COVID-19 mortality and health expenditures across European countries: the positive correlation puzzle

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The pioneering spirit

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Abstract

The positive correlation between health share expenditures and COVID-19 cumulative case fatalities in a cross-section of 31 European countries is puzzling. The positive relationships is also detected in weighted OLS and IV models that control for many usual suspects of the COVID-19 mortality: (1) health indicators (personal risk factors, medical resources), (2) virus ease of circulation, (3) macroeconomic variables related to the economic development and social orientation of the country. COVID-19 case fatalities are lower in countries with significant resources dedicated to health care (hospital beds and medical doctors); the contribution of virus circulation factors is less significant. Policy implications follow.

KEYWORDS

COVID-19, health care systems, Europe, efficiency, mortality, health policy

JEL CLASSIFICATION - H12, I18

1. INTRODUCTION

The SARS-CoV-2 virus, leading to the COVID-19 disease, was and still is a challenge for epidemiologists and medical doctors. While its structure is relatively simple, and its genetic code was quickly deciphered, the virus was surrounded by major uncertainty regarding its dynamics of contamination, potential for muting, and mechanism of destroying human health (Beeching et al., 2020; Adam, 2020). This research note adds an economic puzzle to the long list of medical and epidemic puzzles related to the COVID-19: the positive correlation between the cumulated fatalities and the share of health expenditures to GDP across 31 European countries.

We choose to focus on European countries because the epidemy hit them at the same period, all have universal health care systems that cover all their citizens for all expenses related to major illnesses and would share common civic values to guide policymakers.

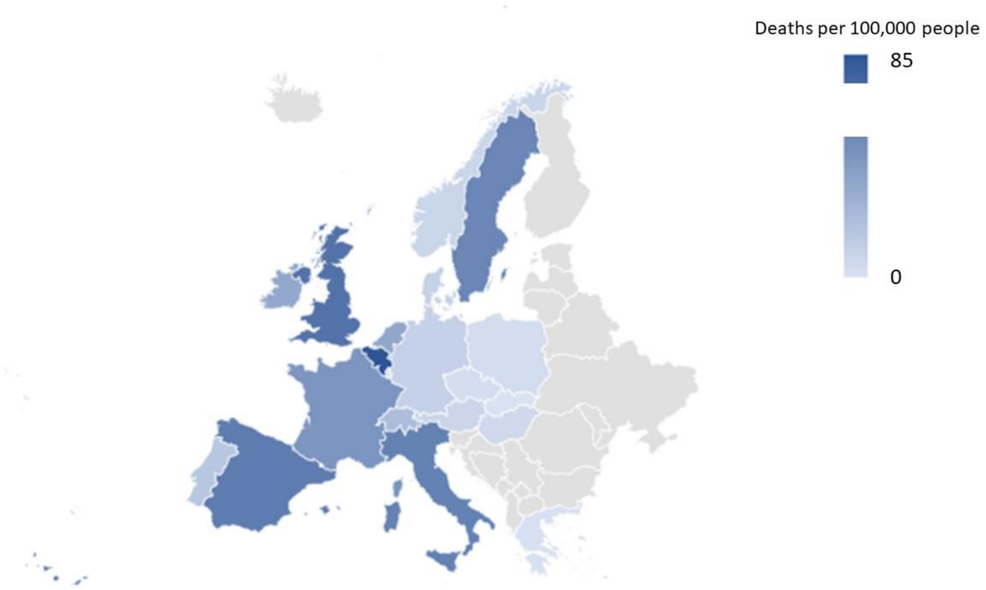
The first wave of COVID-19 hit Europe in early March 2020, reached a peak in April then gradually faded away. According to the European Center of Disease Prevention and Control, if on late April the 14-day COVID-19 death notification was as high as 105, it fell to 4.1 on August 2, 2020. Therefore, late July can be considered as indicating the end of the first wave of the COVID-19 in Europe. As of July 25th, 2020, the COVID-19 crisis caused 20.19 deaths per 100,000 people in the EU.

The probability of dying from the COVID-19 compounds effects of three significant stages: (i) being contaminated, (ii) becoming symptomatically sick and (iii) falling into a serious condition. Contamination depends on the circulation of the virus, while chances of recovery depend on the patient's own risk factors (age, obesity...) and the availability of heavy health equipment and highly skilled medical staff.

Policymakers strived to contain the most dramatic consequences of the epidemic by taking measures that apply to both the contamination stage, and the diagnostic and treatment stage. These national policies, as applied to the COVID-19 epidemic, varied markedly from one country to another. With the notable exception of Sweden, governments implemented lockdown to increase social and physical distance. Some countries moved very fast to closing borders; other countries had a more gradual approach. Testing and patient care strategies also differed from one country to another. First and foremost, countries presented quite different degrees of preparedness for such a crisis in terms of resources, organization of the health care system, and leadership (Obaid et al. 2020).

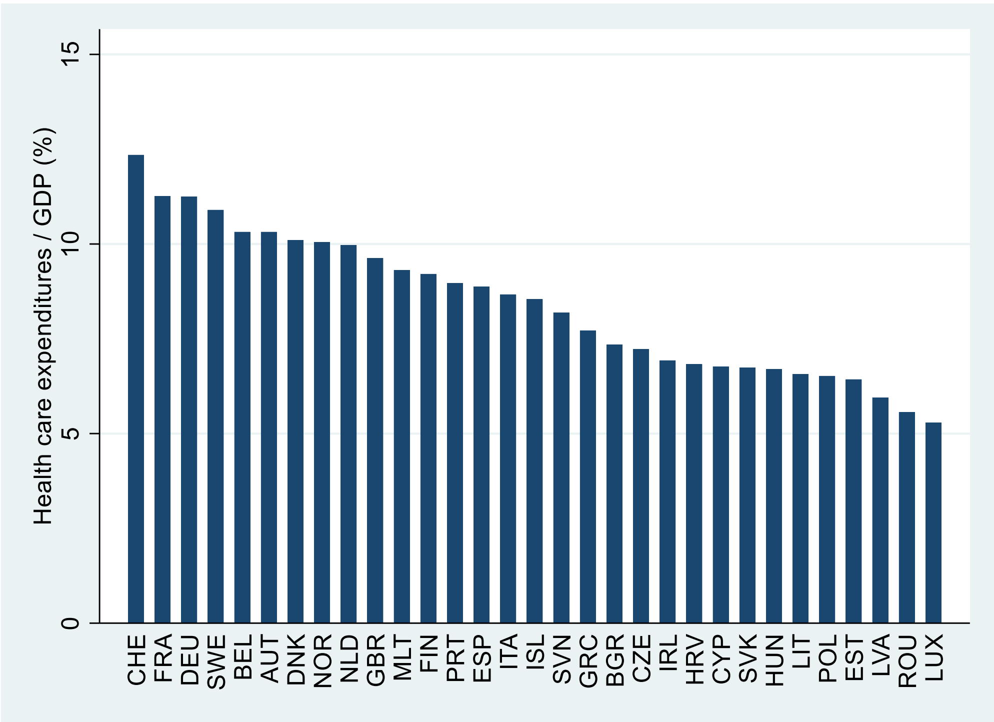
Hence, the COVID-19 death toll varies greatly from one country to another, from zero in Cyprus to 85 per 100,000 people in Belgium (Figure 1).

FIGURE 1 COVID-19 cumulated case fatalities per 100,000 people as of July 25, 2020



Significant variation is also recorded across European countries with respect to the share of health expenditures to GDP, from less than 6% in Romania, to 11.3% in France and Germany, with a maximum of 12.3% in Switzerland (2018, Eurostat) (Figure 2).

FIGURE 2 Health expenditures/GDP (%) in 2018 or latest year available (Eurostat)



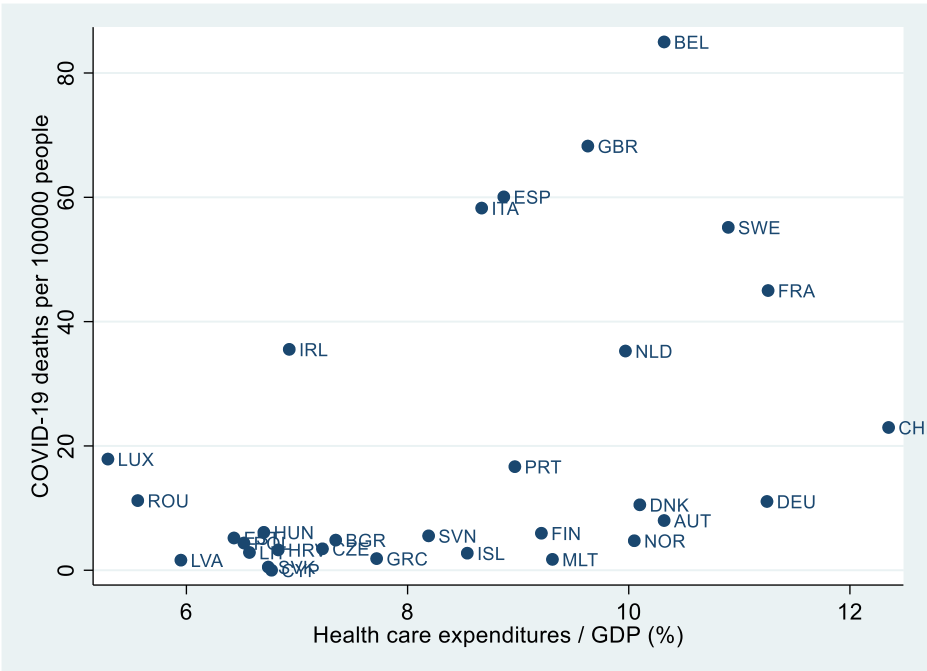
What relationship should one expect between the health share to GDP and the cumulated COVID-19 deaths?

Intuitive reasoning might suggest a negative link: the more resources a country dedicates to health care, the more lives should be saved during a sanitary crisis, both at stage one, virus circulation, and stage two, treatment. For instance, the faster a country can generalize testing and isolate contaminated persons, the lower will be the fatalities.

On the other hand, a positive correlation can be driven by the relationship between another variable and each of the COVID-19 case fatalities and health expenditures. For instance, a higher proportion of old age persons is associated with both a higher share of health expenditures and a higher COVID-19 mortality. If the correlation between the health share and the death rate is still present when controlling for all other observed variables that jointly impact the two variables (age, temperatures, hospital beds, obesity, etc.), then the correlation might reveal differences in the efficiency of the health care systems. All other things being equal, the higher the efficiency of the health care system, the lower should be the health care expenses, and the lower should be the COVID19 death rate (see Online Appendix 1 for the formal explanation).[1]

Figure 3 presents on the horizontal axis the share of health expenditures to GDP (in 2018) and the cumulated COVID-19 deaths on the vertical axis. The distribution of the plots suggests a positive association between the two variables (correlation coefficient 0.51). A similar positive correlation, albeit nonsignificant, was detected by Khan et al. 2020 in a sample of 86 developed and developing countries (with very different health care systems).

FIGURE 3 Health expenditures/GDP (and cumulated COVID-19 deaths per 100,000 people.



[1] Newhouse (2006) argues that the organization of the health care systems has an important role in determining health care expenditures.

This research notes studies whether the positive correlation between the COVID-19 death rates in Europe and the share of health care expenditures holds when controlling for the usual suspects of the COVID-19 mortality and provide a positive answer. We verify that the puzzling correlation resists to IV regressions that would correct for omitted variables and endogeneity. A lower health share coefficient in IV compared to OLS regressions suggests that the omitted variable (efficiency) hypothesis cannot be ruled out. Our analysis also reveals the factors that contributed the most to the COVID-19 first-wave mortality by country. It emphasizes the essential role of medical resources in the fight of the epidemic.

2. THE DATA

Our sample comprises 31 countries: the 27 EU countries, the UK and the EFTA large countries (Iceland, Norway, Switzerland). With a population of 529.06 million people in 2018, they represent a large proportion of all European countries.

Our dependent variable is the COVID-19 total deaths per 100,000 people (or death rate) from the beginning of the epidemic until July 25, 2020. This is a noisy measure, since not all deaths were correctly imputed to the COVID-19 due to test shortages and false negative tests, and some deaths determined by other causes might have been wrongly attributed to COVID-19. When studying the efficiency of the health care systems, it might be meaningful to consider the ratio of fatalities to the number of contaminated people; unfortunately, this indicator can hardly serve for international comparisons, given the initial shortage of tests in many countries, and the substantial differences in testing strategies.

The analysis considers several explanatory variables, grouped in three categories.

I. Health indicators. A key variable is the share of health expenditures to GDP (in percentage points) (Figure 2). The Eurostat data are available for 2018 (thus the COVID-19 extra spending is not included).

Within the health care system, human resources (medical doctors and nurses) and hospital beds (ICU mainly) were key resources in fighting the COVID-19. Both human and material resources were stretched at the peak of the crisis, with large differences from one country to another. Old age and overweight were pointed out as major factors of risk (inter alia, Al Saidi et al., 2020; Beeching et al. 2020, ECDPC 2020); they also contribute to higher health expenses as they are associated to many critical diseases, such as cancer or heart fragility.

II. Virus circulation. Temperature might influence the spread of COVID-19. Population density could also have played a role. The less a country allows for travel and exchange with the rest of the world in the first stages of the epidemic, the lower the speed of contamination. As a proxy for openness, we use the share of exports in GDP.

III. Macroeconomic variables. Public debt to GDP is a proxy for the strain imposed on governments in taking decisive action against the COVID-19. The Gini inequality index is also a proxy for the social orientation of the institutions.[2]

As auxiliary variables, that are useful for the regression analysis, we present the country population and its real GDP per capita or Affluence.

TABLE 1 Summary statistics of the data over 31 countries[3]

	Mean	SD	Min	Max
Key variables				
- COVID deaths per 100,000 people	19.22	23.66	0	85
Health related indicators				
- Health expenditures / GDP, in % (2018)	8.4	1.89	5.29	12.35
- Obesity rate (BMI>30) in % (2016)	22.79	2.51	19.5	28.8
- Rate of aged 80 and more in % (2017)	4.86	0.96	3.2	6.8
- Rate of aged 65-79 in % (2017)	18.37	2.33	13.9	22.3
- Median age (2017)	41.59	2.37	36.3	46.8
- Hospital beds per 10,000 people (2017)	481.67	169.1	221.2	800.2
- Medical doctors per 10,000 people (2016)	35.62	8.26	19.50	54.04
Circulation of the virus				
- Exportations / GDP, in % (2019)	66.88	37.2	31.6	208.8
- Mean temperature (°C)(1961-1990)	8.83	4.45	1.5	19.2
- Geographic density (population per Km²)	172.14	288.31	3.54	1628.37
Macroeconomic variables				
- Real GDP/capita (€) or Affluence (2019)	30,561	18,893	6,800	83,640
- Public debt / GDP, in % (2019)	61.9	36.72	8.4	176.6
- Gini index (2017)	31.2	3.95	24.2	40.4
- Population in millions (2018)	17.07	23.03	0.36	83.17

Source: Eurostat, except rate of obesity (WHO, 2016), the medical doctors per 10,000 people (WHO, 2016, except for Bulgaria and Malta, 2015) the number of COVID deaths (Worldometers), the mean temperature (Climate Research Unit, University of East Anglia), and the Gini coefficient (World Bank).

3. THE ECONOMETRIC ANALYSIS

The COVID-19 case fatality rate can be interpreted as the probability of death, from the beginning of the pandemic to the 25th of July, for an individual living in a given country. As other death probability models, a model based on variables measuring country averages builds on an underlying individual death probability model. It is therefore meaningful to implement weighted regressions, using the population share as a weight for each country (Wooldridge, 2006).[4]

One element of interest is the relationship between the health share expenditures and the COVID-19 fatalities. As we argued before, the coefficients in OLS regressions can be biased, due to endogeneity problems (for instance, old age is determining both health

[2] Kennedy et al. (1998) find that higher Gini coefficients across US states were associated with lower levels of overall health.

[3] The correlation matrix is presented in the Online Appendix.

[4] The results of the unweighted regressions are similar. See Online Appendix 4.

expenses and is a COVID-19 risk factor), and omitted variable (the unobserved efficiency of the health system).

To correct for these potential problems, we also implement a set of IV regressions. Real GDP/capita (or Affluence) is a natural candidate to be the instrument, since it is correlated with the health share but not with the COVID-19 death rate. Why, in our sample, affluence would not be correlated with the death rate? Because all of the 31 countries run universal health care systems that cover all expenses related to the major illnesses. The treatment of COVID-19 did not require expensive drugs, only a dedicated medical staff and ICU hospital beds for the most difficult cases.[5] On the other hand, the affluence should be positively correlated with the share of health care expenditures at country level, for many reasons. In a Belassa-Samuelson framework, richer countries have higher wages, and a higher productivity in the production of tradable goods. Because health care is a non-tradable good and countries should feature a similar productivity, richer countries should have higher health shares. Other explanations were provided to this documented correlation (Hall and Jones, 2007). Getzen (2000) suggests that health care services are a necessity good at the individual level (income elasticity lower than 1) and a luxury good at the country level.

TABLE 2 COVID-19 fatality rate: OLS and IV regressions, weighted by the population

	Weighted OLS			Weighted IV		
	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
Health Expend./GDP	4.267***	5.406***	6.368***	3.905**	4.288***	4.705**
	(1.14)	(1.24)	(1.40)	(1.54)	(1.53)	(1.83)
Obesity rate	1.436*	1.630*	1.217	1.433**	1.609**	1.369
	(0.77)	(0.89)	(1.08)	(0.68)	(0.73)	(0.86)
Age (% above 80)	13.540***	16.418**	12.727	13.801***	17.222***	15.101*
	(2.88)	(6.53)	(9.81)	(2.71)	(5.82)	(8.54)
Hospital beds/10,000	-0.079***	-0.081***	-0.077***	-0.079***	-0.080***	-0.077***
	(0.01)	(0.01)	(0.02)	(0.01)	(0.01)	(0.01)
Medical doctors /10,000	-1.623***	-2.027***	-2.018***	-1.612***	-1.951***	-1.934***
	(0.42)	(0.65)	(0.71)	(0.39)	(0.54)	(0.57)
Mean temperature		1.044	1.105		0.738	0.723
		(0.72)	(1.08)		(0.72)	(0.95)
Density		0.004	-0.000		0.011	0.010
		(0.02)	(0.02)		(0.02)	(0.02)
Exports / GDP		0.289	0.330		0.266	0.286
		(0.25)	(0.25)		(0.20)	(0.19)
Public debt / GDP			0.050			0.033
			(0.17)			(0.14)
Gini index			1.005			0.576
			(1.07)			(0.97)
Constant	-14.634	-54.521	-74.720*	-13.167	-48.378	-59.025*
	(30.10)	(46.44)	(42.07)	(26.37)	(37.49)	(35.59)
R^2	0.804	0.840	0.846	0.803	0.837	0.841
N	31	31	31	31	31	31

Legend: * Significant at 10%. ** Significant at 5%. *** Significant at 1%. Standard errors between brackets.

The correlation between the health share and the COVID-19 death rate holds even if controlling for all these "usual suspects". A one percentage point increase in the share of health expenditures is associated to approximately 4 more cumulated death per 100000

[5] As a caveat, richer people could be in a better health (Semyonov et al 2013), thus could be more resistent to the COVID-19.

people. The coefficient of the health share expenditure in the IV regressions is lower compared to the OLS regressions, suggesting that the effect of a unobserved variable, such as the efficiency of the health system, could be an explanation. However, the coefficient is still positive and statistically significant, revealing a persistent puzzle. It is possible that our instrument is not powerful enough, albeit the Shea's partial R2 (higher than 0.60) and the F-stat>10 suggest that it is (see last lines of Table 3).

The results also show that medical resources appear to be powerful determinants of the success in the fight against the epidemic, a result that has also been emphasized by Khan et al. (2020). Old age also appears to be an important factor, which is in line with the standard facts known about the COVID-19 mortality. On the contrary, macroeconomic variables and variables related to the circulation of the virus are not significant.

TABLE 3 The health share equation: First equation in the 2SLS IV regressions (population weights)

	Model 1 IV	Model 2 IV	Model 3 IV
Obesity rate	0.111	0.037	0.093
	(0.080)	(0.084)	(0.074)
Age (% above 80)	0.962***	0.367	0.825**
	(0.272)	(0.304)	(0.299)
Hospital beds/10,000	0.003***	0.003**	0.002*
	(0.0008)	(0.001)	(0.001)
Medical doctors/10,000	-0.015	0.024	0.018
	(0.031)	(0.010)	(0.037)
Mean temperature		-0.013	-0.012
		(0.073)	(0.070)
Density		0.003	0.003*
		(0.002)	(0.001)
Exports to GDP		-0.030**	-0.032***
		(0.013)	(0.009)
Debt to GDP			-0.007
			(0.007)
Gini index			-0.145*
			(0.007)
Affluence	0.122***	0.113***	0.101***
	(0.018)	(0.028)	(0.025)
Constant	-2.916	1.813	4.392
	(2.372)	(3.368)	(3.059)
N	31	31	31
R2	0.787	0.837	0.867
Shea's Partial R2	0.727	0.637	0.615
F	44.30	16.54	16.46

Legend: * Significant at 10%. ** Significant at 5%. *** Significant at 1%. Standard errors between brackets.

In line with the above-mentioned papers and theory, affluence is strongly correlated with the health share (which justifies its use as an instrument). The Gini index is negatively associated (more egalitarian countries spending relatively more on health care).

As expected, old age (a pull factor) and hospital beds/1,000 people (a push factor) are both associated with higher health shares in a given country. However, the number of doctors per 10,000 population is not associated to higher share of health expenditures.

4. DISCUSSION

We document a positive correlation between the share of health expenditures in the GDP prior to the epidemic and the death rates during the first wave, as it appears in a cross-section of 31 European countries.

We show that the correlation is robust to including the usual suspects in the case fatality regression model. The comparison of the health share coefficient between OLS and IV models suggest that unobserved variables, such as the efficiency of the health care system, can be at work. However, the "puzzle" is still present in IV models that strive to control for such a bias. This might be related to the quality of our instrumental variable, although theory and empirical tests suggest it is a satisfactory choice. Another explanation, difficult to verify, would involve possible heterogeneity in the reporting of the COVID case fatalities.

The COVID-19 death rate equation points out to the essential role played by the medical resources in taming COVID mortality, compared to personal risk and virus circulation factors. In the light of this result, to prepare for a would-be second wave, resource constrained governments might aim to invest in emergency measures to strengthen their hospitals, rather than to impose new lockdowns, which are less efficient and much more harmful for the economy.

In the long run, countries should aim to improve the efficiency of the health care systems, by allowing for additional flexibility following for instance the example of Germany. One should not neglect the lasting economic consequences of the lack of medical preparedness.[6] The EU could help, by developing a common strategy, following the example of the countries which have had the best results in managing both the epidemic and the economic crisis.

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[6] As an example, in the first two quarters of 2020, the GDP fell by 2% and 10.1% in Germany, compared to 5.9% and 13.8% in France (Eurostat, 2020).

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ONLINE APPENDIX.

APPENDIX 1 The efficiency channel

In a very simple way, the health expenditures H can be written as a function of variables related to the demand (pull) and supply (push) for health services, themselves related to the personal characteristics of the population, and public choices about how many resources to dedicate to the health sector:

$$H = AX - \upsilon, \tag{1}$$

where X is the vector of relevant variables and A is the vector of coefficients. υ is an unobserved variable, that captures the efficiency of the medical system. A larger υ requires less health expenditures for the same service.

Then, denoting by Y the mortality factors specific to the COVID-19 other than those included in X, such as the temperature or the degree of country openness, the COVID-19 death rate D is given by :

$$D = BX + GY - \mu\upsilon \tag{2}$$

In this expression, the coefficient $\mu > 0$ captures the effect of the general efficiency of the health care system on the efficiency of treating COVID-19 cases. Replacing υ as implicitly defined by the former equation in the second, we obtain:

$$D = (B - \mu A)X + GY + \mu H \tag{3}$$

When the efficiency factor is brought into the picture, death rates (D) and health expenditures (H) exhibit a positive correlation. The coefficients of variables in the set X are subject to offsetting forces, since both vectors B and A contain positive scalars.

APPENDIX 2. The correlation matrix

	DEATHR~O	HLTHEX~P	OBE~2016	A~802017	A~652017	AGEMED	BEDS2017
DEATHRATIO	1.0000						
HLTHEXTOGDP	0.4428	1.0000					
OBESITY2016	-0.0739	-0.3510	1.0000				
AGABO~802017	0.3615	0.3437	-0.1214	1.0000			
AGEAB~652017	0.1175	0.2043	0.0455	0.8046	1.0000		
AGEMED	0.0139	0.2480	-0.0809	0.7470	0.8331	1.0000	
BEDS2017	-0.3749	-0.2459	0.1894	-0.0009	0.1362	0.3408	1.0000
MED10000	-0.0543	0.3209	-0.1363	0.5120	0.4873	0.5061	0.0243
MEANTEMP	0.0808	-0.1128	0.4462	0.2402	0.3632	0.2538	0.1444
DENSITY	0.0584	0.1959	0.3856	-0.1042	0.0414	0.0564	-0.0344
EXPTOGDP	-0.1447	-0.3660	0.2158	-0.5060	-0.4500	-0.2868	0.0661
DEBTTOGDP	0.3471	0.1894	-0.0073	0.5839	0.3743	0.2168	-0.2020
GINI	0.1283	-0.2466	0.2908	0.3788	0.2931	0.1728	0.1389
AFFLUENCE	0.2595	0.4053	-0.3160	-0.2247	-0.5042	-0.3295	-0.4291
POPMIL	0.5009	0.3783	0.0223	0.4840	0.3187	0.3408	0.0887

	MED10000	MEANTEMP	DENSITY	EXPTOGDP	DEBTTO~P	GINI	AFFLUE~E
MED10000	1.0000						
MEANTEMP	0.1253	1.0000					
DENSITY	-0.1776	0.4997	1.0000				
EXPTOGDP	-0.2427	0.1633	0.4274	1.0000			
DEBTTOGDP	0.2649	0.4299	-0.0268	-0.3703	1.0000		
GINI	0.1541	0.1805	-0.0987	-0.0534	0.1581	1.0000	
AFFLUENCE	-0.0283	-0.3555	0.0116	0.3549	-0.1603	-0.1617	1.0000
POPMIL	-0.0098	0.1870	-0.0016	-0.4266	0.3621	0.2461	-0.0395

APPENDIX 3. The list of countries and the symbol (United Nations) used in the text

Country	Symbol (UN)
Austria	AUT
Belgium	BEL
Bulgaria	BGR
Croatia	HRV
Cyprus	CYP
Czech Republic	CZE
Denmark	DNK
Estonia	EST
Finland	FIN
France	FRA
Germany	DEU
Greece	GRC
Hungary	HUN
Ireland	IRL
Italy	ITA
Latvia	LVA
Lithuania	LIT
Luxembourg	LUX
Malta	MLT
Netherlands	NLD
Poland	POL
Portugal	PRT
Romania	ROU
Slovak Republic	SVK
Slovenia	SVN
Spain	ESP
Sweden	SWE
United Kingdom	GBR
Iceland	ISL
Norway	NOR
Switzerland	CHE

APPENDIX 4. Unweighted OLS regression

	OLS1	OLS2	OLS3	IV1	IV2	I3
HLTHEXTOGDP	4.784**	8.926***	9.419***	9.213*	7.405**	7.188**
	(2.18)	(2.78)	(2.93)	(5.11)	(3.21)	(3.14)
OBESITY2016	1.111	2.161	1.671	1.989	1.776	1.227
	(1.51)	(1.75)	(1.88)	(1.73)	(1.58)	(1.59)
AGABO~802017	10.750**	12.301**	9.223	8.824*	12.525***	9.892*
	(4.36)	(4.94)	(6.15)	(4.68)	(4.20)	(5.05)
BEDS2017	-0.041*	-0.043*	-0.041*	-0.031	-0.045**	-0.043**
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
MED10000	-1.083**	-1.509***	-1.495**	-1.263**	-1.406***	-1.347***
	(0.51)	(0.52)	(0.54)	(0.53)	(0.46)	(0.46)
MEANTEMP		1.274	1.154		1.087	0.851
		(1.08)	(1.27)		(0.95)	(1.07)
DENSITY		-0.042*	-0.039*		-0.035*	-0.029
		(0.02)	(0.02)		(0.02)	(0.02)
EXPTOGDP		0.249*	0.241*		0.215*	0.197
		(0.13)	(0.14)		(0.12)	(0.12)
DEBTTOGDP			0.048			0.053
			(0.14)			(0.11)
GINI			0.982			0.805
			(1.11)			(0.92)
_cons	-40.205	-111.108*	-123.265*	-86.457	-90.848	-92.880
	(46.19)	(58.43)	(61.50)	(66.09)	(57.37)	(57.36)
r2	0.450	0.557	0.575	0.358	0.551	0.563
N	31	31	31	31	31	31

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