# The role of health expenditures in health outcomes: Evidence from the Covid-19 pandemic *

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28 April, 2020

**Abstract**

In this paper, I applied the canonical epidemiology model to study the impacts of health care, showing that health expenditures significantly affected the fatality rate resulting from a COVID-19 outbreak. Using the most up-to-date reported cases and deaths from the European Centre for Disease Prevention Control and the health expenditures from the World Development Indicators, I found that an increase of the GDP-share of total health expenditures by one standard deviation reduced the CFR by 0.5 percentage points, an equivalent of total 15,000 lives worldwide. Furthermore, countries that drew resources from private and external sources on top of the public one had a lower fatality rate from the outbreak.

**Keywords:** Case fatality rate (CFR); Covid-19; Health expenditure; government expenditure; private expenditure.

**JEL Codes: H5, I1**

*I thank the Institute for Applied Economics and Social Value for financial assistance. Data reported in this paper are available in Mendeley Data (doi: 10.17632/4xmz24r2km.1). All of the errors are my own.

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# 1 Introduction

The National Health Service (NHS) is the pride of the United Kingdom [1]. It provides a comprehensive service, free of charge and available to all, irrespective of their background. However, it is often claimed[2] that the NHS has been underfunded because of a decade of government-enforced austerity in the wake of the 2008 financial crisis. This underfunding has put the NHS under immense pressure amid the COVID-19 outbreak, as there is a shortage of everything from personal protective equipment and ventilators to doctors, nurses and trained support staff.

It is, hence, important to build a causal link between health expenditures and health outcomes. However, evidence for such link remains elusive because of a number of challenges. The first challenge arises because health expenditures do not act alone in determining mortality rate, life expectancy and other health outcomes. Instead, health outcomes result from a variety of confounding factors (Nixon and Ulmann, 2006). For instance, life expectancy can be a function of a nutrition regime or environmental conditions (e.g. pollution levels). The second challenge is a lack of data across countries. Most studies focus on either a single country or a subset of countries without applying a global lens. Furthermore, they tend to assess the contemporary relationship between health expenditures and health outcomes. This approach results in two problems. First, there is arguably a time lag between health investment and its outcomes. Second, a reverse causality might occur. Indeed, countries would invest more on health care in response to the deteriorating national health status.

The COVID-19 outbreak provided an excellent opportunity to investigate the return gained from health expenditures. By employing the SIR model from epidemiology literature, I was able to uncover a link between investment in the healthcare system and the case fatality rate during the COVID-19 pandemic. This is because the case fatality rate

[1] A number of surveys, such as Opinium Researchs Pride of Britain in 2016 and the Mintels British Lifestyle in 2018, claimed the NHS was top of the Britains pride list

[2] A 2018 report by the British Medical Association showed that NHS funding would grow 3.4% in real terms each year from 2019/2020 to 2023/2024. Because there would be lack of investment in other areas such as education and training, the overall increase would be closer to 3%. This is far lower than the average growth rate between 1948/1949 and 2016/2017, which was 3.7%.

is a result of health infrastructures, which are the direct result of health expenditures. In addition, as the COVID-19 outbreak is a global crisis, there is a worldwide effort to collect data on the number of cases. To my knowledge, this is the first paper that provides a comprehensive study with more than 200 countries. By using the health expenditures in 2016 to assess the case fatality rate of the COVID-19 pandemic in 2020 there is little chance of the reverse causality. A four-year time lag is an appropriate duration to gauge the impact of health expenditures. And, finally, I took the causation seriously by looking at the impact of past expenditures on present fatality. I also applied an instrumental approach to address the problem of endogeneity.

In this paper, I employed the most up-to-date daily COVID-19 reports, collected by the European Centre for Disease Prevention and Control, on the number of cases and deaths. Furthermore, I used health expenditure data from the World Development Indicators (WDI). The data reported total health expenditures in more than 200 countries, together with components such as public, external and private expenditures. These features allowed me to investigate the comprehensive impact of health expenditures.

To my knowledge, this is the first paper that examines the impact on a health outcome that is often overlooked in the literature: the case fatality rate (CFR). Relative to other popular health outcomes such as mortality rate and life expectancy, the CFR is solely a function of health infrastructure. It allowed me to uncover the direct path from health expenditures to health outcomes.

The result in the paper is striking. An increase of 2.7 percentage points of the share of total health expenditures (one standard deviation) reduced the CFR by 0.5 percentage points, or an equivalent of total 15,000 lives worldwide. The impact varied by the nature of the expenditures. An increase of the share of government expenditures and private expenditures by one standard deviation lowered the CFR by 0.13 and 1.4 percentage points respectively. Perhaps the biggest impact came from external expenditures, where an increase in external expenditures by one standard deviation (0.7 percent of GDP) lowered the CFR by 10 percentage points. These results showed that countries with significant private and external health expenditures coped better with the COVID-19 outbreak as far as CFR was concerned.

The paper is organized as follows. Section 2 provides a brief literature review. Section 3 presents the model that guides my empirical analysis. Section 4 describes the data. Section 5 presents the results. Section 6 provides the sensitivity analysis and Section 7 offers my conclusion.

## 2 Literature review

My paper grows out of an established literature that investigates the link between health expenditures and health outcomes[3]. Berger and Messer (2002) showed that health expenditures, among other factors, had a significant impact on the mortality rate in Organisation for Economic Co-operation and Development (OECD) countries. Cremieux et al. (2005) considered a particular type of expenditures - pharmaceutical spending. They found that Canadian provinces with more pharmaceutical spending had lower infant mortality rates and higher life expectancies. Elola, Daponte and Navarro (1995) showed that the impact of health expenditures changed depending on the type of healthcare system in place: the national health services seemed to be more efficient than the social security systems. Few papers considered a large number of countries in their studies. Jabaa, Balana and Robua (2014) used the life expectancy and the health expenditures from the World Development Indicators (WDI) that covered 175 countries from 1995 to 2010. They found a strong correlation between the input and output of the healthcare system across countries with different income levels and geographical locations.

My paper is also related to a growing literature that employs the epidemiology model, proposed by Kermack and McKendrick (1927) to study the impact of the COVID-19 outbreak. Eichenbaum, Rebelo and Trabandt (2020) applied this model to investigate the macroeconomic impacts of the pandemic. They showed that in response to the disastrous effects of the pandemic, people reduced their consumption and economic activities. These demand and supply forces, while helping to stop the spread of the virus, brought the

[3] For more studies in this literature, please see Nixon and Ulmann (2006)

economy into a major recession. Atkeson (2020) also used this framework to simulate the spread of the virus under various scenarios. While these papers focus on investigating the impacts of the pandemic, my paper aimed to find the degree of our preparedness to this crisis. It will serve as a lesson to our preparation for the next crisis.

# 3 Model

Following the literature on epidemiology (for instance, Anderson and May, 1991, or the more recent Wang et al., 2020) I applied the SIR model in this paper. According to this model, the infectious group (I) grew because of the interaction with the susceptible people (S). A number of the infected people recover (R), while a fraction of them will not make it:

$$\Delta D_t = \pi \Delta I_t \tag{1}$$

In the equation above, the fraction $\pi$ is called the Case Fatality Rate (CFR). I assumed that this CFR is a function of the healthcare system resource. More health expenditures arguably improve the CFR. For instance, COVID-19 patients with severe respiratory problems rely on ventilators for their survival. The chairman of the British Medical Association suggested that a lack of ventilators was a consequence of under-funding the NHS[4].

I model this CFR $\pi$ as a function of the health capacity of the people and the country, as follows:

$$\pi = f(e) = \alpha * e \tag{2}$$

where $e$ refers to the health expenditures in the country. As a result we have:

[4] The Mirror, "Coronavirus: Under-funded NHS is lacking ventilators and intensive care doctors" 15 March 2020

$$\frac{\partial^2 \Delta D_t}{\partial \Delta I_t \partial e} = \alpha \tag{3}$$

The equation above yields the following regression:

$$\Delta D_{it} = \beta_0 + \beta_1 \Delta I_{it} + \beta_2 e_i + \beta_3 \Delta I_{it} e_i + \beta_4 t + \Gamma Z_{it} + F_c + \epsilon_{it} \tag{4}$$

In the equation above, $\Delta D_{it}$ and $\Delta I_{it}$ were the number of new deaths and new cases in country $i$ at time $t$; $e_i$ was the expenditure on health care. The vector of controls $Z_{it}$ included the expected death rate, life expectancy and share of senior population. Moreover, I used the linear trend $\beta_4 t$ to account for the fact that the number of deaths was rising by the day, because the health system was overwhelmed by the number of cases, *ceteris paribus.*

As Europe was the epicenter of the pandemic, it was possible that the virus was more deadly on some continents than on others. I added the continent fixed effect $F_c$ to control for all continent-variant factors. It served to pick up the geographical differences that might affect the number of deaths

My coefficient of interest is $\beta_3 = \alpha$. It shows the impact of health expenditure on the CFR. In Equation 2, the overall health expenditure $e$ is used as the main independent variable. This total expenditure is the sum of three components:

$$\text{Total Expenditure} = \text{Government Expenditure} + \text{External Expenditure} + \text{Private Expenditure}$$

The parameter $\alpha$ in Equation 2 is the average effect of these components. Admittedly, each component has heterogeneous impact on the CFR. The richness of my data allowed me to assess these components separately. In particular, I wrote Equation 2 as:

$$\pi = f(e) = \alpha_g * ge + \alpha_e * ee + \alpha_p * pe \tag{5}$$

Therefore I wrote the marginal effect of each expenditure component as:

$$\frac{\partial^2 \Delta D_t}{\partial \Delta I_t \partial ge} = \alpha_g$$
$$\frac{\partial^2 \Delta D_t}{\partial \Delta I_t \partial ee} = \alpha_e \tag{6}$$
$$\frac{\partial^2 \Delta D_t}{\partial \Delta I_t \partial pe} = \alpha_p$$

which yielded the following regressions:

$$\begin{aligned} \Delta D_{it} = \beta_0 + \beta_1 \Delta I_{it} + \beta_2 ge_i + +\beta_3 pe_i + \beta_4 ee_i + \beta_5 \Delta I_{it} ge_i \\ + \beta_6 \Delta I_{it} pe_i + \beta_7 \Delta I_{it} ee_i + \beta_8 t + \Gamma Z_{it} + F_c + \epsilon_{it} \end{aligned} \tag{7}$$

where $ge_i, pe_i, ee_i$ were the government health expenditure, external expenditure and private expenditure, respectively.

# 4 Data

I used the most up-to-date COVID-19 dataset, provided by the European Centre for Disease Prevention and Control. It contained the daily number of new cases and new deaths in each country in the entire world, beginning on December 31, 2019, and running through April 23, 2020.

Furthermore I used another dataset from the WDI. It contained information on the factors that could affect the CFR, such as the expected death rate in the country, the life expectancy and the share of the senior population (aged 65 and above). This information was only available through 2018. But most importantly, WDI reported the current health expenditure of each country. It was the level of current health expenditure expressed as a percentage of GDP. Estimates of current health expenditure included healthcare goods and services consumed during each year. This indicator did not include capital health expenditure such as buildings, machinery, IT and stocks of vaccines for emergencies or outbreaks.

In addition to the total expenditure, it also reported each component of the expenditures. In particular, it contained information on government expenditure, external expenditure and private expenditure. Among them, external sources were composed of direct foreign transfers and foreign transfers distributed by government encompassing all financial inflows into the national health system from outside the country. Private health expenditure included direct household (out-of-pocket) spending, private insurance, charitable donations, and direct service payments by private corporations.

The data also contained a special component of private expenditure, which is out-of-pocket spending. That was defined as any direct outlay by households, including gratuities and in-kind payments, to health practitioners and suppliers of pharmaceuticals, therapeutic appliances, and other goods and services whose primary intent was to contribute to the restoration or enhancement of the health status of individuals or population groups.

I used the health expenditures in 2016 for two main reasons. First it was the latest available year that had a wide coverage of countries. Second it is likely that the health expenditures in 2016 had an impact on the health outcomes in 2020, while it is less likely that a reverse causality took place.

Table 1 shows the summary statistics of key variables. We can see that in a typical day, there are 212 new cases with 15 deaths per country. Health expenditures accounted for 7 percent of GDP. Two thirds of these expenditures came from the public source. External expenditure accounted for less than 5 percent of the total expenditure.

In terms of expenditures per capita, countries spent on average $1,578 USD on each persons health, or 2,029 in Purchasing Power Parity (PPP) price. About one-fifth of these expenditures were made directly by the households.

**Table 1:** Summary Statistics

| VARIABLES | (1) Obs | (2) mean | (3) s.d. | (4) min | (5) max |
|---|---|---|---|---|---|
| Number of new cases | 12,206 | 211.9 | 1,502 | 0 | 37,289 |
| Number of deaths | 12,206 | 14.97 | 117.4 | 0 | 4,928 |
| Health Exp. (% GDP) | 11,399 | 6.849 | 2.757 | 1.750 | 17.07 |
| Govt. Exp. (%GDP) | 11,399 | 4.077 | 2.646 | 0.425 | 13.97 |
| Private Exp.(%GDP) | 11,399 | 2.524 | 1.433 | 0.0849 | 8.125 |
| Ext. Exp. (%GDP) | 8,812 | 0.319 | 0.710 | 0 | 6.777 |
| Health Exp. per capita (USD) | 11,359 | 1,578 | 2,133 | 16.4 | 9,870 |
| Health Exp. per capita (PPP) | 11,246 | 2,029 | 1,996 | 29.9 | 9,870 |
| Out-of-pocket per capita (USD) | 11,359 | 312 | 394 | 1.47 | 2,908 |

# 5 Results

Table 2 reports the results of Regression 4. The covariates had the effects that were expected. More precisely, the expected death rate and the life expectancy that indicated the general health of the population had a negative impact on the number of deaths from the COVID-19 outbreak. This number, however, got worse when the share of senior population was large and as the pandemic progressed. For instance, *ceteris paribus*, the number of deaths increased by 1 every 10 days.

What is of particular interest is the coefficient of the interaction term $\beta_3$ in the Regression 4. Column 1 of Table 2 shows that an increase of 10 percentage points of the share of current health expenditure in the GDP resulted in a reduction of 2 percentage points in the CFR. Put another way, an increase of this share by one standard deviation (i.e. 2.7 percent of the GDP) lowered the CFR by a 0.5 percentage point. As the number of worldwide cases has reached more than 3 million, this result indicates that more than 15,000 lives in the world would be saved. Columns 2 and 3 in Table 2 report the impact of current health expenditure per capita. The results were interestingly significant. For every $1,000 USD of additional health spending per person, the CFR fell by 0.3 percentage points, an equivalent of 9,000 lives.

Health expenditures can come from different sources: public, private or external. It is interesting to see the impact of each source, as expressed in Equation 5. From Column 1 of Table 3, we see that the marginal impact of private expenditure seems to exceed that of public expenditure. In particular, if we increased the share of public health expenditure and private expenditure in a country's GDP by 10 percentage points, the CFR would decrease by 0.5 and 10 percentage points, respectively. Given that the standard deviation of the public health expenditure was twice as large, an increase in the share of public expenditure by one standard deviation achieved a reduction in the CFR that was one-tenth of the same increase in the share of private expenditure. The impact of external health expenditure was also strikingly significant. An increase in its share by one standard deviation (i.e. 0.7 percent of the GDP) lowered the CFR by 10 percentage points. All these results point to the importance of private and external expenditures. In other words, although public expenditures are still very important (they accounted for two-thirds of total expenditures) additional sources of expenditures might prevent the national health system from being under-funded and under-prepared for a health crisis.

Columns 2 and 3 in Table 3 provided further evidence of the impact of each component. More precisely, if the government allocated an additional 10 percent of its total expenditure to health care, the CFR could be lowered by 1 percentage point (Column 2). And if every resident could afford to spend $1,000 USD out-of-pocket on health care, the CFR could be reduced by 2 percentage points (Column 3).

# 6 Sensitivity analysis

To draft effective policies, the relationships that research uncovers must stem from causality rather than correlation. The first issue with the identification strategy is the possibility of reverse causality. It is possible that countries will invest more on health care after experiencing the disastrous effects of the outbreak. However, in my analysis the expenditures were made three years before the outbreak, making this concern less likely.

Another issue is that both health expenditures and COVID-19 death rates stem from

**Table 2:** The role of current health expenditure

| | (1) Number of deaths | (2) Number of deaths | (3) Number of deaths |
|---|---|---|---|
| Number of new cases | 0.098*** | 0.090*** | 0.092*** |
| | (0.002) | (0.001) | (0.001) |
| Current Health Expenditure (%GDP) | -0.468 | | |
| | (0.338) | | |
| Cases#Current Health Expenditure | -0.002*** | | |
| | (0.0001) | | |
| Current Health Expenditure per capita (1000 USD) | | -2.689*** | |
| | | (0.479) | |
| Cases#Current Health Expenditure per capita | | -0.003*** | |
| | | (0.0001) | |
| Current Health Expenditure per capita (PPP price) | | | -3.021*** |
| | | | (0.543) |
| Cases#Current Health Expenditure per capita (PPP price) | | | -0.003*** |
| | | | (0.0002) |
| Expected Death rate | -5.294*** | -7.393*** | -6.763*** |
| | (0.919) | (0.977) | (0.948) |
| Life expectancy | -1.894*** | -2.371*** | -1.979*** |
| | (0.420) | (0.421) | (0.415) |
| Share of population aged over 65 | 267.569*** | 382.986*** | 344.942*** |
| | (53.351) | (55.277) | (53.227) |
| Days in the pandemic | 0.099*** | 0.095*** | 0.095*** |
| | (0.022) | (0.022) | (0.022) |
| Continent FE | YES | YES | YES |
| Observations | 11047 | 11007 | 10894 |
| R-squared | 0.703 | 0.708 | 0.707 |
| Adj. R-squared | 0.703 | 0.707 | 0.707 |

Note: Standard errors in parentheses. The coefficients are estimated from Equation 4.

* p<0.1, ** p<0.05, *** p<0.01

**Table 3:** The role of health expenditure by components

| | (1) Number of deaths | (2) Number of deaths | (3) Number of deaths |
|---|---|---|---|
| Cases#Government Health Expenditure | -0.0005** | | |
| | (0.0002) | | |
| Cases#Private Health Expenditure | -0.010*** | | |
| | (0.001) | | |
| Cases#External Health Expenditure | -0.149** | | |
| | (0.065) | | |
| Cases#Government Health Expenditure (%Government Expenditure) | | -0.001*** | |
| | | (0.00004) | |
| Cases#Out-of-pocket expenditure per capita (1000USD) | | | -0.023*** |
| | | | (0.002) |
| Continent FE | YES | YES | YES |
| Observations | 8718 | 11091 | 11007 |
| R-squared | 0.755 | 0.711 | 0.702 |
| Adj. R-squared | 0.755 | 0.711 | 0.702 |

Note: Standard errors in parentheses. The coefficients are estimated from Equation 7.

* p<0.1, ** p<0.05, *** p<0.01

some common but omitted factors. For instance, the general state of health in a country can influence both the expenditures and the CFR. In my setting, these factors were already controlled by the life expectancy, the expected death rate and elderly population.

Although the omitted variable concern is partially addressed as mentioned above, one cannot be entirely sure if all the omitted variables are considered. One way to address this problem is to apply the Instrumental Variable (IV) method (Wooldridge, 2010, section 5.3). The main challenge of this approach is to find the appropriate instrument for health expenditures. Newhouse (1987) was the first to draw attention to the strong positive relationship between per capita health spending and per capita GDP. His findings were then confirmed and expanded upon by others (Parkin, McGuire and Yule, 1987; Di Matteo, 2000; Braendle and Colombier, 2016). In addition to income per capita, other candidates were suggested, such as the share of senior population or life expectancy (L. Di Matteo and R. Di Matteo, 1998; D. Cantarero, 2003; Bilgel and Tran, 2013).

In this study, I used the income per capita as the instrument for two main reasons. First, income per capita seemed to be the most-preferred instrument (Ke, Saksena and Holly, 2011; Lago-Penas, Cantarero-Prieto and Blazquez-Fernandez, 2013). Second, other instruments, such as the share of senior population or life expectancy, are likely to affect our dependent variable, which violates the instrument exogeneity condition. These factors were already controlled in my regression specifications.

The first stage statistics are reported in the on line Appendix. Table 6 in the Appendix presents the first stage statistics. In Panel A, the estimated coefficients of the instruments, i.e. GDP per capita at purchasing power parity and its interaction with the number of new COVID-19 cases, were reported. The coefficients in Columns 1 and 2 correspond to the regression in Column 1 in Table 2, while the coefficients in Columns 3 and 4 correspond to the regression in Column 2 in Table 2. In all specifications, the estimated coefficients were statistically significant, which show the relevance of my instruments.

Panel B in Table 6 reports further tests for my IV. The Sargan-Hansen test showed that my instruments are valid, i.e. they were uncorrelated with the error terms and all the excluded instruments were correctly excluded. In other words, the equations were exactly identified. Furthermore, both the Anderson (1951) canonical correlation test and the Cragg and Donald (1993) test revealed that the rank condition is satisfied, i.e. the model was not under-identified. Finally, the hypothesis of weak instruments was rejected by the conventional Anderson and Rubin (1949) and the Stock and Wright (2000) tests and the more recent Sanderson and Windmeijer (2016) test.

Table 4 reports the estimated coefficients with the IV approach. Relative to the results shown in Table 2 with the OLS estimators, the estimated coefficients were qualitatively and quantitatively similar.

Another sensitivity concern was the time period used in calculating the CFR. In Equation 1 the CFR was calculated as the ratio of the number of new deaths with respect to the number of new cases on the same day. However, the people who passed away might have tested positive in the days before their death. In particular, if people who tested positive passed away one day later, we can rewrite Equation 1 as follows:

$$D_t = \pi I_{t-l} \tag{8}$$

In order to check whether my results were sensitive to the time lag between the test and the time the patient passed away, I chose l equals one week and rewrote Regression 4 as follows:

$$D_{it} = \beta_0 + \beta_1 I_{i,t-7} + \beta_2 e_i + \beta_3 I_{i,t-7} e_i + \beta_4 t + \Gamma Z_{it} + F_c + \epsilon_{it} \tag{9}$$

Table 5 reports my results with the new regression. Again relative to my results in Tables 2 and 3, the estimated coefficients were qualitatively and quantitatively similar. Put another way, my results were not sensitive to the time lag chosen when calculating the CFR.

**Table 4:** IV treatment

| | (1) Number of deaths | (2) Number of deaths |
|---|---|---|
| Current Health Expenditure(%GDP) | 24.70*** | |
| | (6.78) | |
| Current Health Expenditure(%GDP)#Cases | -0.003*** | |
| | (0.0003) | |
| Current Health Expenditure per capita | | -3.40*** |
| | | (0.80) |
| Cases#Current Health Expenditure per capita | | -0.002*** |
| | | (0.0002) |

Note: All the controls as in Regression 4 are included. The regressions in Columns 1 and 2 correspond to the ones in Columns 1 and 2 in Table 2, respectively.
* p<0.1, ** p<0.05, *** p<0.01

**Table 5:** The role of current health expenditure - One week lag

| | (1)<br>Number of deaths | (2)<br>Number of deaths | (3)<br>Number of deaths | (4)<br>Number of deaths |
|---|---|---|---|---|
| Cases#Current Health Expenditure | -0.002*** | | | |
| | (0.000) | | | |
| Cases#Current HealthExpenditure_pc | | -0.002*** | | |
| | | (0.000) | | |
| Cases#Current Health Expenditure per capita (PPP price) | | | -0.003*** | |
| | | | (0.000) | |
| Cases#Government Health Expenditure (%GDP) | | | | 0.001*** |
| | | | | (0.000) |
| Cases#Private Health Expenditure (%GDP) | | | | -0.013*** |
| | | | | (0.001) |
| Cases#External Health Expenditure (%GDP) | | | | -0.135* |
| | | | | (0.074) |
| Expected Death rate | -5.013*** | -6.907*** | -6.198*** | -1.580* |
| | (0.885) | (0.940) | (0.914) | (0.853) |
| Life expectancy | -1.807*** | -2.261*** | -1.922*** | -0.658* |
| | (0.404) | (0.406) | (0.401) | (0.382) |
| Share of population aged over 65 | 252.645*** | 360.138*** | 318.140*** | 64.909 |
| | (51.135) | (52.908) | (50.994) | (49.692) |
| Days in the pandemic | 0.117*** | 0.115*** | 0.115*** | 0.094*** |
| | (0.022) | (0.022) | (0.022) | (0.021) |
| Observations | 9705 | 9672 | 9568 | 7559 |
| R-squared | 0.788 | 0.791 | 0.79 | 0.848 |
| Adj. R-squared | 0.788 | 0.79 | 0.79 | 0.847 |

Standard errors in parentheses. The coefficients are estimated from Equation 9. Columns 1 and 2 correspond to the

* p<0.1, ** p<0.05, *** p<0.01

# 7 Conclusions

In this paper, I applied the canonical epidemiology model to study the impacts of health expenditures. By allowing the case fatality rate to be a direct function of this variable, I showed that it had a significant impact. An increase of the GDP-share of total health expenditure by one standard deviation reduced the CFR by 0.5 percentage points, an equivalent of 15,000 lives. If we could afford to spend $1,000 USD more per person, we could lower the CFR by 0.3 percentage points, or 9,000 lives.

More interestingly, the paper showed the importance of other sources of health expenditures. In particular, the marginal effect of private and external expenditures were ten times as large as that from public expenditures. Therefore, while public expenditures remained a very important component of the national healthcare system (they accounted for two-thirds of total health expenditures), countries should not rely entirely upon this component. Instead, more source diversification will help countries prepare better with a health crisis.

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# References


**Anderson, R., and R. May.** 1991. *Infectious Diseases of Humans: Dynamics and Control.* Oxford University Press.

**Anderson, T. W.** 1951. "Estimating linear restrictions on regression coefficients for multivariate normal distributions." *Annals of Mathematical Statistics*, 22: 327351.

**Anderson, T. W., and H. Rubin.** 1949. "Estimation of the parameters of a single equation in a complete system of stochastic equations." *Annals of Mathematical Statistics*, 20: 4663.

**Atkeson, A.** 2020. "What will be the economic impact of COVID-19 in the US? Rough estimates of disease scenarios." mimeo.

**Berger, and Messer.** 2002. "Public financing of health expenditures, insurance, and health outcomes." *Applied Economics*, 34: 21052113.

**Bilgel, F., and K. Tran.** 2013. "The determinants of Canadian provincial health expenditures: evidence from a dynamic panel." *Applied Economics*, 45: 201–212.

**Braendle, T., and C. Colombier.** 2016. "What drives public health care expenditure growth? Evidence from Swiss cantons, 1970-2012." *Health Policy*, 120(9): 1051–60.

**Cantarero, D.** 2003. "Decentralization and health care expenditure: the Spanish case." *Applied Economics Letters*, 12: 933–6.

**Cragg, J. G., and S. G. Donald.** 1993. "Testing identifiability and specification in instrumental variables models." *Econometric Theory*, 9: 222240.

**Cremieux, Mieilleur, Ouellette, Petit, Zelder, and Potvin.** 2005. "Public and private pharmaceutical spending as determinants of health outcomes in Canada." *Health Economics*, 14: 107116.

**Di Matteo, L.** 2000. "The determinants of the public private mix in Canadian health care expenditures: 1975 1996." *Health Policy*, 52: 87–112.

**Di Matteo, L., and R. Di Matteo.** 1998. "Evidence on the determinants of Canadian provincial government health expenditures: 1965 1991." *Journal of Health Economics*, 17: 21128.

**Eichenbaum, M., S. Rebelo, and M. Trabandt.** 2020. "The Macroeconomics of Epidemics." NBER working paper 26882.

**Elola, J., A. Daponte, and V Navarro.** 1995. "Health indicators and the organization of health care systems in western Europe." *American Journal Public Health*, 85(10): 13971401.

**Jabaa, E., C. Balana, and I. Robua.** 2014. "The relationship between life expectancy at birth and health expenditures estimated by a cross-country and time-series analysis." *Procedia Economics and Finance*, 108–114.

**Kermack, W., and A. McKendrick.** 1927. "A Contribution to the Mathematical Theory of Epidemics." *Proceedings of the Royal Society of London*, 115(772): 700–721.

**Ke, X., P. Saksena, and A. Holly.** 2011. "The Determinants of Health Expenditure: A Country-Level Panel Data Analysis." World Health Organization.

**Lago-Penas, S., D. Cantarero-Prieto, and C. Blazquez-Fernandez.** 2013. "On the relationship between GDP and health care expenditure: A new look." *Economic Modelling*, 32: 124–129.

**Newhouse, J.P.** 1987. "Cross-national differences in health spending: What do they mean?" *Journal of Health Economics*, 6: 159–162.

**Nixon, J., and P. Ulmann.** 2006. "The relationship between health care expenditure and health outcomes: Evidence and caveats for a causal link." *European Journal Health Economics*, 7: 7–18.

**Parkin, D., A. McGuire, and B. Yule.** 1987. "Aggregate health expenditures and national income: is health care a luxury good." *Journal of Health Economics*, 6: 10927.

**Sanderson, E., and F. Windmeijer.** 2016. "A weak instrument F -test in linear IV models with multiple endogenous variables." *Journal of Econometrics*, 190: 212–221.

**Stock, J. H., and J. H. Wright.** 2000. "GMM with weak identification." *Econometrica*, 68: 10551096.

**Wang, Huwen, Z. Wang, Y. Dong, R. Chang, C. Xu, X. Yu, S. Zhang, L. Tsamlag, M. Shang, J. Huang, Y. Wang, G. Xu, T. Shen, X. Zhang, and Y. Cai.** 2020. "Phase-adjusted estimation of the number of coronavirus disease 2019 cases in Wuhan, China." *Cell Discovery*, 6(1): 1–8.

**Wooldridge, J.** 2010. *Econometric Analysis of Cross Section and Panel Data.* . 2 ed., MIT Press.