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Association between Economic Growth, Mortality, and Healthcare Spending in 31 High-Income Countries

https://doi.org/10.1515/fhep-2021-0035
Received June 28, 2021; accepted October 3, 2022

Abstract: This study aims to investigate the association between gross domestic product (GDP), mortality rate (MR) and current healthcare expenditure (CHE) in 31 high-income countries. We used panel data from 2000 to 2017 collected from WHO and OECD databases. The association between CHE, GDP and MR was investigated through a random-effects model. To control for reverse causality, we adopted a test of Granger causality. The model shows that the MR has a statistically significant and negative effect on CHE and that an increase in GDP is associated with an increase of CHE ($p < 0.001$). The Granger causality analysis shows that all the variables exhibit a bidirectional causality. We found a two-way relationship between GDP and CHE. Our analysis highlights the economic multiplier effect of CHE. In the debate on the optimal allocation of resources, this evidence should be taken into due consideration.

Keywords: health spending, healthcare expenditure, mortality, GDP, high-income countries

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1 Introduction

Western countries' socio-economic growth led to a continuous increase in populations' health in the last centuries (Hitiris and Posnett 1992; Heijink, Koolman, and Westert 2013; Ray and Linden 2020). During the last decades, countries' healthcare spending has grown continuously, becoming a major expenditure item, and threatening the overall sustainability of healthcare systems (Ortiz-Ospina and Roser 2017; OECD Statistics, 2021). Plenty of literature shows conflicting views about the relationship between economic variations and measurable health outcomes. Many studies suggest that healthcare funding can strongly impact individuals' health, influencing mortality rate, child mortality, and life expectancy (Bradley et al. 2011, 2016; Golinelli et al. 2018; Karanikolos et al. 2013; Mattei et al. 2017; Mays and Smith 2011; Oviedo Tejada et al. 2019; Toffolutti et al. 2019; Whitehead and Bergeman 2017). Other authors criticize the consistency of these findings, arguing that it is health expenditure to be influenced by the population's health condition (Badulescu et al. 2019; Catalano et al. 2011; Lopez-Valcarcel and Barber 2017).

The Organization for Economic Cooperation and Development (OECD) includes 37 member countries with different economic profiles; one of the most important indicators used to measure economic development is Gross Domestic Product (GDP) (Bolnick et al. 2020; Manuel et al. 2019; OECD 2019; Health Resources – Health Spending – OECD Data). Although increasing shares of GDP have been allocated to healthcare spending, many OECD countries present a stationary trend since 2009 (OECD 2019; Health Resources – Health Spending – OECD Data). Indeed, after the 2008 economic crisis, many national governments have reviewed the budget for public health and other social programs adopting austerity policies (Karanikolos et al. 2013). There is evidence that a lot of cost-effective investments in health can lead to development and economic growth, an opinion shared by both the WHO and the European Commission (Suhrcke et al. 2006; WHO 2001). Although allocating a big proportion of countries' GDP on healthcare absorbs resources from other sectors, the debate is open on whether healthcare expenditure should be considered an economic multiplier that allows the well-being of individuals on the one side and the economic growth of societies/populations on the other.

Several authors showed that increasing healthcare spending causes improvements in social security, safety, and welfare (McKeown 1976; Raghupathi and Raghupathi 2020; Sharma 2018; Yang 2020). Spending on health helps people with acute conditions to recover and return to work quickly. People with chronic conditions (e.g. diabetes, hypertension, arthritis, etc.) may remain in the workplace thanks to medical treatment. In general, spending on improving health outcomes builds human capital (Bloom and Canning 2005). Healthier adults are more productive, healthier children perform better in school, thus contributing to the country's productivity which ultimately leads to economic growth. However, other authors state that there is not a perfect correlation between investments in healthcare, population health and economic growth and that this may depend on many other factors such as the epidemiological characteristics, the economic, social and educational level of the population, and the type of healthcare system (Golinelli et al. 2017, 2018; Raghupathi and Raghupathi 2020; Sharma 2018; Yang 2020). The latter includes healthcare financing, service provision, and regulatory issues and should be taken into due consideration when assessing healthcare services' responsiveness and impact on economic growth and population health (Böhm et al. 2013).

1.1 Rationale of the Study

The study of the association between GDP, health expenditure and health status has seen opposite strands of literature that sought to demonstrate the characteristics of the relationship between these factors. On the one hand, the more a country invests in healthcare, especially in cost-effective measures, the stronger the decrease of all-cause mortality and the increase of life expectancy should be. On the other hand, health expenditure is highly dependent on a wide range of social, economic and individual factors. First of all, health expenditure is closely related to the available resources of a country and, consequently, to its wealth, typically quantified by GDP (Badulescu et al. 2019; Hsueh et al. 2019). Moreover, health expenditure is mainly influenced by contingent health factors. For example, ageing and high frequencies of chronic and acute diseases translate into an increase in health expenditure (Badulescu et al. 2019; Hou et al. 2020). All these variables can be considered interdependent. Increased country's economic resources can determine increased health spending, which in turn can cause an improvement in the health status of the population and can contribute to a country's economic growth.

This animated debate leads to questioning what the characteristics of the association between economic growth, population health condition and health spending are. Exploring the association of these three variables is crucial for policymakers to evaluate what has been done in the past in terms of allocated resources and to try to better understand the relationship between health expenditure, GDP, and health status to face future challenges.

1.2 Aim of the Study

This study aims to investigate the characteristics of the association between GDP, population mortality and healthcare spending in OECD high-income countries.

2 Methods

Based on the OECD framework's suggestions (OECD/Eurostat/WHO 2017), we conducted a panel study using data across 31 high-income countries (High Income) from 2000 to 2017 (18 years). The key advantages of using panel data are large sample size, controlling a wide range of time invariant cross-specific attributes, relaxing the assumption of a homogeneous relation across countries, and including country or time effects.

Socioeconomic data (Table 1) for every year considered and in reference to each of the 31 OECD Countries were extracted from WHO and OECD Database (Global Health Expenditure Database; OECD Statistics 2021). The 31 OECD

Table 1: Random effects model: dependent and independent variables description in reference to the 31 OECD countries included[a].

Variable	Description	Measure	Source	Abbreviations
Current Health Expenditure	Current expenditure on health (all functions), all providers, all financing schemes	Expenditure per capita in PPP Int$	WHO Health Expenditure database https://apps.who.int/nha/database	CHE
All-cause mortality rate	All-cause of death	Death per 100,000 population (age-standardized rate)	OECD database	MR
GDP	Gross domestic product (expenditure approach)	Per capita, current prices, current PPP	OECD database	GDP
Elderly Population	People aged ≥65 years	Share of the total population (%)	OECD database	EP
Education	Upper secondary education	Share of population (%)	OECD database	EDUC
Type of Healthcare System	Single Payer Insurance-based Private Mixed System	–	https://doi.org/10.1016/j.healthpol.2013.09.003	SP, IB, PVT, MIX

[a]OECD High-Income Countries included: Australia, Austria, Belgium, Canada, Switzerland, Czech Republic, Germany, Denmark, Spain, Finland, France, United Kingdom, Greece, Ireland, Island, Israel, Italy, Japan, Republic of Korea, Lithuania, Luxemburg, Netherland, Norway, New Zealand, Poland, Portugal, Slovakia, Slovenia, Sweden, Turkey, United States.

Countries considered were: Australia, Austria, Belgium, Canada, Switzerland, Czech Republic, Germany, Denmark, Spain, Finland, France, United Kingdom, Greece, Ireland, Island, Israel, Italy, Japan, Republic of Korea, Lithuania, Luxemburg, Netherland, Norway, New Zealand, Poland, Portugal, Slovakia, Slovenia, Sweden, Turkey, United States. The expenditure item analysed (Table 1) was per capita, in US dollars, and adjusted via the purchasing power parity (PPP) coefficient (with 2018 as the base year) of the study period. The panel data presents few missing data in time, making our database unbalanced.

2.1 Dependent Variables

The objective of our study was to investigate the association between GDP, population mortality and healthcare spending in 31 OECD countries. Accordingly, we considered current health expenditure (CHE), countries' GDP and age-standardized all-cause mortality rate (MR) as dependent variables of our analysis (Table 1).

Health expenditure data aggregation relies on definitions from the OECD manual (OECD/Eurostat/WHO 2017), which provides a systematic and comparable description of the financial flows related to the consumption of healthcare goods and services. CHE is the final consumption expenditure of resident units on health care goods and services, including the health care goods and services provided directly to individual persons as well as collective health care services. It includes inpatient health expenditure, outpatient health expenditure and out-of-pocket health expenditure.

We included per capita GDP in our model to account for OECD countries' economic trend and to evaluate whether economic wealth cross-influences with the other dependent variables. We analyzed age-standardized all-cause mortality rate for females plus males (MR) as a dependent variable of our study given that it is usually considered as a measure of population health and as an indicator of performance of the healthcare system (Golinelli et al. 2017).

2.2 Control Variables

We included the following control variables in the construction of the analysis model: education level (EDUC), elderly population (EP) and type of healthcare system (HS) (Table 1).

EDUC is the share (%) of the population with upper secondary education. The negative relationship between EDUC, health and economic outcomes was proved by many studies (Hummer and Hernandez 2013; Kitagawa and Hauser 1973).

Higher education is linked with a better lifestyle, fewer risk factors and with a more conscious use of healthcare services, thus this variable can be considered a proxy for behaviour (Boing, Subramanian, and Boing 2019). Furthermore, increasing levels of education could contribute to enhance individuals' health literacy. This may increase the appropriateness of healthcare resources consumption, thus reducing overuse of healthcare services and overall inappropriate health expenditure.

EP is the share (%) of the population aged 65 or more (elderly population, EP). Growing elderly population might imply a greater consumption of healthcare resources and a different level of population health (e.g. increased mortality rate). Furthermore, a demographic profile that is unbalanced towards people aged ≥65 years can affect a country's level of productivity and therefore its GDP and growth.

We included the type of health care system as a control variable of our analysis. Multiple health care system classifications have been proposed in the literature and most of these focus on health care financing mechanisms (Toth 2020). For the purpose of this study, we decided to used Bohm classification (Böhm et al. 2013), that subdivides healthcare systems into three large models (Organisation for Economic Co-operation and Development (OECD) 1987; Toth 2016): single-payer national health service (SP); social insurance-based health services (IB); private or voluntary private insurance (PVT); other mixed or hybrid models (MIX) can be present. Different types of health systems might have different impacts on the health outcomes (Toth 2020) and on health spending (Golinelli et al. 2017, 2018). For instance, public and universalistic healthcare systems (i.e. Beveridge models) may guarantee greater accessibility to services and are therefore characterized by lower mortality rate (Aísa, Clemente, and Pueyo 2014; Lorenzoni, Belloni, and Sassi 2014). Free market or predominantly private health systems are usually characterized by higher per capita health expenditure (OECD 2019). The characteristics of a country's healthcare system may therefore influence its health spending and the health condition of its population (Catalano et al. 2011; Golinelli et al. 2018; Mattei et al. 2017).

2.3 Statistical Analysis

We summarized dependent and control variables using mean and standard deviation aggregating for five different periods of time (years 2000, 2005, 2010, 2015) and health system (SP, IB, PVT and OTH).

The association between healthcare spending, GDP and mortality was investigated through a random effects model. Such specification allows the practitioner to infer a different slope and intercept for each country, and to entail in the set of covariates categorical variables which are constant over time. Let be $y_{i,t}$ the observed dependent variable at time t and for the ith country, then the random effect model can be specified as

$$y_{i,t} = X'_{i,t}\beta + \epsilon_{i,t} \tag{1}$$

with

$$\epsilon_{i,t} = \alpha_i + \lambda_t + u_{i,t},$$

where $X_{i,t}$ is the $K \times 1$ vector of covariates for the ith country at time t, α_i is the individual (random) effect (with variance σ_α^2), λ_t is the time (random) effect and $u_{i,t}$ is the "idiosyncratic" error (with variance σ_u^2). All the covariates observed over time were lagged once in order to prevent multicollinearity and to assess a short-term effect on the dependent variable. The Wald-modified test was used to assess heteroscedasticity, in presence of which robust standard errors should be used. Furthermore, we controlled for the presence of time trends in the dependent variable by entailing a time trend in the set of regressors. Finally, we controlled for the correlation among the covariates to avoid any multicollinearity problem, finding no significant correlation in the set of regressors.

The aim of our study is to investigate the characteristics of the association between countries' GDP, mortality and health spending. To control for possible reverse causality, we estimated the same model with the same control variables but using GDP, mortality and health spending as the dependent variables and including the other two variables in the set of covariates. The set of models that we estimated is the following

$$CHE_{i,t} = Z'_{i,t}\theta + \zeta_{i,t} \tag{2}$$

$$MR_{i,t} = W'_{i,t}\gamma + \omega_{i,t} \tag{3}$$

$$GDP_{i,t} = D'_{i,t}\delta + \eta_{i,t} \tag{4}$$

where $CHE_{i,t}$, $MR_{i,t}$ and $GDP_{i,t}$ are respectively the current expenditure item, the mortality rate and GDP at time t and for the ith country, $Z_{i,t}$ is the vector of exogenous variables including MR, GDP, EDUC, EP and HS, $W_{i,t}$ is the vector of exogenous variables including lCHE, GDP, EDUC, EP and HS, and $D_{i,t}$ is the vector of exogenous variables including CHE, MR, EDUC, EP, and HS; $\zeta_{i,t}$,$\omega_{i,t}$ and $\eta_{i,t}$ are the error terms.

Then, we tested for the presence of Granger causality relying on an extension of the heterogeneous panel causality test proposed by Dumitrescu and Hurlin (Dumitrescu and Hurlin 2012) (DH). This test allows for heterogeneity of the causal relationship and heterogeneity of the regression model, and for the presence of

Table 2: Descriptive statistics of all variables included in the random effects model (SD: Standard Deviation).

Variable Healthcare System	2000	2005 SP (n = 6)	2010	2015	2000	2005 IB (n = 12)	2010	2015	2000	2005 MIX (n = 12)	2010	2015	2000	2005 PVT (n = 1)	2010	2015
CHE[a] (SD)	2111.46 (414.08)	2904.25 (529.62)	3738.65 (739.89)	4344.04 (997.18)	1757.56 (987.38)	2355.31 (1309.6)	3132.53 (1557.79)	3664.44 (1610.37)	1662.75 (1038.7)	2245.68 (1221.03)	2975.63 (1529.33)	3498.14 (2217.77)	4564.46	6454.68	7930.15	9491.09
MR (SD)	940.38 (105.46)	848.85 (63.47)	766.13 (66.82)	723.97 (48.77)	998.64 (206.09)	921.35 (201.81)	837.79 (158.57)	773.15 (127.64)	1040.28 (197.73)	987.98 (261.94)	866.98 (229.02)	824.62 (199.76)	994.6	910.3	835.3	837.8
GDP[a] (SD)	27796.45 (4485.07)	34243.96 (6323.2)	39858.28 (7548.64)	46256.4 (10737.66)	24294.45 (12070.41)	29432.1 (14249.93)	36508.22 (16941.28)	43742.62 (19872.88)	20577.84 (9693.57)	25968.17 (9233.97)	32052.12 (12421.44)	37741.7 (15171.18)	36304.6	44043.73	48395.8	56770.42
EDUC, % (SD)	60.91 (20.34)	66.3 (17.36)	70.46 (16.28)	74.82 (13.51)	67.65 (17.68)	73.19 (15.75)	77.09 (15.53)	79.65 (14.38)	73.05 (16.43)	77.69 (13.65)	77.98 (12.52)	82.08 (9.09)	87.44	87.77	88.97	89.54
EP, % (SD)	14.74 (2.31)	15.06 (2.57)	15.87 (2.72)	17.62 (2.83)	13.14 (3.51)	13.98 (3.92)	14.89 (4.35)	16.53 (4.71)	14.48 (2.13)	15.56 (2.28)	16.63 (2.28)	18.13 (2.3)	12.43	12.4	13.09	14.86

[a]per capita US $. CHE, current health expenditure; MR, mortality rate; GDP, gross domestic product; EDUC, educational level; EP, elderly population; SP, single payer; IB, insurance based; MIX, mixed; PVT, private.

control variables. We applied the test for all the combinations of dependent variable-covariate of interest, for a total of 6 Granger-causality tests.

Several measures, such as the Akaike information criterion (AIC) and the Schwarz criterion (BIC), were calculated to quantify the goodness of fit and complexity of the model.

For all analyses, the significance level was established at $\alpha = 0.05$. All data were analysed using the R software version 4.0.2 (R Core Team 2020).

3 Results

3.1 Descriptive Statistics

Descriptive statistics of the variables entailed in the analysis are presented in Table 2.

Our results show an increase in CHE during the study period, in countries with single-payer health systems, as well as in insurance-based, mixed (other) and private ones. Mean CHE was 2111.46 US$ in 2000 and increased to 4344.04 US$ in 2015 in countries with single-payer healthcare systems, while it grew from 1757.56 US$ in 2000–2664.44 in 2015 in countries with an insurance-based healthcare system (Table 2). Conversely, the all-cause mortality rate reduced during the study period in all countries with single-payer, insurance-based, mixed and private healthcare systems. As an example, MR moved from 940.38 deaths per 100.000 population in 2000 to 723.97 in 2015 in countries with single-payer healthcare systems (Table 2).

GDP increased in all high-income countries considered. Mean GDP was 27796.45 US$ per capita in 2000 and increased to 46256.4 in 2015 among countries with single-payer healthcare systems, while it grew from 24294.45 in 2000–43742.62 in 2015 in countries with an insurance-based healthcare system (Table 2). EDUC e EP increased from 2000 to 2015 in all countries considered (Table 2).

3.2 Panel Estimation with Random Effects Model

In Table 3 we report the panel estimation with random effects model following equation (2) (Model #1), equation (3) (Model #2) and equation (4) (Model #3). These models allowed us to investigate the association between CHE, MR and GDP.

The results of the random effects model in Table 3 show that the all-cause mortality has a statistically negative and significant effect on CHE, but that this relationship cannot be confirmed in the opposite direction (Model #2 in Table 3). We also found a statistically significant association between countries' MR and

Table 3: Panel estimation with random effects model (*p*-values between parentheses) with $N = 31$ and $T = 18$.

	Dependent variable		
	CHE	**MR**	**GDP**
CHE	–	−0.018 (0.109)	5.053[a] (0.000)
MR	−1.605[a] (0.000)	–	−10.322[a] (0.004)
GDP	0.076[a] (0.000)	−0.001 (0.370)	–
EDUC	−4.495[a] (0.045)	−1.442[a] (0.007)	107.875[a] (0.000)
EP	65.447[a] (0.000)	−3.665 (0.082)	−402.413[a] (0.000)
Health care system (vs. *IB*)			
MIX	613.448[a] (0.000)	−85.778[a] (0.011)	291.608 (0.854)
SP	207.567[a] (0.000)	−61.529[a] (0.001)	1487.45 (0.127)
PVT	3228.64[a] (0.000)	172.376[a] (0.000)	−8120.15[a] (0.003)
LogLik	−2973.334	−2452.600	−4055.102
AIC	5964.669	4923.200	8128.204
BIC	6000.130	4958.685	8163.666
Chisq (8)	2353.38[a]	118.962[a]	358.033[a]

[a]Denotes a significant result; LogLik is the log-likelihood of the model; AIC and BIC are the Akaike and Schwarz criteria respectively; Chisq (8) is the joint test on omitted variables for all the regressors with 8 degrees of freedom. CHE, current health expenditure; MR, mortality rate; GDP, gross domestic product; EDUC, educational level; EP, elderly population; SP, single payer; IB, insurance based; MIX, mixed; PVT, private.

GDP when the latter is the dependent variable (Model #3 in Table 3). As in the case of CHE, GDP does not exhibit a significant effect on MR. Our results further show that an increase in GDP (Model #1 in Table 3) is associated with a significant increase of CHE ($b = 0.076$, $p < 0.001$) (Table 3). For instance, for each additional 1000 dollars of per capita Gross Domestic Product, the per capita current health expenditure increases by 76 US dollars. This association seems to be bi-directional, since CHE is significantly associated with an increase in GDP ($b = 5.053$, $p < 0.001$).

EDUC is negatively associated with CHE ($b = -4.495$, $p < 0.001$) and MR ($b = -1.442$, $p = 0.007$), while it is positively associated with GDP ($b = 107.875$, $p < 0.001$). As the proportion of the population ≥65 years (EP) increases, CHE increases ($b = 65.447$; $p < 0.001$) and GDP decreases ($b = -402.413$; $p < 0.001$) (Table 3). EP is not significantly associated with MR.

The types of health services are all associated with CHE and MR, while only the private health system is associated with GDP.

Table 4: Granger causality with covariates. Table reports the test statistics of the DH test with *p*-values between brackets.

Variable 1	Variable 2	H_0: Variable 1 does not Granger cause Variable 2	H_0: Variable 2 does not Granger cause Variable 1	Direction of causality
MR	CHE	7.955[a] (0.000)	14.761[a] (0.000)	Bi-directional
MR	GDP	8.367[a] (0.000)	7.374[a] (0.000)	Bi-directional
GDP	CHE	46.844[a] (0.000)	37.859[a] (0.000)	Bi-directional

[a]Denotes a significant result. CHE, Current health expenditure; MR, mortality rate; GDP, gross domestic product.

3.3 Granger Causality

Table 4 shows the results of the DH test on the presence of Granger causality between the variables of interest (CHE, MR, GDP), net of covariates. We found a bidirectional association between all the variables included in our study. According to the size of the test, the stronger Granger causality was exhibited between GDP and CHE which were highly influenced by each other in both directions (Table 4).

4 Discussion

This study explored the characteristics of the association between GDP, all-cause mortality, and current health expenditure among high-income countries. Our analysis shows a clear direction of the causality between the variables of interest. Both from panel regression and Granger causality analysis emerge possible bidirectional associations. However, we found no statistically significant association between healthcare spending, as the independent variable, and mortality rate in the random-effect panel model analysis. This suggests that the association between healthcare expenditure and population's health is neither perfect nor linear, confirming that the relationship between economic resources invested in health care and improvement of population's health condition can be difficult to assess, as confirmed by many authors (Raghupathi and Raghupathi 2020; Sharma 2018; Yang 2020).

Healthcare spending growth inevitably raises questions about the 'value' of spending. In 1976, McKeown argued that medical care had contributed little to population health improvements, although not considering the latter part of the 20th century in which medical care made a substantial contribution to gains in life expectancy (McKeown 1976). According to McKeown and other authors, population health is influenced by factors outside the provision of healthcare, such as population ageing, social security, educational level, and many others (Raghupathi and Raghupathi 2020; Sharma 2018; Yang 2020), that we partially included in our analysis. However, the level of detail of our analysis may be too broad and fail to identify relationships between more specific expenditure items and health outcomes. This leads to consider the association between healthcare spending and population health worthy of further study, possibly with a different level of detail. Previous analysis conducted with higher detail in Italy showed that only allocating resources on specific items of health expenditure was associated with mortality rate (Golinelli et al. 2017). For instance, the study highlighted that public spending on directly provided services was one of the driving forces for the Italian population's health. Accordingly, to verify the value of the economic and financial resources invested in healthcare, it may be necessary to analyze with greater granularity.

In our analysis, we also found a significant association between GDP and mortality rate when the latter is used as covariate, and we found a strong two-way relationship between GDP and health spending, both in the causality analysis and in the random-effect panel model. Since 1965, healthcare spending has grown almost twice as fast as the gross national product (Levit, Freeland, and Waldo 1989). OECD analysis showed that the percentage of GDP dedicated to healthcare continues to grow driven by demographics factors in particular the ageing of the population and the prevalence of chronic diseases (Chang et al. 2019; De La Maisonneuve and Oliveira Martins; Dieleman et al. 2018). Plenty of literature confirms this parallel growth of GDP and health spending. For instance, Raghupathi found that an increase in healthcare expenditure has a positive relationship with economic performance (Raghupathi and Raghupathi 2020). Citizens' well-being results in an overall better economy. The healthcare system is a large sector of the economy (10% of GDP among OECD countries) and a major source of employment. Therefore, investing carefully in healthcare would boost GDP, given the role of the healthcare system as a trainer, employer and purchaser of goods and services in economic growth. Accordingly, the same authors suggested taking into due consideration the type of healthcare system to verify if a link to productivity and economic growth exists. This is precisely what we have done in the scope of our study to assess whether different healthcare systems are associated with different economic impacts. We found no statistically significant difference in expenditure between insurance-based, single-payer or mixed healthcare systems. Accordingly, the association between GDP and healthcare spending should not be considered related to the characteristics of healthcare systems and funding. Instead, our results suggest that net of other factors, healthcare spending is strongly two-way related to higher productivity, as it may contribute to greater capacity to work, increased employment and tax revenues, and therefore to economic growth (National Academies of Sciences, Engineering, and Medicine; Division of Behavioral and Social Sciences and Education; Committee on Population Malay K. Majmundar, Mark D. Hayward 2018; Watt, Charlesworth, and Gershlick 2019).

Our analysis also shows interesting results regarding the association between educational level and CHE, and between the proportion of people aged ≥65 years, CHE and GDP. The negative association between the share of population with upper secondary education and current health expenditure is noteworthy. Countries with a higher educational level spend less on average. It has been confirmed by many authors that higher education is correlated to higher health literacy (Rudd 2007). Individuals with a high level of education might be better orientated in the use of health services and likely to consume resources more consciously. From another perspective, the inability of patients to properly understand health information and to navigate the healthcare system is an important predictor of inappropriateness in access to healthcare. In addition, people living with problematic health literacy are discouraged to be engaged in the provision of health services and are expected to show poor self-efficacy in dealing with their health-related conditions. From this point of view, patients with poor health literacy are at higher risk of exacerbation of their health problems, which in turn contributes to rising healthcare costs (Palumbo 2017). It is important to notice that educational level is also associated with both GDP and mortality rate. The directions of these associations are rather intuitive: an increase in EDUC increases GDP (Krueger et al. 2001), while it decreases mortality rate (Stringhini et al. 2017).

Our analysis highlights that a higher share of the population aged 65 or more (elderly population, EP) is associated with higher spending on health. This kind of association is straightforward. The growing elderly population implies a greater consumption of healthcare resources, mainly due to the burden of chronic diseases, and leads to a different population health outcome (e.g. increased mortality rate). Furthermore, EP is negatively associated with GDP. This finding is also intuitive. A demographic profile that is unbalanced towards people aged ≥65 years can affect a country's level of productivity and therefore its GDP and growth.

According to our findings, health expenditure is a robust economic multiplier among high-income countries. Advancement in health standards is conducive to economic resilience (Briguglio et al. 2009). Such evidence could be extremely useful to policymakers, for example considering the effects of the recent COVID-19 pandemic on countries' economic status. As the pandemic forced to shut down almost every country's economy, billions of people lost their jobs worldwide. This dramatic situation exposed a profound debate on the optimal allocation of resources, and the consequent blunt choice between material well-being and health.

What emerged from our study is that investing in health will benefit both the well-being of the general population as well as the whole economy.

4.1 Study Limitations

Our study has some limitations. We acknowledge that measuring health outcomes with MR may misestimate the effects of health spending on the overall population health status. This study uses ecological-level data only. One potential risk in using ecological measures is the 'ecological fallacy'. However, because this study only uses the country itself as the unit of analysis and does not generalize about individuals or specific population groups within each region, the risk of ecological fallacy can be considered strongly reduced (Schwartz 1994). Another limitation is that the analytic approach of this study may not support causal inference: contingent economic hardship may lead simultaneously to worse health outcomes and reduced tax revenues, thus creating an apparent association between lower spending on health and mortality. In addition, the level of geographical aggregation could influence the association between expenditure and mortality.

5 Conclusions

In this study, we analyzed the association between healthcare expenditure, gross domestic product, and mortality rate among 31 high-income OECD countries from 2000 to 2017 and found a clear direction of the causality between them. Considering the countries' educational level, the share of elderly population and type of health care system, we found a strong two-way relationship between GDP and health spending, both in the causality analysis and in the random-effect panel model. Our analysis reinforces the economic multiplier effect of healthcare spending. In the debate on the optimal allocation of resources often resulting from economic crises, this evidence should be taken into great consideration.

Research funding: The author(s) received no financial support for the research, authorship, and/or publication of this article.
Author contributions: FS and DG had the idea, contributed to study design and data interpretation, and drafted the manuscript; FE and FT contributed to design, data acquisition, and interpretation, and drafted the manuscript; AB contributed to data acquisition and analysis; AB, DG e FS contributed to the conception and data interpretation, and critically revised the manuscript. All authors gave their final approval and agreed to be accountable for all aspects of the work.

Competing interests: No potential competing interest was reported by the authors.
Availability of data and material: The data that support the findings of this study are available in the Global Health Expenditure Database at https://apps.who.int/nha/database and in the OECD Statistics database at https://stats.oecd.org/Index.aspx?ThemeTreeId=9.
Code availability: The code used in this project was developed using the R software version 4.0.2 and is available upon request.

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