The macroeconomic determinants of COVID-19 mortality rate and the role of post subprime crisis decisions

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Abstract

We investigate, for the first time, the empirical drivers of the Covid-19 cross-country mortality rates at a macroeconomic level. The intensity of the pandemic (number of infected people), the demographic structure (proportion of people age 65 or above) and the openness degree (number of tourists arrivals) seem to be significant predictors in addition to health infrastructures (number of hospital beds, physicians). We also find that the subprime crisis and the austerity policies conducted in certain countries, by reducing the public health expenditures in the last ten years and altering the adaptation capacity of the health system, have probably intensified the tragic consequences of the Covid-19 pandemic. Pollution seems to have only played a marginal role as well as control strategies (travel restrictions, testing policy). We do not find consistent effects against the Covid-19 virus due to past exposal to other types of epidemics like Malaria or Tuberculosis.

Keywords: Covid-19 pandemic, fatalities, macroeconomic drivers, health infrastructure, health spending, Covid-19 control strategies, pollution, immunity, austerity policies.

1. Introduction

The coronavirus 2019 (COVID-19), as labelled by the World Health Organization (WHO), has been declared to cause Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) since it was first described in China in last December 2019. Some countries experienced more tragic consequences than other ones, with higher levels of mortality rates. For Rubino et al. (2020), the disparity in the differences in the total number of fatalities between Italy and China suggests that investigation into several factors, such as the demographic structure, sociological interactions, availability of medical equipment, variants in immune proteins or past immunity to related CoVs. More generally, we need to better understand the drivers of the Covid-19 spread and thus the links between many macroeconomic factors and the virus outbreak.

While China, most of Asian and European countries are unlocking the coronavirus lockdown, populations from these countries are starting to ask governments leaders to justify the policies they decided to implement in recent months to fight the pandemic (about testing, masks wearing, delay of reaction against virus) but also about economic, social and health policies conducted in a longer horizon. The discontent of caregivers in the face of the lack of

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investment in hospitals and reduction of some health expenditures last years lead to social disturbances and threat to break the sustainability of the current health system. Growing inequalities induced by the current crisis are likely to intensify these social disturbances in next months or years to come. Very recently, legal proceedings to attack the bad management of some governments face the Covid-19 have been launched. Recently, Dalglish (2020) wrote that the US and UK Governments have provided among the world's worst responses to the pandemic, with sheer lies and incompetence from the former, and near-criminal delays and obfuscation from the latter. The need of suitable policies is crucial regarding the importance of public speeches. Ajzenmann et al. (2020), working on Brazil case study, suggest that statements on public health behavior from political leaders are taken seriously by their followers, regardless of how scientifically accurate they are.

As a consequence, we need to better investigate the role of governments as well as macroeconomic drivers of the Covid-19 epidemic. What are the drivers of the Covid-19 pandemic and potential explanations of the cross-country fatalities differences? Is the mortality rate the output of a stochastic process? In contrast, can we explain the cross-country differences about mortality rates by some socio-macroeconomic factors and by the different public policies conducted by the governments during the pandemic crisis and even before?

At this time, the economic research articles concerning the Covid-19 virus focus mainly on epidemiologic and microeconomic theoretical issues and mostly on social distancing. For example, Alvarez et al. (2020) study the optimal lockdown policy for a central planner, Toxvaerd (2020) investigates optimal social distancing and Greenstone and Nigam (2020) monetize the benefits of this social distancing. On a macroeconomic point of view, Bodenstein et al. (2020) also show that social distancing can reduce the economic costs generated by the pandemic in terms of output, consumption and investment. The features of the Covid-19 economic crisis and the expected macroeconomic policy actions to mitigate the economic damages from the pandemic have been recently discussed by Baldwin and Weder di Mauro (2020a and 2020b) and Gerrieri et al. (2020). De Ridder (2020) investigated more precisely the multipliers during the pandemic**.**

However, we also need to empirically investigate the macroeconomic drivers of the crisis intensity and evaluate the role of governments and public policies in the dynamics of the epidemic across countries. To this aim, we build a cross-section dataset of 125 countries after collecting data from World Bank about demographics structure, health infrastructures and spending as well as tourism flows and we add some more original data about control and restriction policies such as testing or travel restrictions.

We find that structural determinants such as demographics, tourism arrivals, health infrastructures and epidemic dynamics are significant drivers of deaths ratios across countries. Air quality and, more importantly, control strategies seem to have played only a minor role. Finally, we find evidence that the relative disinvestment in health systems in the last years in lots of industrialized countries might be partially at the origin of the dramatic mortality Covid-19 rates. Austerity policies implemented consecutively to the subprime crisis have probably intensified the severity of the current Covid-19 crisis, by altering the sustainability of the health system and its adaptation capacity. Our preliminary macroeconomic work shows for the first time the importance of the public policies played in the last years in the dramatic effects of such a pandemic.

2. Theoretical background and assumptions

The Covid-19 spread is related to microeconomic and macroeconomic drivers. Microeconomic aspects (the health level of individuals, hygiene attitudes etc) are obviously not completely taken into account *via* this macroeconomic model. However, we think that macroeconomic drivers are important factors to explain the cross-country differences among the virus intensity and capture a large part of the variance of the fatality rates. We consider several Covid-19 factors: the dynamics of the epidemic as well as demographics, health infrastructures, openness degree, pollution, education level and control strategies to explain the cross-countries differences about the dramatic intensity of the Covid-19 virus.

Our assumptions can be detailed as following:

- We first consider the time series dynamics of the Covid-19 outbreak. The number of infected cases (normalized to the population) is taken into account to capture the dynamics of the epidemic in a given country. We easily understand that higher infected cases in a given country are likely to lead to higher number of potential deaths in this country. This assumption can be motivated by a direct size effect and an indirect saturation point effect: too much people arriving in hospitals at the same time can generate supplementary number of deaths in the hospitals. That's why lockdown policies are necessary to flat the epidemic curve and minimize this effect. A recent study in France (Roux et al., 2020) estimated that the lockdown policy to flat the epidemic curve avoided 60000 supplementary deaths. Using the Ferguson et al. (2020) simulation model of COVID-19's spread and mortality impacts in the United States, Greenstone and Nigam project that 3-4 months of moderate distancing beginning in late March 2020 would save 1.7 million lives by October 1. Previously, Tobias (2020) evaluates the lockdown policies in Spain, Italy after one-month follow-up and find a change in the trend slope for both countries confirming the successful restricting policies in flattening the epidemic curves.
- We take into account demographic factors. The age structure of the population is also expected to be a major driver considering the nature of the virus that particularly hit the older adults – age over 65 years old – and the more vulnerable people (see Zheng et al., 2020; Du et al., 2020 among others). Dowd et al. (2020) examine the role of age structure in deaths in Italy and South Korea and illustrate

how the pandemic could unfold in populations with similar population sizes but different age structures. Since the virus is more likely to affect countries with the most important parts of older people, we will control for the number of over 65 ages and above people in our regressions and expect a positive effect of the dependency rate on mortality ratio. Countries like Italy have been probably strongly impacted by the pandemic than South Korea due to the different age structures. Bayer and Kuhn (2020) go beyond this assumption: when the population between age 30-49 who live with their parents is important in one country, the fatality rate is more important in this country and intensifies the effect of the age dependency structure. In this preliminary study, we focus primarily on the direct proportion of older people in the studied countries.

- Control strategies like social distancing or school closure are likely to stop the spread of the virus (Zhang et al., 2020). More generally, current short-run policies and control strategies such as travel restrictions, surveillance and tracking/testing policies can help to reduce the Covid-19 spread. Different strategies were used to selectively control travelers entering Singapore, Japan or Hong-Kong from mainland China and then from northern Italy, Iran, and South Korea (Legido-Quigley et al., 2020). We try to investigate if such policies have helped to reduce the mortality rate using a hand-collected set of binary variables measuring the degree of testing or surveillance strategies and travel restrictions. Kucharski et al. (2020) empirically demonstrate that the Wuhan Covid-19 transmission declined during late January, 2020 coinciding with the introduction of travel control measures in contrast with modest effects detected by Chinazzi et al. (2020).
- The health infrastructures (number of physicians, hospitals beds, etc…) are expected to be key macroeconomic drivers of the mortality rates differences across countries. Indeed, The COVID-19 pandemic has tested the capacity of health systems worldwide. The surge in coronavirus cases has crippled health systems in many countries, due to shortage of hospital beds, manpower and equipment (personal protective equipment, ventilators) whereas the supply of essential resources (like manpower, protective gear) can be inelastic in the short term. Germany has experienced lower mortality rates than France or Italy since the beginning of the crisis, probably considering higher number of hospital beds and equipments. In this way, the situation for developing countries might be particularly tragic if the number of infected cases would strongly increase in developing countries. Sustainable public spending in health infrastructures is thus necessary to prevent dramatic effects of epidemics. Beyond health infrastructures and equipments, some countries have prevented smaller transmission chains from amplifying into widespread community transmission since the health systems in these locations (Singapore, Hong-Kong, Japan) have generally been able to adapt (Legido-Quigley et al., 2020).
- The supply of essential resources (like manpower, protective gear) can be inelastic in the short term (Singh et al., 2020) and so a sustainable investment in health by

maintaining or increasing health expenditures over time is essential to reduce the dramatic consequence of epidemics. Thus, we consider health expenditures and more precisely health expenditures dynamics (recent growth rates during the last three or four our ten years) as a proxy of health system sustainability. We expect that higher health expenditures have helped countries to reduce the negative consequences of Covid-19 outbreak. In contrast, we expect that negative consequences from the subprime crisis and consecutive austerity policies, especially in Europe, by reducing the trends in public health spending (OECD, 2018), can be partly responsible of the severity of the current Covid-19 crisis, by reducing the number and quality of equipment as well as reducing the frequency of visits to the doctor and thus virus detection and care. We thus compute different growth rates of public health spending over the three, four and last ten years to investigate the impact of the health investment on the Covid-19 number of deaths.

- The original presence of the virus and then virus spread is initially linked to clusters existence. The emergence of patient zero and then clusters can be linked to tourism and airport flows. For example, we can assume that COVID-19 has been imported in Europe and America from China through work-related travels. Indeed, the virus would be present in Europe or USA since the military games in Wuhan in last October. Tourists arrivals variable is used to proxy this phenomenon. Besides, population density can exacerbate initial clusters and the presence of “patient zero” (see for example Ahmadi et al., 2020).
- We control the air quality by adding the CO2 emissions. Indeed, high levels of pollution and bad air quality are expected to increase the spread of the virus and increase the mortality rate. Pollution is indeed a factor that is likely to perturb the immune system and thus increase the spread of infectious diseases (Caren 1981; Bauer et al. 2012) like the coronavirus. More specifically, very recent empirical studies have explored the possibility of a link between pollution levels and the lethality of Covid-19; pollution may therefore have already "weakened the respiratory system, which is then less well equipped to fight the virus” (Ogen, 2020).
- We try to test if education level can help to reduce the intensity of the Covid-19. Indeed, education can help people to better respect the social distancing, the mask wearing, the testing procedures and other hygiene’s behaviors. Schooling variable is used but on a more structural view we also test the level of education expenditures. Finally, the growth rate of education expenditures over the last years is also calculated.
- We finally examine if some countries have been able to develop immunity against the Covid-19 virus due to past exposal to other types of epidemics like Malaria or Tuberculosis. Indeed, some researchers assumed that some drugs commonly used to fight the Malaria like the Chloroquine phosphate have shown apparent efficacy against Covid-19 virus and can help to reduce the intensity of the virus and thus the mortality rates. (Gao et al., 2020).

Performing a cross-section study about Covid-19 pandemic implies specific issues to take into account. Indeed, the pandemic is mostly localized in developed countries and the number of cases and deaths is concentrated in some developed countries. As a consequence, it is difficult to test some variables due to lack of observations and under representation across countries. Some variables can have unexpected signs: for example, when we want to empirically test the "Covid-19" testing policies, we are likely to find a positive relationship between the mortality ratio and the "testing" variable. In other words, more testing in a country (like in Germany, US, Singapore, South Korea) would increase the fatality rate of the virus. This result has no sense but could be explained by the fact that only few countries and only few developed countries – not developing countries for economic reasons – have implemented this systematic testing policy. The same is possible for tracking policies. Finally and most importantly, we need to take into account similar issues for health indicators like the under five years mortality rate, neonatal rate that are "development indicators" due to the fact that these indicators reveal large differences between developing countries and developed one but no clear-cut differences among developing countries that are largely represented in our dataset. We encounter the same problem when we want to test the immunity effect. If the number of Covid-19 cases in some developing countries could be explained by the fact that people are already in touch with some important viruses like Malaria or Tuberculosis, this effect is difficult to test at a large world scale with cross-section data considering over-representation (for the moment) of this kind of epidemics in developing countries.

3. Methodology and data

We consider a macroeconomic model in which the ratio of Covid-19 deaths to population is explained by different macroeconomic factors: health variables (number of hospital beds, number of physicians, specialists), public policies towards health and education (health expenditures over GDP in levels and in growth rate, education expenditures over GDP and growth rates over the last years), population variables (age structure of the population proxied by the ratio of over 65 people over the entire population, population density), environmental and air variables (CO2 emissions). Current measures and control strategies to mitigate the Covid-19 outbreak have been instituted since last January in China and last February in Europe or March in US and over the world. Thus, several control strategies and health system adaptation have been also considered: travel restrictions, testing and surveillance policies. The number of infected cases (also normalized to the population) is taken into account and proxies the dynamics of the epidemic in a country and the likelihood of a congestion effect in hospitals.

All macroeconomic variables have been collected from World Bank for 125 countries. The number of Covid-19 infected cases (as a cumulated value) and the number of official deaths have been collected from the popular John Hopkins University on 28th April 2020. The data about current Covid-19 policies and control strategies have been hand-collected from S. Porcher (2020). Considering the lack of available data for some variables, the number of observations falls to 69 countries for some specifications. In addition, the intensity of the epidemics did not cover all areas of the globe and some countries experienced only very low number of infected people; for robustness issues, we consider only countries with a positive number of Covid-19 cases. The list of remaining countries available for the different specifications can be found in appendix. Although a bit different for tables 1, 2 and 3 respectively, the samples lead to similar conclusions.

We estimate a model of the following form:

$Deaths\ ratio_i = \beta_{0+}\beta_1 EpidemicDynamics_i + \beta_2 Demographics_i + \beta_3 Health_i + \beta_4 Openess_i + \beta_5 Strategies_i + \beta_6 Pollution_i + \beta_7 Immunity_i + u_i$ with i denotes the country index and *u* an *iid* error term.

The fatality ratio is computed as cumulated deaths divided by population. This endogenous variable is a linear function of a set of covariates: Epidemics dynamics is proxied by the number of infected people (Covid-19 cases) to take into account the fact that more infected people are likely to lead to a higher number of deaths (size effect, high burden to manage for the health infrastructures and hospitals etc…). Demographics is mainly captured by the age dependency ratio i.e. the old-age part of the population (part of people 65 ages and above divided by the total population). We also control for the population density (people per squared km of land area). Health infrastructures variables are captured by the number of beds in hospitals and the number of physicians (alternatively to avoid collinearity).We also test the sustainability of the health system by computing the growth rates of health expenditures between 2007 and 2017 (last available data) and last 4 years (2013 to 2017) to evaluate the impact of the recent policies. Openness is referred as the exposure over the world; we use the number of tourist's arrivals as a proxy of this openness degree and probability that an infected foreigner introduce the virus in another country. Finally, we use a set of control strategies and policies variables to investigate the effects of travel restrictions and testing or surveillance strategies consisting in tracking infected people and massively test the presence of Covid-19 immunity into the population. Pollution is tested since air quality is likely to intensify the Covid-19 spread. Note that we also test education policies in the same way considering that high level of education can help populations to better apply social distancing and barriers to the virus. In addition, we tested the interaction between Covid-19 between other viruses like Malaria and Tuberculosis.

In a first step, we first estimate the previous model by Ordinary Least Squares. Considering potential heteroscedasticity issues regularly present in cross-countries studies, we use Hubert-White standard errors corrections. In a second step, regarding both potential heteroscedasticity and eventual endogeneity issues in our model, we also compute GMM regressions to test the robustness of our previous OLS results.

4. Results

OLS results are displayed in tables 1 and 2 and some GMM estimations are presented in Table 3 as a robustness check. These results show that demographics and health variables are significant at usual confidence levels and have expected signs: a high number of hospital beds or a high number of physician's density can help to reduce the mortality indicator. Countries with a high number of bed hospitals and physicians are probably better armed to fight the virus. Other proxies like neonatal or under five years mortality rates have been used instead and give not significant results. The rationality behind this result is linked to the overrepresentation of developed and emerging countries experiencing lot of Covid-19 cases in the database. However, it is well known that these indicators are not really different between them. The cross-country variance of this variable is thus very low and could explain the fact that the number of beds and physicians are more adapted here to proxy the quality of health infrastructures across countries.

Some other structural effects are at work to explain the intensity of the virus across countries. The age structure of the population and the proportion of old-age people is a very important predictor of mortality ratios. Our macroeconomic result is in the vein of medical studies and recent economic work from Bayer and Kuhn (2020) by outlining that the ageing countries are more vulnerable to the Covid-19 outbreak.

Additionally, the number of tourist's arrivals is positively related to the mortality ratio variable: a country with a higher number of tourists is probably likely to host some infected people and so generate a patient zero and then a cluster area. The number of cumulated infected people is also a significant predictor of the mortality rate: in countries characterized by a strong dynamics of Covid-19 epidemic, the number of deaths is also very high (Italy, France, UK, USA etc…). The higher number of infected people can thus lead to a hospital "congestion" effect – hospitals reaching a saturation point –and increase the difficulty for the hospital caregivers to fight the virus and reduce the number of deaths. Lockdown policies in order to flat the epidemic curves were precisely instituted against this "saturation" phenomenon and preserve the hospitals.

The pollution variable is positively related to the mortality ratio in some specifications only and even though the coefficient is weakly significant suggesting that the pollution dynamics is probably only a marginal driver of Covid-19 mortality. More generally, this result seems however confirm that the Covid-19 cases and deaths could be intensified in countries in which the air is of a poor quality with large emissions of CO_2, NO_2 and other particles that weaken vulnerable people in line with pneumonia.

Finally, the mortality rate is negatively related to health expenditures change over the last four years. This result is robust when the last four years are considered instead. In other words, countries that have neglected health infrastructures expenditures by reducing health expenditures during the recent period seem to have increased the vulnerability of their health system. A sustainable health and care system is thus highly recommended to prevent future pandemics. OECD (2018) explained that OECD spending on health care grew by an average of 2.0% in 2017 - a marked decrease from the 3.3% growth observed in 2015 and 2016 and significantly below the rates experienced before the subprime crisis. During the financial crisis, many countries severely affected, especially in Europe, aimed to reduce public health spending to rein in public budget. We suggest that these reductions have intensified the mortality rates in the concerned countries. Figure 1 outlines the negative relationship between change in health public spending in the last four years and the mortality rates.

We also tested education expenditures in the same way but did not find any robust effects. The decline in education does not seem to have impacted the mortality rates. Note that we test the schooling variable to proxy the education level of each country assuming a link between education level and ability for countries to follow testing, tracking policies, social distancing, and hygiene measures.

In addition, we tested the effects of control policies throughout testing, surveillance, tracking and travel restrictions dummies variables but did not find any significant effect. Travel restrictions seem to have no effect on the mortality rates and are in the vein of Chinazzi et al. (2020) study that found travel restrictions to and from Mainland China only modestly affected the epidemic trajectory. Note however that wrong signs for travel restrictions variable can also be explained by endogeneity/simultaneity issues since most developed countries implementing travel restrictions are the most impacted by the Covid-19 outbreak and ex post developed restrictions after the beginning of the epidemic).

In the same way, we also try to test previous immunity via Malaria and Tuberculosis exposure but did not find significant results. The coefficient associated to Malaria when added to baseline regressions is negative but not significant, probably due to the low number of countries available to conduct this test. Tuberculosis coefficient is not significant as well. In this last case, though the number of available observations is optimal, the links between Tuberculosis and Covid-19 have not been previously demonstrated.

We proceed to a lot of diagnostic tests and test a high number of alternative specifications. At first, since the number of hospitals beds, the number of physicians or other health proxies are partly correlated between them, we consider only physicians (Table 1) or the number of beds (Table 2) alternatively (and not simultaneously). We also control the multicollinearity between the number of tourists (arrivals) and the number of Covid-19 cases (Cumulated Cases) by assuming specifications in which only one of these both variables is added as an explanatory variable.

Table 1: Model(1) OLS results

Model (1)	1.0		1.1		1.2		1.3		1.4	
Variables	**Coeff**	**T-stat**	**Coeff**	**T-stat**	**Coeff**	**T-stat**	**Coeff**	**T-stat**	**Coeff**	**T-stat**
Constant	-5.45E-05*	-1.91	-3.96E-05	-2.59	-3.60E-05*	-1.70	-0.000150**	-2.05	-0.000140*	-1.91
Age65	9.95E-06*	1.74	9.02E-07	0.39	8.58E-06*	1.66	9.12E-06*	1.84	8.91E-06*	1.73
Tourism arrivals	1.79E-12**	2.35	1.38E-12	1.95	1.75E-12**	2.26	1.80E-12**	2.20	1.84E-12**	2.24
Cumulated Cases	0.086532***	4.37	0.076481	3.68	0.086502***	4.43	0.084598***	4.31	0.086282***	4.27
Physicians	-5.15E-05**	-2.13			-4.84E-05	-1.63	-5.26E-05**	-2.19	-5.32E-05**	-2.23
Health Exp			-0.000120	-2.81	-0.000280**	-2.05	-0.000323*	-1.83	-0.000287	-1.64
Pollution ratio					-1.43E-06	-0.07	3.79E-06	0.18	1.93E-05	0.89
Travel							0.000127*	1.67	0.000108	1.45
Testing							4.04E-05	0.68	4.52E-05	0.73
Density									-3.44E-08***	-2.88
R2/DW	**0.64/2.40**		**0.60/2.09**		**0.64/2.25**		**0.64/2.25**		**0.67/2.00**	
N	**71**		**113**		**69**		**69**		**69**	

Table 2: Model(2) OLS results

Model (2)	2.0		2.1		2.2	
Variables	**Coeff**	**T-stat**	**Coeff**	**T-stat**	**Coeff**	**T-stat**
Constant	-5.43E-05***	-3.31	-7.46E-05**	-2.31	-6.30E-05*	-1.67
Age65	4.38E-06**	2.43	4.43E-06**	2.41	4.20E-06**	2.37
Tourism arrivals	2.27E-12***	2.74	2.25E-12***	2.72	2.24E-12***	2.69
Cumulated Cases	0.045159***	4.78	0.045565***	5.27	0.046323***	5.28
Pollution ratio	1.61E-05*	1.75	1.64E-05*	1.65	1.56E-05	1.53
Beds	-1.04E-05***	-2.87	-1.05E-05***	-2.88	-1.01E-05***	-2.71
Health Exp	-5.43E-05***	-3.31	-5.29E-05*	-1.73	-5.02E-05*	-1.67
Travel			2.33E-05	0.84	1.65E-05	0.52
Density					-3.20E-08	-1.29
Testing			5.11E-06	0.19	3.84E-06	0.14
R2	**0.66/2.10**		**0.65/2.05**		**0.65/2.04**	
N	**77**		**77**		**77**	

Table 3: GMM results

Variables	Coeff	z-stat	Variables	Coeff	z-stat
Constant	-0.000150**	-2.20	**Constant**	-5.43E-05***	-3.47
Age65	9.12E-06**	1.98	**Age65**	4.38e-06 ***	2.55
Tourism arrivals	1.80E-12**	2.36	**Tourism arrivals**	2.27E-12***	2.87
Cumulated Cases	0.084598***	4.63	**Cumulated Cases**	0.045159***	5.01
Pollution	3.79E-06	0.19	**Pollution**	1.61E-05*	1.83

ratio			**ratio**		
Physicians	-5.26E-05**	-2.35	**Beds**	-1.04E-05***	-3.01
Health Exp	-0.000323**	-1.97	**Health Exp**	-5.15E-05**	-2.17
Travel	0.000127*	1.80			
Density					
Testing	4.04E-05	0.73			
N	**77**		**N**	**77**	

Note : lagged covariates have been used as instruments to compute GMM regressions

Figure 1: Health Expenditures change (2013-17) versus Covid-19 mortality rates

Conclusions

This paper is a first attempt to empirically examine the macroeconomic drivers of the Covid-19 cross-country differences in fatalities. Our results are consistent with some other pieces of the very recent interdisciplinary literature and reveal new interesting conclusions about the lack of sustainability of recent health policies that weaken the health infrastructures over the world. In one sense, the subprime crisis consequences and austerity policies after 2008, by reducing the public health spending, are partly responsible for the tragic situations in some countries, especially European countries like Italy. At the epicenter of the pandemic in Bergamo, several doctors wrote: *"We need a long-term plan for the next pandemic. Coronavirus is the Ebola of the rich and requires a coordinated transnational effort. (…) The more medicalized and centralized the society, the more widespread the virus. This catastrophe unfolding in wealthy Lombardy could happen anywhere"* (Nacoti et al., 2020). Governments should consider a sustainable and coordinated health policy to prevent future pandemics. If our preliminary results need to be cautiously interpreted, panel dataset should be able to extend this preliminary work in the future about the key macro drivers of the Covid-19 fatality.

Appendix 1. Data sources

Data are collected from The World Bank, John Hopkins University and from S. Porcher database on **28th April 2020**.

- **Covid-19 cases and deaths** on a daily basis reported by John Hopkins University ; cumulated values divided by population to get ratios per capita have been computed
- **Hospital beds** include inpatient beds available in public, private, general, and specialized hospitals and rehabilitation centers. In most cases beds for both acute and chronic care are included.
- **Physicians** include generalist and specialist medical practitioners per 1,000 people.
- **Population ages 65** and above as a percentage of the total population. Population is based on the de facto definition of population, which counts all residents regardless of legal status or citizenship.
- **Population density** is midyear population divided by land area in square kilometers. Population is based on the de facto definition of population, which counts all residents regardless of legal status or citizenship--except for refugees not permanently settled in the country of asylum, who are generally considered part of the population of their country of origin. Land area is a country's total area, excluding area under inland water bodies, national claims to continental shelf, and exclusive economic zones. In most cases the definition of inland water bodies includes major rivers and lakes.
- Level of current **health expenditures** expressed as a percentage of GDP. Estimates of current health expenditures include healthcare goods and services consumed during each year.
- **Under-five mortality rate** is the probability per 1,000 that a newborn baby will die before reaching age five, if subject to age-specific mortality rates of the specified year.
- **International inbound tourists** (overnight visitors) are the number of tourists who travel to a country other than that in which they have their usual residence, but outside their usual environment, for a period not exceeding 12 months and whose main purpose in visiting is other than an activity remunerated from within the country visited. When data on number of tourists are not available, the number of visitors, which includes tourists, same-day visitors, cruise passengers, and crew members, is shown instead. Sources and collection methods for arrivals differ across countries. In some cases data are from border statistics (police, immigration, and the like) and supplemented by border surveys. In other cases data are from tourism accommodation establishments. The data on inbound tourists refer to the number of arrivals, not to the number of people traveling. Thus a person who makes several trips to a country during a given period is counted each time as a new arrival.
- **General government expenditure on education** (current, capital, and transfers) is expressed as a percentage of GDP. It includes expenditure funded by transfers from international sources to government. General government usually refers to local, regional and central governments.

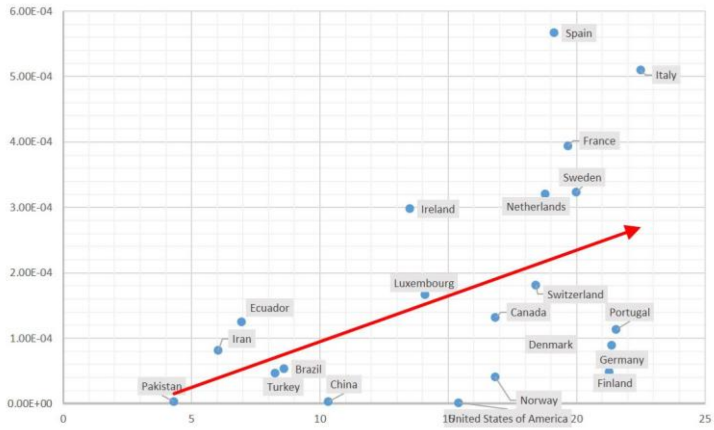
- **Carbon dioxide (CO_2) emissions** are those stemming from the burning of fossil fuels and the manufacture of cement. They include carbon dioxide produced during consumption of solid, liquid, and gas fuels and gas flaring.
- **Gross enrollment ratio** is the ratio of total enrollment, regardless of age, to the population of the age group that officially corresponds to the level of education shown
- **Travel** takes 1 if travel restrictions are implemented and 0 either; 0.5 if travel restrictions are regional or partial (from S. Porcher database)
- **Testing** takes 1 if there is a testing policy and 0 either; 0.5 if the testing policy is limited to hospitalized people or people in contact with confirmed cases (from S. Porcher database)
- **Incidence of malaria** is the number of new cases of malaria in a year per 1,000 population at risk.
- **Incidence of tuberculosis** is the estimated number of new and relapse tuberculosis cases arising in a given year, expressed as the rate per 100,000 population
-

Appendix 2. List of countries

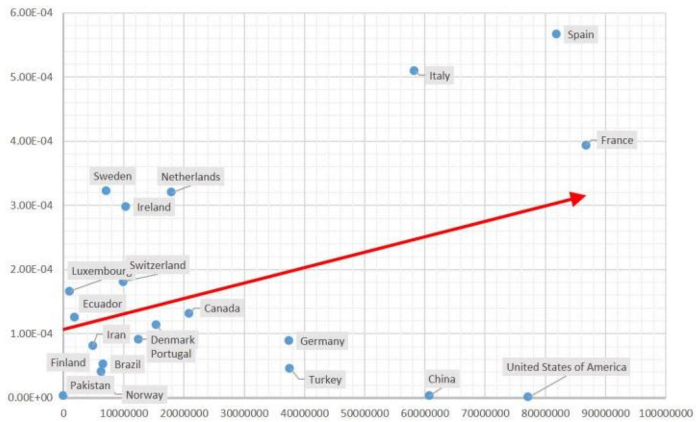
Countries included in table 1 (except specification 1.1) : UAE, Austria, Belgium, Burkina Faso, Bangladesh, Bolivia, Canada, Switzerland, Chile, Colombia, Cyprus, Czech Republic, Germany, Denmark, Algeria, Ecuador, Egypt, Spain, Estonia, Finland, France, UK, Guinea, Greece, Honduras, Croatia, Hungary, India, Ireland, Iceland, Israel, Italy, Jamaica, Jordan, Japan, Republic of Korea, Lebanon, Sri Lanka, Luxembourg, Latvia, Mexico, Mali, Netherlands, Norway, New Zealand, Oman, Panama, Peru, Poland, Portugal, Qatar, Romania, Russia, Saudi Arabia, Senegal, Singapore, El Salvador, Serbia, Slovakia, Slovenia, Sweden, Eswatini, Thailand, Tunisia, Uruguay, USA, Vietnam, South Africa, Zambia.

Countries included in tables 2 and 3 : UAE, Argentina, Armenia, Austria, Azerbaidjan, Bulgaria, Bahrain, Bosnia, Belarus, Bolivia, Brazil, Canada, Switzerland, Chile, China, Colombia, Costa Rica, Cuba, Cyprus, Czech Republic, Germany, Ecuador, Egypt, Spain, Estonia, Finland, France, UK, Georgia, Greece, Guatemala, Honduras, Croatia, Hungary, Indonesia, Ireland, Iran, Iceland, Israel, Italy, Jamaica, Jordan, Japan, Kazakhstan, Kyrgyzstan, Republic of Korea, Kuwait, Lebanon, Luxembourg, Latvia, Morocco, Moldova, Mexico, North Macedonia, Malta, Malaysia, Norway, Oman, Panama, Peru, Poland, Portugal, Romania, Russia, Saudi Arabia, El Salvador, Serbia, Slovakia, Slovenia, Sweden, Tunisia, Turkey, Ukraine, Uruguay, USA, Uzbekistan, Vietnam.

Appendix 3. Positive correlations between 65 age and above population and confirmed deaths ratios



Appendix 4. Positive correlations between arrivals and and confirmed deaths ratios



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