Vasconcelos C. Financiamento, gasto público e gestão dos recursos em saúde: o cenário de um estado brasileiro. Ciênc Saúde Colet 2012; 17:1849-56.
29. Marques R, Mendes A. A problemática do financiamento da saúde pública brasileira: de 1985 a 2008. Economia e Sociedade 2012; 21:345-62.
30. Mendes A, Weiler J. Renúncia fiscal (gasto tributário) em saúde: repercussões sobre o financiamento do SUS. Saúde Debate 2015; 39:491-505.
31. Araújo C, Gonçalves G, Machado J. Os municípios brasileiros e os gastos próprios com saúde: algumas associações. Ciênc Saúde Colet 2017; 22:953-63.
32. Departamento de Informática do SUS. Informações de saúde. http://www2.datasus.gov.br/DATASUS/index.php?area=0205&id=6937 (accessed on 20/Jun/2020).
33. Sistema de Informações sobre Orçamentos Públicos em Saúde. Consulta de despesa por fonte e RP. http://siops.datasus.gov.br/consdespfonterpuf.php (accessed on 20/Jun/2020).

34. Instituto Brasileiro de Geografia e Estatística. Censo Demográfico de 2010. Rio de Janeiro: Instituto Brasileiro de Geografia e Estatística; 2012.
35. Marshall R. Standard expected years of life lost as a measure of disease burden: an investigation of its presentation, meaning and interpretation. In: Preedy V, Watson R, editors. Handbook of disease burdens and quality of life measures. New York: Springer; 2010. p. 401-13.
36. Andrews M, Elamin O, Hall AR, Kyriakoulis K, Sutton M. Inference in the presence of redundant moment conditions and the impact of government health expenditure on health outcomes in England. Econom Rev 2017; 36:23-41.
37. Baum C, Schaffer M, Stillman M. Instrumental variables and GMM: estimation and testing. Stata J 2003; 3:1-31.
38. Franco LJ, Ferreira SRG. Epidemiology of diabetes mellitus in Latin America. In: Ekoé J, Rewers M, Williams R, Zimmet P, editors. The epidemiology of diabetes mellitus. Chichester: John Wiley and Sons; 2008. p. 147-62.
39. Nolte E, McKee M. Does health care save lives? Avoidable mortality revisited. London: The Nuttfield Trust; 2004.

Resumo

O financiamento da saúde pública é uma responsabilidade compartilhada entre as três esferas governamentais brasileiras, i.e., a federal, estadual e municipal. Logo, gastos divergem pelo território e não se poderia esperar que contribuíssem de forma homogênea para os desfechos de saúde em todos os tipos de doença. Este artigo busca identificar como gastos municipais afetam a taxa de mortalidade no Estado do Paraná dado sua causa mortis*. Consideramos anos de vida perdidos para cada município, os capítulos da Classificação Internacional de Doenças (10ª revisão) e estimamos a elasticidade dessa medida em relação aos gastos públicos em saúde. Considerando uma possível endogeneidade, este artigo segue a abordagem variável instrumental em um painel de método generalizado de momentos (GMM-IV) com efeitos fixos. Nossos resultados mostram que um aumento de 1% nos gastos municipais com saúde pode diminuir o número médio de anos perdidos entre 0,176% e 1,56% para algumas causas especificas de mortalidade. Nosso estudo pode lançar alguma luz sobre a perspectiva política das finanças dos estados.*

Financiamento da Assistência à Saúde; Orçamentos; Anos de Vida Perdidos; CID-10; Recursos em Saúde

Resumen

La financiación de la salud pública es una responsabilidad compartida entre las tres esferas del gobierno brasileño, a nivel federal, estatal y municipal. En este sentido, los gastos son desiguales en el territorio, y no se puede esperar que contribuyan de forma homogénea a los resultados de salud en las distintas categorías de enfermedades. La función de este trabajo es identificar cómo los gastos de los municipios afectan a la tasa de mortalidad en el Estado de Paraná, por causa mortis. Se consideraron los años de vida perdidos para cada municipio, los capítulos de la Clasificación Internacional de Enfermedades (10ª revisión), y se estimó la elasticidad de esta medida en relación con el gasto sanitario público. Teniendo en cuenta la posibilidad de endogeneidad, este trabajo sigue el enfoque de variables instrumentales en un panel de los método generalizado de momentos (GMM-IV) con efectos fijos. Nuestros resultados muestran que un aumento del 1% en el gasto sanitario puede disminuir el número medio de años perdidos específicamente por algunas causas del 0,176% al 1,56%, a nivel municipal. Esto puede arrojar algo de luz sobre la perspectiva política dentro de las finanzas de los estados.

Financiación de la Atención de la Salud; Presupuestos; Años de Vida Perdidos; CIE-10; Recursos en Salud

Submitted on 22/Nov/2021
Final version resbumitted on 11/Apr/2022
Approved on 16/May/2022