Positive cases and the death of COVID-19 pandemic at different quantiles: The determinants

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Abstract

Purpose
The present study aims to investigate factors that might significantly contribute to the number of positive cases and death from pandemic COVID19 in most affected countries in the world.

Design/methodology/approach
Cross-section data are collected of affected countries and in contrast to a simple linear regression method, this study employs rigorous statistical tool namely a quantile regression method to examine the impact of these factors.

Findings
The empirical results from the analysis show that at different quantiles, there are an increasing number of positive cases among developed countries but only at lower quantiles of the number of positive cases. Government health expenditure significantly contributes to the number of death cases from the pandemic at higher quantiles of death number distribution. Besides, the ageing population also provides the number of death cases from the pandemic, particularly at lower and middle quantiles of the death toll.

Originality
The study adopts quantile regression that can explain the asymmetric effects of the predictor variables on the dependent variable at various quantiles in a population.

Keywords: pandemic COVID19; health expenditure; quantile regression.

Category of paper: Research paper

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INTRODUCTION

The COVID-19 pandemic recently occurred due to the outbreak of the unknown pneumonia aetiology in Wuhan city, Hubei Province, China since December 2019 (Lu et al., 2020). Scientifically, the COVID-19 has a different corona viruses-specific nucleic acid sequence from a known human corona virus's species. They are similar to some of the beta corona viruses, which scientists identified in bats (de Wit et al., 2016; Yin & Wunderink, 2018). Human corona virus was relatively harmless respiratory pathogens. Somehow, it has been given the worldwide attention as important pathogens after the outbreak of severe acute respiratory syndrome (SARS) in China on 2002 and the Middle East respiratory syndrome (MERS) in Saudi Arabia in 2012 (Yin & Wunderink, 2018). The corona viruses are zoonosis and they can cause ultimately severe disease in humans. Previously, the 2002 SARS was originated from the Himalayan palm civet or raccoon while MERS was from dromedary camels (He et al., 2020). Before the Covid-19 pandemic occurred, we had the first pandemic in the 21st century that emerged in 2009, namely H1N1 or formerly known as swine flu (Al Hajjar & McIntosh, 2010; Peiris et al., 2009). The World Health Organization (WHO) has prepared influenza surveillance centres in countries over the world ever since the world had experienced the three influenza pandemics which killed a significant number of people in the past century (Balkhy & Al-Hajjar, 2006). Early pandemics occurred were Avian Influenza or Spanish flu (H1N1) in 1918, Asian Flu (H2N2) in 1957, and Hong Kong Flu (H3N2) in 1968. Among those pandemics, Avian flu had caused 20 to 50 million deaths, while, H2N2 and H3N2 caused a million to 1.5 million and a million deaths, respectively (Balkhy & Al-Hajjar, 2006; Peiris et al., 2009). The virus that caused the past pandemics originated from animal influenza viruses (World Health Organization, 2010).

There are similarities as well as differences between seasonal and pandemic influenza. Both can cause infections in all age groups, and most cases will result in self-limited illness in which the person recovers fully without treatment. However, typical seasonal influenza might lead to death mostly among the elderly, and patients with comorbidities and those who get infected fell into a severe illness. The past H1N1 pandemic affected and caused death despite the age group and the health conditions of the patients (World Health Organization, 2010). The three influenza pandemics occurred in the 20th century alone due to the infection spread and it was difficult to do further experiments in developing vaccines due to lack of technology (Balkhy & Al-Hajjar, 2006). Besides, most viruses that cause pandemics were originated from the animals (Pike et al., 2014; World Health Organization, 2010) thus scientists took time to perform experimental study on the origin of the virus strain.

Previously in 1918, the first benign wave of Spanish flu was intricate with the soldiers who fought in the First World War. Factors contributing to the flu were the mix of French soldiers and workers from the five continents, the inferior quality of life among soldiers, agglomeration, stress, fear, war gasses, cold weather, humidity and contact with birds, pigs and other animals, both wild and domestic (Erkoreka, 2009). The Spanish flu that emerged in 1918 was a zoonotic disease, and it differs with the H1N1 virus pandemic that occurred in 2009 (Peiris et al., 2009). The clinical severity of the H1N1 pandemic was studied and shown that the older group of people had a low risk of infection. However, once the most aged patients, who above 65 years old infected, they had a high probability of dying. The age group of five to fourteen years old had the highest number of hospitalization due to H1N1. In contrast, 50 to 64 years age group has the highest risk of death as accord to the data collected in 19 administrative regions

(Argentina, Australia, Canada, Chile, China, France, Germany, Hong Kong, Japan, Madagascar, Mexico, the Netherlands, New Zealand, Singapore, South Africa, Spain, Thailand, United States, and the United Kingdom) (Van Kerkhove et al., 2011).

The pandemic badly affected the well-being of humans. It gave an impact on economics both in the short and long term. During the outbreak of Avian flu (H5N1) in 2003, a year after severe acute respiratory syndrome coronavirus (Sars-Cov), it had caused the government to destroy a lot of affected poultry. Consequently, this severely damaged poultry production in several countries. In the short run, the pandemic halted the economic growth in Asia and led to a significant reduction in trade, particularly in services. In the long-run, economic growth was declining and it led to poverty escalation (Bloom et al., 2005).

Chinese Centre for Disease Control and Prevention (CCDC) recently identified COVID-19 through the throat swab taken from that unknown aetiology of pneumonia patients in China (Sohrabi et al., 2020). CCDC found the causative agents were relative to the first SARS (Siu & Wong, 2004). On 30 January 2020, World Health Organization (WHO) declared a global health emergency due to the rapid escalation of COVID-19 cases in China (Chen et al., 2020; Velavan and Meyer, 2020). As of 28 February 2020, the number of those infected with COVID-19 has exceeded 83,652 globally, and more than 2858 have died of COVID-19 with the highest mortality rate of 4.47% in Wuhan (Chen et al., 2020).

Briefly, the cases are in clusters, which arrive in waves and emerge into massive outbreaks all over the world where the first outbreak has indeed happened in Wuhan, China (World Health Organization, 2020). Based on the report from WHO on 23 January 2020, the disease to which has reported in Thailand, Japan, Hong Kong Special Administrative Region, Taipei Municipality, China, Macau Special Administrative Region, United States and the Republic of Korea, and the patients had a travel history to Wuhan (World Health Organization, 2020). Italy is one of the most significant and most severe clusters of COVID-19 in the world, and it occurred on 20 February 2020, a male Italian from Lombardy was having atypical pneumonia and admitted to the hospital, which later he was confirmed positive COVID-19. Then in 24 hours, there were 36 more cases exist, and none of whom had contacted with the first patients or with anyone known to have COVID-19 (Livingston and Bucher, 2020).

In Europe, the United Kingdom, Germany, and France were at the highest risk of infected as the disease importation estimated from affected areas in China through air travel (Pullano et al., 2020). On 27 January 2020, 41 travel-related cases were confirmed, and it was coming from China. Twenty-seven cases imported to Asia, six to North America, five to Oceania, and three to Europe (Pullano et al., 2020; Team, 2020). China has announced travel quarantine from Wuhan since the discoveries of this fatal infectious disease. Unfortunately, during the time of the quarantine, residents, and visitors had made several billion trips throughout China to celebrate Lunar New Year. Therefore, newly infected persons who travelled out of Wuhan just before the quarantine might have remained infectious and undetected in various cities in China for within weeks (Du et al., 2020). Unfortunately, even though several measures had taken into action after the confirmation of human-to-human transmission, the travel quarantine should also be implemented (Peeri et al., 2020). Moreover, due to the inadequate risk assessment by the Chinese government to contain the virus, the outbreak broke into more countries and infected more people. Currently, the cases of COVID-19 has exceeded SARS in the number of cases and deaths from the disease (Peeri et al., 2020).

Earlier, patients who confirmed infected with SARS-COV-2 presented primarily with fever, myalgia or fatigue, and dry cough (Zhou et al., 2020). To date, some COVID-19 patients have developed mild symptoms such as dry cough, sore throat, and fever and most of the cases have spontaneously resolved. However, some patients suffered fatal complications including organ failure, septic shock (life-threatening low blood pressure), pulmonary oedema (excess fluids in lungs making the patient hard to breath),severe pneumonia, and acute respiratory distress syndrome (severe lung condition) (Chen et al., 2020). According to the World Health Organization, 54.3% of those infected with COVID-19 are male with a median age of 56 years old (Sohrabi et al., 2020). The older with multiple underlying illnesses such as cerebrovascular, endocrine, digestive, and respiratory disease are among the vulnerable group to COVID-19. Patients in such conditions required intensive care support. Moreover, patients in intensive care more likely to report dyspnoea, dizziness, abdominal pain, and anorexia (Wang et al., 2020).

Researches on this fatal infectious disease have been increasing since its outbreak. Most researches focused on its aetiology (causation of the disease), epidemiology, and clinical symptoms. Earlier infection, the morbidity has remained low, but, it kept surging within December 2019 and January 2020 due to the population movement before lunar Chinese New Year (Yang et al., 2020). Later, the number of COVID-19 cases escalated exponentially, and the outbreak was spread to the other countries, alarmed the countries around the world (Zu et al., 2020).The evidence-based outcome found out from the clusters of infected family members and medical workers, which confirmed the presence of human-to-human transmission by droplets (Chan et al., 2020), contact and fomites, which are the objects that could carry the infections such as cloths (Guan et al., 2020; Zhou et al., 2020).

Previously, some researchers stated that the patients infected with COVID-19 might resolve in a certain period. Nevertheless, some patients may get infected with severe COVID-19 disease and may lead to death. Those people can also be known as a high-risk group of patients or vulnerable group. They are susceptible to get infected, and their condition could be worse, which may need intensive care. Patients who were diagnosed of COVID-19 and had pre-existing cardiovascular disease (CVD) have an increased risk of severe disease and death. Moreover, the infection was associated with multiple direct and indirect cardiovascular complications (Driggin et al., 2020). Patients with end-stage heart failure also have a probability of having a high mortality rate after infection with pneumonia (Dong et al., 2020).

From the research conducted after the outbreak of the COVID-19 in China, the demographic result has shown that, the median age of patients who admitted and confirmed COVID-19 were 51 years old (Wu et al., 2020). Meanwhile, the median age of deceased patients due to COVID-19 was 68 years old and were significantly older than recovered patients who were 51 years old (Chen et al., 2020). From the evidence-based research, male were predominant among the deceased patients. Aside from that, chronic hypertension and other cardiovascular comorbidities commonly found among the deceased. Also, patients who were older and had hypertension were already in critical condition during the admission, and the disease was progressed rapidly to death within two to three weeks. Furthermore, acute cardiac injury and heart failure may also contribute to the critical illness state associated with high mortality (Chen et al., 2020).

The rate of infections also could increase in a less hygienic place. Besides, the congregate nature and hygienic challenges of shelter life create the potential for rapid transmission of COVID-19 (Baggett et al., 2020). The Boston Health Care for the Homeless Program (BHCHP) identifies an increasing number of COVID-19 cases from a single large homeless shelter in Boston (Baggett et al., 2020). It is sufficient to trace the contact and isolate the cases to control the infectious disease outbreaks. Nevertheless, it might require intensive public health effort and cooperation to effectively reach and monitor all contacts (Hellewell et al., 2020). Early interventions to reduce the average frequency and intensity of exposure to the virus might reduce infection risk, reduce average viral infectious dose to those exposed, and result in less severe cases which are less infectious (Dalton et al., 2020). Moreover, enhance hygiene and social distancing measures may reduce the number of cases and its severity (Dalton et al., 2020).

From the above discussion, we can determine the increasing number of cases and death from this COVID-19 pandemic by few factors such as the age of population particularly the elderly, the use of basic sanitation among population, availability of health facilities in the countries reflected by the spending on health services by the government as well as the standard of living of the countries. Thus, the present study aims to investigate factors that might significantly contribute to the number of positive cases and death from pandemic COVID19 in most affected countries in the world. In contrast to a simple linear regression method, this study employs rigorous statistical tools, which is a quantile regression method to examine the impact of these factors. The availability of health infrastructure indicated by government health expenditure, the proportion of the population who are above 65 years old, availability of basic sanitation and economic development were factors that might contribute to a higher and lower number of cases and death from the pandemic. The quantile regression can explain the asymmetric effects of the predictor variables on the dependent variable at various quantiles in a population.

DATA AND METHODOLOGY

Data and variables

Data used in the current study are secondary data which are listed and defined in Table 1. Data collected are for 118 countries that are affected by the current pandemic. There are few countries excluded in the study due to the unavailability of data on several independent variables. The list of countries provided in the appendix. There are two indicators used for the availability of health infrastructure in the country. Those are domestic general government health expenditure (% of GDP) and domestic general government health expenditure (% of current health expenditure). For the variable 'population ages 65 and above as a percentage of the total population', the population is based on the de facto definition of population, which counts all residents regardless of legal status or citizenship. As for the percentage of people using at least essential sanitation services, this is referring to improved sanitation facilities that are not sharing with other households. This indicator encompasses both people using basic sanitation services as well as those using safely managed sanitation services. Improved sanitation facilities include flush/pour flush to piped sewer systems, septic tanks or pit latrines; ventilated improved pit latrines, composting toilets, or pit latrines with slabs. GDP per capita is another variable used to represent the economic development of the country.

-Table 1 -

Method of analysis

To account for the nonlinearity in the relationship between government health expenditure, ageing population, availability of basic sanitation, economic development with the number of cases and death from the pandemic, the current study relies on the quantile regression framework. The method adopted due to the rationale that the distribution of the number of positive cases or death can best be captured by using several quantiles. The quantile regression, which proposed by Koenker and Bassett (1978), can provide information on the non-linear and asymmetric effects of the conditional variables on the dependent variable at various quantiles in a population.

The traditional least squares regression gives an incomplete description of a conditional distribution since it only allows us to approximate the conditional mean and conditional median located at the centre of the distribution (Mosteller and Tukey, 1977). Quantile regression, on the other hand, is used to get information about points in the conditional distribution other than the conditional mean (Eide and Showalter, 1997; Buchinsky, 1994, 1995).Other advantages of quantile regression are:

1. The quantile regression estimator minimizes the weighted sum of absolute residuals rather than the sum of squared residuals, and thus the estimated coefficient vector is not sensitive to outliers.
2. A quantile regression model employs a linear programming representation and simplifies examination.
3. The quantile regression approach is useful when the conditional distribution does not have a standard shape, such as an asymmetric, fat-tailed, or truncated distribution (Kang and Liu, 2014).

This approach is different from the conventional piecewise regressions that segment the dependent variable (unlimited distribution), and then run an ordinary least squares (OLS) on the subsets. Piecewise regressions are not an appropriate alternative to the quantile regression due to severe sample selection problems (Koenker and Hallock, 2001). Moreover, piecewise regressions are least-squares based and can be sensitive to the Gaussian assumption or the presence of outliers. Koenker (2005) has more discussion on the model specifications of quantile regression for further references.

The basic quantile regression model specifies the conditional quantile as a linear function of explanatory variables. The model is written as follows:

$$y_i = x_i'\beta_\theta + u_{\theta i}, 0 < \theta < 1$$
$$Quant_\theta(y_i|x_i) = x_i\beta_\theta \quad (1)$$

where y is the dependent variable, x is a matrix of explanatory variables, u is an error term whose conditional quantile distribution equals zero, and $Quant_\theta(yi|xi)$ denotes the θth quantile of y conditional on x. The distribution of the error term u is left unspecified. An individual coefficient$\beta_{\theta j}$ associated with the jth independent variable in the vector x_i, called x_{ij}, could be interpreted as 'how y_i in its θth conditional quantile reacts to a (ceteris paribus) marginal change in x_{ij}'. The method allows us to identify the effects of the covariates at different locations in the conditional distribution of the dependent variable. The θth regression quantile estimate, $\widehat{\beta_\theta}$, is from the following minimization problem which solved via linear programming:

$$\min_\beta \sum_{y_i \geq x_i'\beta} \theta|y_i - x_i'\beta| + \sum_{y_i \geq x_i'\beta}(1-\theta)|y_i - x_i'\beta|,$$

A special case of the quantile regression is the median regression, which obtained by setting θ=0.5.Other variations of θ could be used to obtain other quantiles of the conditional distribution.

In this study, the relationships among selected explanatory variables across the conditional distribution of the number of cases and death using the 10^{th}, 25th, 50^{th}, 75^{th}, and 90^{th}quantiles reported. Besides, the bootstrap method used to obtain estimates of the standard errors for the coefficients in quantile regression, as illustrated in Buchinsky (1995). The method is important as it is a consistent and robust in estimation, particularly when the error term is non-normally distributed and heteroscedastic. The following equations are the models used in the current empirical study:

$$numcase_i = \beta_0 + \beta_1 health\_gdp_i + \beta_2 pop65plus_i + \beta_3 bsan_i + \beta_4 gdppc_i + \in \quad (2)$$

$$numcase_i = \beta_0 + \beta_1 health\_gexp_i + \beta_2 pop65plus_i + \beta_3 bsan_i + \beta_4 gdppc_i + \in \quad (3)$$

$$numdeath_i = \beta_0 + \beta_1 health\_gdp_i + \beta_2 pop65plus_i + \beta_3 bsan_i + \beta_4 gdppc_i + \in \quad (4)$$

$$numdeath_i = \beta_0 + \beta_1 health\_gexp_i + \beta_2 pop65plus_i + \beta_3 bsan_i + \beta_4 gdppc_i + \in \quad (5)$$

It is important to note that there are two indicators used for government health expenditure in both positive cases and death cases equations. The indicators are used alternately in each equation.

RESULTS AND ANALYSIS

Table 2 displays descriptive statistics of data or variables in the study. A minimum number for positive COVID-19 cases among the countries for the study as at 14 April 2020 is 106, while the maximum is 582,594. As of the number of death cases, the minimum is zero death, and the maximum is 23,649. On average, the number of positive cases is 16,272, and the number of death cases is 1,014. Domestic general government health expenditure (as % of GDP) on average is about 4 per cent. The lowest percentage is 0.18, and the maximum is 10.5 among the countries in the study. An alternative indicator of health infrastructure, namely domestic general government health expenditure (% of current health expenditure) is also adopted, and the average percentage is higher than domestic general government health expenditure (% of GDP), that is, 56.6 per cent. Meanwhile, the minimum percentage of this variable is 5.09, and the maximum percentage is 94.8. From the standard deviation of the data, it is found that there is less variance of domestic general government health expenditure (as % of GDP) due to a small number of standard deviation. For data on population ages 65 and above (% of the total population), the minimum is 1 per cent, while the maximum is 27 per cent with an average of 10.6 per cent among countries. Data on people using at least basic sanitation services (% of the population) is 85.5 per cent on average among countries in study with minimum and maximum of 10.5 and 100 per cent, respectively. Real GDP per capita (US$) data is US$19,293 on average among the countries. The minimum real GDP per capita is US$394, which reflects an underdeveloped nation and the maximum is US$109,453 represents a developed nation.

-Table 2-

Looking at variables number of cases (numcase) and the number of death (numdeath), the skewness statistics of both data are greater than one and positive. It indicates that the dependent variables have skewed distribution. Positive skewness indicates that the size of the right-handed tail is larger than the left-handed tail. Kurtosis measures the degree of peakedness of a distribution. Normal distribution usually represented by kurtosis statistics equal to 3. As for both dependent variables, the Kurtosis statistics are not equal to 3. The kurtosis greater than 3, in both cases, implies that the dataset has heavier tails than a normal distribution (more in the tails). Thus, the assumption of the normal distribution of the error terms in OLS is not guaranteed and using linear regression might produce misleading results. However, quantile regression can overcome these problems as it takes consideration of the conditional distribution, which does not have a normal distribution.

- Table 3-

- Figure 1-

The first regression analysis conducted by estimating equation (2) at five quantiles, namely 10^{th}, 25^{th}, 50^{th}, 75^{th} and 90^{th} quantiles of dependent variables. All data of dependent variables are not transformed into log to avoid loss of data due to a value of zero in a number of cases or death in few countries. A similar list of independent variables used for each quantile, and it enables us to examine the impact of explanatory variables at different points of the number of positive and death COVID-19 cases distribution. The results using the number of positive cases as a dependent variable reported in Table 3. In comparison, OLS estimates are also reported in the second column of Table 3. Based on the OLS regression, only the coefficient of government health expenditure is significant at the current levels with a positive sign. The value of coefficient indicates that a one per cent increase of government health expenditure as a percentage of GDP contributes to an increase of positive cases by 9,710.7, other things constant. All other variables are not significantly determining the positive number of cases. On the other hand, when quantile regression conducted, it shows a different picture. In particular, using quantile regression, government health expenditure is not significant at all quantiles. Surprisingly, the real GDP per capita, which is previously not significant in OLS, is now contributing positively and significantly to the number of positive cases at 10^{th} and 25^{th} quantiles distribution. The positive relationship found to be stronger at 10^{th} quantile of the number of positive cases as compared to at 25^{th} quantile. At 10^{th} quantile of the number of positive cases, an increase of real GDP per capita by US$1 increases the number of positive cases by 0.28 units as compared to only 0.05 units at 25^{th} quantile. However, at a higher number of positive cases (50^{th} quantile and above), the variable does not significantly affect the cases. The results generally indicate that the lower quantiles of positive cases are highly occurred in developed nations (higher GDP per capita) as compared to less-developed nations (lower GDP per capita). In fact, in Europe, the United Kingdom, Germany, and France were at the highest risk of infected as the disease importation estimated from affected areas in China through air travel (Pullano et al., 2020). On 27 January 2020, 41 travel-related cases were confirmed, and they were coming from China. Hence, one of the factors that lead to the surging numbers of COVID-19 cases in most developed nations was because of international travel, especially those who were from affected areas in China. The results also reflect that the number of positive cases is escalating in many countries, developed and less-developed alike. This is shown by insignificant impact of real GDP per capita at higher quantiles of number of positive cases.

Results of the slope equality tests, proposed by Koenker and Basset (1982) also reported. For each explanatory variable, we test, for example, the following hypotheses: H_0: $\beta_{0.25} = \beta_{0.50} = \beta_{0.75}$ and H_1: $\beta_{0.25} \neq \beta_{0.50} \neq \beta_{0.75}$ for each coefficient of the independent variable. The test also conducted for other different quantiles—the results displayed in the lower part of Table 3. The results, however, show that the *p*-values of *F* statistics for all coefficients are more than 0.05, which does not reject the null hypothesis. Therefore, the relationship between each independent variable and the dependent variable at different quantiles is not different significantly.

Figure 1 shows the pattern of coefficients for each explanatory variable. The results show evidence of asymmetries in estimation. The increasing trend of responsiveness could be seen for coefficients of variables pop65plus and health_gdp but decreasing trend for the coefficient of bsan at higher quantiles. Focusing on significant variable of GDP per capita (gdppc), there is fluctuation in the magnitudes of coefficients from lower to higher quantiles. In particular, there is a decline in magnitude of GDP per capita coefficient from 10^{th} to 25^{th} quantile of positive case number (0.28 to 0.049). It could be inferred that serious impact of the pandemic to developed countries occurs at the initial phase of spread when the number of cases is still small. Obviously, most affected countries, particularly developed countries such as in Europe and Singapore, are then reacting fast to the pandemic by imposing lockdown and border restrictions. It most likely causes insignificant impact of the pandemic at the higher quantiles of cases in these countries. The figures also show the 90% confidence intervals, depicted by the shade areas. The pseudo R^2 statistics are calculated based on Koenker and Machado (1999) and reported for each quantile regression in the table. From the value of pseudo R^2 at each quantile, it could be concluded that the variance of the number of cases from the pandemic is more likely to well explained by regressors at higher quantiles as compared to lower quantiles.

-Table 4-

- Figure 2-

To further support our findings, second regression performed using another indicator of government health expenditure, namely domestic general government health expenditure (as % of current health expenditure) reflected by equation (3). Using OLS regression, real GDP per capita found to be the only factor positively and significantly affects the number of positive cases from COVID-19. The coefficient is significant at the 10 per cent level. When the quantile regression applied on similar data, this variable is highly significant (at 1 per cent level) at lower quantiles of 10^{th}, 25^{th} and 50^{th} of the number of positive case distribution. The findings also support the increase of positive cases of COVID-19 in most developed countries at lower quantiles of cases number. As for the slope equality tests, the results show that the *p*-values of *F* statistics for variable 'pop65plus' (population ages 65 and above as % of the total population) does reject the null hypothesis that coefficients are equal at quantiles 25^{th} and 50th. The results indicate that the relationship between the independent variable and the dependent variable at 25^{th} and 50^{th} quantiles are different significantly. Referring to the coefficients of this variable (pop65plus) in equations, the magnitude of coefficients is quite significant in 50^{th} quantile as compared to 25^{th} quantile with a positive sign.

Figure 2 similarly shows the pattern of coefficients for each explanatory variable at different quantiles. The increasing trend could be seen for the coefficient of gdppc and a slight decline for coefficients of health_gexp and pop65plus at higher quantiles. Having said the coefficient of gdppc is significant and increasing in magnitude from lower to higher quantile, the magnitude is quite small within the range of 0.027 to 0.122. Again, this implies that the state of development of the countries is somehow or rather one of the factors contributes to increasing number of positive cases and it is believed that tourism and worker immigration are the attributes particularly in European countries, Japan and South Korea. The pseudo R^2 statistics seem to reflect better goodness fit of the model at higher quantiles, particularly at 90th quantile.

-Table 5-

- Figure 3-

The current study also attempts to explore the contribution of factors on the number of death cases in the countries studied. This further exploration is required to look at the impact of possible factors on severe cases from the pandemic, which affects the life of patients. For that, similar regressions applied to data of death cases with similar independent variables. Results using indicator of government health expenditure as % of GDP displayed in Table 5. The OLS regression in the second column of Table 5 shows that government health expenditure contributes significantly to the increase in the number of death cases in general. A one per cent increase in health expenditure increases the death number by 538, other things equal. However, using quantile regression, it is found the significant and positive impact of government health expenditure only apparent at the 90th quantile of the number of death distribution but not at the lower or middle quantiles. In the 90th quantile of death cases, a one per cent increase in health expenditure contributes to an increase of 1,359 in death cases. The results reflect the fact that large public spending on health infrastructure is insufficient to combat the increasing toll of death from the pandemic. Significant expenses on health infrastructure could still contribute to a higher number of death cases from the pandemic due to an inefficient allocation of public fund on health infrastructure, especially on the preparation of pandemic cases. Processes in the health system may be inefficient for two distinct, but related reasons. The first reason is that health system inputs such as expenditure or other resources may be directed towards creating some outputs that are not priorities for society. The second reason for inefficiency is that there could be misuse of inputs in the process of producing valued health system outputs. Waste of inputs at any stage of the production process mean that there will be less output than what is possible for a given initial level of resources, leading to what can be loosely thought of as waste (Cylus et.al, 2016). Gupta and Verhoeven (2001), for example, found that on average, the government expenditure towards education and health are inefficient in the case of 37 African countries over the period 1984–1995 using the non-parametric approach Free Disposal Hull (FDH). Another study by Jarasuriya and Woodon (2003) on 76 developing countries over the period 1990–1998 found no relationship between spending and the two outputs (literacy and life expectancy) when they take account the per capita GDP. These findings imply that an increase in public spending does not guarantee an improvement in education or health. Using DEA approach to assess health expenditure for 46 European and Central Asia countries, Yi-Chang Hsu (2013) was in the opinion that these countries could produce more quantity of outputs by about 2.1% while maintaining the same level of inputs. Using similar method, Lavado and Domingo (2015) analyzed the efficiency of health and education expenditure in Asian countries and found that countries could reach a higher level of efficiency given their input level (expenditures on education and health). Focusing on health indicators, the study also concluded that countries can improve health outcomes by about 4%. A study on three CEMAC countries (Cameroon, Chad and Central African Republic), Fonchamnyo and Sama (2016) showed that Cameroon is the best in term of efficiency in spending on education and health, and Chad is the worst regarding public spending on education, despite it spends more on education than the other. Central African

Republic is the least efficient in public spending on health. Authors also stated that decision makers should fight against corruption and assess the quality of budgetary and financial management. Afonso and Kazemi (2017) used four models to assess the efficiency of public spending in four main sectors: administration, education, health and infrastructure for 20 OECD countries over the period 2009–2013. Switzerland is found to have the best practice over the whole period followed by Luxembourg, Norway and Canada. But the worst are Greece, Italy, Portugal and Spain. Furthermore, authors pointed out that France, Denmark, Belgium, Finland, Sweden and Austria could improve their efficiency by using less total expenditure and concluded that countries that spend more are less efficient.

The slope of equality test results also supports a significant difference between coefficients of government health expenditure between 75th and 90th quantiles. The magnitude of the coefficient is quite significant in the 90th quantile as compared to in the 75th quantile. The trend of coefficients for each regressor displayed in Figure 3. In almost all cases, the magnitude and direction of coefficients change after 80th quantile. The lower trend could be observed only for the coefficient of basic sanitation (bsan) after this quantile. An increasing trend is seen for health_gdp, pop65plus and gdppc coefficients. Focusing of the significant variable of health_gdp, there is a sharp increase in the magnitude of coefficient from 75th quantile to 90th quantile of death number. It implies the seriousness of inefficiency problem of public expenditure in health sector to almost all affected countries. Undoubtedly, some free-market economists argue government spending has a significant potential to be more inefficient than the private sector spending due to poor information and lack of incentives, which leads to misallocation of resources. Slight fluctuation traced prior increasing trend for gdppc coefficient at higher quantiles but this variable is not significant in the model. As of goodness of fit, referring to Pseudo R^2, the quantile model is considered a good model at higher quantile, mainly 90th quantile of the number of death cases.

-Table 6-

- Figure 4-

When ‘domestic general government health expenditure as a percentage of current health expenditure’ used as an indicator of health expenditure, both OLS and quantile regression could not trace the significant impact of this variable on the number of death from the pandemic. On the other hand, the results show that the population ages 65 and above (% of the total population) significantly contribute to the number of death cases. In OLS regression, an increase of one per cent of the population ages 65 and above out of the total population contributes to a significant increase in death cases by 159, ceteris paribus. Quantile regression provides more extensive analysis and able to trace that the significant impact is at 25th and 50th quantiles of death numbers. It implies that the ageing population contributes to the surging death numbers from the pandemic at lower and middle quantiles of death number distribution but not at higher quantile distribution. In other words, serious and significant impact of aging population on the death toll is obvious at the initial phase/wave of the pandemic event when the number of death is quite small. When the number of death increases, aging population alone is insignificant contributor as there are many other factors might cause the escalating number of death. Developing countries are mainly facing the issue of aging population as a result of fertility declines over the last two decades and falling death rates. This phenomenon increases the prevalence of such chronic "adult" diseases as cancer, hypertension, and heart disease (in comparison to parasitic diseases and childhood infectious and diarrheal diseases). The numbers of people over age 65 in developing countries will more than double between 1985 and 2015. By the year 2025, this elderly group will exceed 10 percent of the population in many developing countries, a proportion close to that in the United States today (Mosley et al., 1990; World Bank, 1991). In the case of Brazil, the changing age structure shows that the proportion of the elderly in the population increases. Age structure changes alone imply a 60 percent increase in deaths due to diseases (heart disease, stroke, cancer) from 1980 to 2020 (Briscoe, 1990) and this group of population is highly impacted from the risk of COVID-19 pandemic when it started.

The F statistic for the test of slope equality between coefficients in 10^{th} and 50^{th} quantiles does show significant differences at a 10 per cent significance level. COVID-19 disease could be fatal, especially to a vulnerable group of people. The group is older adult with multiple illnesses; such as cerebrovascular, endocrine, digestive, and respiratory disease. Most patients in such conditions required intensive care support. Moreover, patients in intensive care more likely to report dyspnoea, dizziness, abdominal pain, and anorexia (Wang et al., 2020). From the research conducted after the outbreak of the COVID-19 in China, the demographic result has shown that, the median age of patients who admitted and confirmed COVID-19 were 51 years old (Wu et al., 2020). Meanwhile, the median age of deceased patients due to COVID-19 was 68 years old and was significantly older than recovered patients who were 51 years old (T. Chen et al., 2020).Italy has experienced a higher case fatality rate compared to other countries at an earlier period, and they also claimed that COVID-19 is more lethal on older patients(Onder et al., 2020).

Figure 4, which shows the trend of coefficients in quantile regression, also supports different magnitudes of the coefficient for variable pop65plus. The graph shows an apparent increasing trend in this coefficient after middle quantiles. From the value of pseudo R^2 at each quantile, we conclude that the model is much better in terms of goodness fit at higher quantiles of the number of death cases.

In summation, the results from the empirical analysis found several shreds of evidence on the increasing number of positive cases among developed countries but only at lower quantiles of the number of cases. Government health expenditure is only significantly contributing to the number of death cases from the pandemic but not to the number of positive cases. The impact is found positively on the number of death cases at higher quantile, which is 90^{th} quantile. Indeed, this implies that even with significant expenses on health infrastructure, the number of death cases from the pandemic could still be escalating. Thus, it perceived that efficient allocation of funds by the government on health infrastructure, especially on medical facilities of the pandemic patients is lacking. Nevertheless, the ageing population is also another factor that contributes to the number of death from the pandemic, particularly at lower and middle quantiles of the death toll. The worrisome that this group of population is vulnerable to the pandemic probably lessens with the number of recoveries evidenced in some countries.

CONCLUSION

The present study mainly investigates factors that significantly contribute to the number of positive cases and death from pandemic COVID-19 in most affected countries in the world. In opposition to the simple linear regression method, our study employs rigorous statistical tools, namely the quantile regression method to examine the impact of several factors. The factors are the availability of health infrastructure indicated by government health expenditure, the proportion of the population who are above 65 years old, availability of basic sanitation and economic development. The empirical results show that at different quantiles, there are an increasing number of positive cases among developed countries but only at lower quantiles of the number of positive cases. Government health expenditure is significantly contributing to the number of death cases from the pandemic at higher quantile of death number distribution. Besides, the ageing population also contributes to the number of death from the pandemic, particularly at lower and middle quantiles of the death toll.

Since the virus has spread to most developed countries which are centre of tourism activities as well as migrated workers, governments in these countries had come with various measures. As in China, they had put the cities in lockdown, implementing travel warnings, bans, and cancellations, extending the national holidays and closing schools, and postponing classes (Chen et al., 2020). This spread can thus be prevented through less travelling from regions with the highest risk of the virus (Muhammad et al., 2020).

Nonetheless, efficient allocation of government funds is crucial to mitigate this virus or future viruses. In general, public expenditures have risen faster than revenues, so that annual deficits in developing countries have increased from less than 3 percent to more than 4 percent of GNP since the early 1970s (World Bank, 1988). The growing deficits do not bode well for spending on health or on education, which has potentially positive effects on health in addition to its other benefits. Between the early 1970s and 1985 in developing countries, the share of central government budgets directed toward health fell from 7 to 4 percent (World Bank, 1988). Sun et al (2017) highlighted the importance of health financing and governance in improving the efficiency of health systems, to ultimately improve health outcomes. A radical restructuring of public-private roles may improve equity, efficiency, and health outcomes. In many countries we observe relatively little public health money going to cost-effective programs. In almost all developing countries, the total health expenditure for curative care is between 70 and 85 percent, leaving only 15 to 30 percent for spending on preventive care and community services. There should be a shift involves expanded financial and producing responsibilities for the private sector, combined with a reallocation of government funds within the public sector. This shift holds out the promise of increasing both efficiency (greater improvement in health indicators at lower cost) and equity (greater health gains for the poor). Most importantly, this shift could also lessen the possibility that vulnerable group, particularly the elderly, to be seriously affected from the future pandemic.

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REFERENCES

Afonso A & Kazemi M. Assessing public spending efficiency in 20 OECD countries. In: B. Bökemeier C & GreinerA, editors. Inequality and finance in macrodynamics. Dynamic modeling and econometrics in economics and finance (Vol. 23). Cham, Springer; 2017.

Al Hajjar, S., & McIntosh, K. The first influenza pandemic of the 21st century. *Annals of Saudi Medicine*. 2010; 30(1): 1–10.

Baggett, T. P., Keyes, H., Sporn, N., & Gaeta, J. M. Prevalence of SARS-CoV-2 Infection in

Residents of a Large Homeless Shelter in Boston. *Jama*. 2020; 323(21):2191-2192

Balkhy, H., & Al-Hajjar, S. Avian influenza: are our feathers ruffled? *Annals of Saudi Medicine*.2006; 26(3): 175–182.

Bastola, A., Sah, R., Rodriguez-Morales, A. J., Lal, B. K., Jha, R., Ojha, H. C., Shrestha, B., Chu, D. K. W., Poon, L. L. M., & Costello, A. The first 2019 novel coronavirus case in Nepal. *The Lancet Infectious Diseases*. 2020;20(3): 279–280.

Bloom, E., de Wit, V., & Carangal-San Jose, M. J. Potential Economic Impact of an Avian Flu Pandemic on Asia. *ERD Policy Brief*. 2005; 42: 1–17. papers2://publication/uuid/6EC6623E-7E32-4FED-994F-4BBCC240D34C. Accessed 1 June, 2020

Briscoe J. *Brazil. The new challenge of adult health*. *World Bank Country Study*. Washington DC, World Bank; 1990

Buchinsky, M. Changes in U.S. wage structure 1963–1987. *Econometrica* . 1994; 62 (2): 405–458.

Buchinsky, M. Estimating the asymptotic covariance matrix for quantile regression models: a Monte Carlo study. *J. Econometrics*. 1995;68:303–338.

Chan, J. F.-W., Yuan, S., Kok, K.-H., To, K. K.-W., Chu, H., Yang, J., Xing, F., Liu, J., Yip, C. C.-Y., & Poon, R. W.-S. A familial cluster of pneumonia associated with the 2019 novel coronavirus indicating person-to-person transmission: a study of a family cluster. *The Lancet*. 2020; *395*(10223): 514–523.

Chen, N., Zhou, M., Dong, X., Qu, J., Gong, F., Han, Y., Qiu, Y., Wang, J., Liu, Y., & Wei, Y. Epidemiological and clinical characteristics of 99 cases of 2019 novel coronavirus pneumonia in Wuhan, China: a descriptive study. *The Lancet*. 2020; *395*(10223): 507–513.

Chen, P., Mao, L., Nassis, G. P., Harmer, P., Ainsworth, B. E., & Li, F. Wuhan coronavirus (2019-nCoV): The need to maintain regular physical activity while taking precautions. *Journal of Sport and Health Science*. 2020; 9(2):103-104.

Chen, T., Wu, D., Chen, H., Yan, W., Yang, D., Chen, G., Ma, K., Xu, D., Yu, H., & Wang, H. Clinical characteristics of 113 deceased patients with coronavirus disease 2019: retrospective study. *Bmj*. 2020;368.

Cylus J, Papanicolas I, Smith PC. A framework for thinking about health system efficiency. In: Cylus J, Papanicolas I, Smith PC, editors. Health system efficiency: How to make measurement matter for policy and management [Internet]. Copenhagen (Denmark): European Observatory on Health Systems and Policies; 2016. (Health Policy Series, No. 46.) 1. Available from: https://www.ncbi.nlm.nih.gov/books/NBK436891/

Dalton C, Corbett S, Katelaris A. Pre-emptive low cost social distancing and enhanced hygiene implemented before local COVID-19 transmission could decrease the number and severity of cases. *Med J Aust*. 2020;212(10):1-10.

de Wit E, van Doremalen N, Falzarano D, Munster VJ. SARS and MERS: recent insights into emerging coronaviruses. *Nat Rev Microbiol*. 2016;14(8):523-534.

Dong N, Cai J, Zhou Y, Liu J, Li F. End-stage Heart Failure with COVID-19: Strong Evidence of Myocardial Injury by 2019-nCoV. *JACC Hear Fail*. 2020. https://heartfailure.onlinejacc.org/content/jhf/early/2020/04/07/j.jchf.2020.04.001.full.pdf.

Driggin E, Madhavan M V, Bikdeli B, et al. Cardiovascular considerations for patients, health care workers, and health systems during the coronavirus disease 2019 (COVID-19) pandemic. *J Am Coll Cardiol*. 2020;75(18):2352-2371.

Du Z, Wang L, Cauchemez S, et al. Risk for Transportation of Coronavirus Disease from Wuhan to Other Cities in China. *Emerg Infect Dis*. 2020;26(5):1049-1052.

Eide, E., Showalter, M.H. Factors affecting the transmission of earnings across generations: a quantile regression approach. *J. Hum. Resour*. 1997; 34 (2): 253–267.

Erkoreka A. Origins of the Spanish Influenza pandemic (1918–1920) and its relation to the First World War. *J Mol Genet Med an Int J Biomed Res*. 2009;3(2):190-194.

Fonchamnyo D C & Sama MC(2016). Determinants of public spending efficiency in education and health: Evidence from selected CEMAC countries. *Journal of Economic Finance*. 2016; 40:199–210.

Guan W, Ni Z, Hu Y, et al. Clinical characteristics of 2019 novel coronavirus infection in China. *N Engl J Med*. 2020;382(18):1708-1720.

Gupta S & Verhoeven M. The efficiency of government expenditure, experiences from Africa. *Journal of Policy Modeling*. 2001; 23: 433–467.

He F, Deng Y, Li W. Coronavirus Disease 2019 (COVID-19): What we know? *J Med Virol*. 2020;92(7):719-725.

Hellewell J, Abbott S, Gimma A, et al. Feasibility of controlling COVID-19 outbreaks by isolation of cases and contacts. *Lancet Glob Heal*. 2020;8(4):488-496.

Hsu Y-C. The efficiency of government spending on health: Evidence from Europe and Central Asia. *The Social Science Journal.* 2013: 665–673.

Jayasuriya R & Wodon Q. Measuring and Explaining Country Efficiency in Improving Health and Education Indicators. *MPRA Paper 11183*. 2003. University Library of Munich, Germany.

Kang, Y.-J. Lessons learned from cases of COVID-19 infection in South Korea. *Disaster Medicine and Public Health Preparedness*. 2020:1–20.

Kang & Liu. Corporate social responsibility and corporate performance: A quantile regression approach. *Quality & Quantity*. 2014; 48: 3311-3325

Koenker R & Bassett G. Regression quantiles. *Econometrica* . 1978; 46 (1): 33–50.

Koenker R & Hallock KF. Quantile regression. *J. Econ. Perspect*. 2001; 15: 143–156.

Koenker R. *Quantile Regression*. New York, Cambridge University Press; 2005.

Koenker R, Machado, JAF. Goodness of fit and related inference processes for quantile regression. *J. Amer. Statist. Assoc*. 1999; 94 (448): 1296–1310.

Lavado R & Domingo G. Public Service Spending: Efficiency and Distributional Impact – Lessons from Asia. *ADB Economics, Working Paper Series*. 2015;435.

Livingston E, Bucher K. Coronavirus disease 2019 (COVID-19) in Italy. *Jama*. 2020;323(14):1335-1335.

Lu H, Stratton CW, Tang Y. Outbreak of Pneumonia of Unknown Etiology in Wuhan China: the Mystery and the Miracle. *J Med Virol*. 2020;92(4):401-402.

Mosteller, F.,Tukey, J.W.*Data Analysis and Regression*. Reading, MA: Addison-Wesley Publishing Co.; 1977.

Mosley WH, Jamison DT &Henderson DA. The health sector in developing countries: Problems for the 1990s and beyond. *Annual Review of Public Health.* 1990;11:335-358.

Muhammad A, Ali J, Manan A, Khan H, Owais M. Strategies to Control and Prevent Novel Coronavirus 2019: A Quick Overview. *J Liaquat Univ Med Heal Sci*. 2020;19(01):1-5.

Onder G, Rezza G, Brusaferro S. Case-fatality rate and characteristics of patients dying in relation to COVID-19 in Italy. *Jama*. 2020;323(18):1775-1776.

Peeri NC, Shrestha N, Rahman MS, et al. The SARS, MERS and novel coronavirus (COVID-19) epidemics, the newest and biggest global health threats: what lessons have we learned? *Int J Epidemiol*. 2020;0(0):1-10.

Peiris, J. S. M. M., Tu, W. W., & Yen, H. L. A novel H1N1 virus causes the first pandemic of the 21st century. *European Journal of Immunology*. 2009;*39*(11): 2946–2954.

Phan, L. T., Nguyen, T. V, Luong, Q. C., Nguyen, T. V, Nguyen, H. T., Le, H. Q., Nguyen, T. T., Cao, T. M., & Pham, Q. D. Importation and human-to-human transmission of a novel coronavirus in Vietnam. *New England Journal of Medicine*. 2020; 382(9): 872–874.

Pike, J., Bogich, T., Elwood, S., Finnoff, D. C., & Daszak, P. Economic optimization of a global strategy to address the pandemic threat. *Proceedings of the National Academy of Sciences of the United States of America*. 2014;111(52): 18519–18523.

Pullano G, Pinotti F, Valdano E, Boëlle P-Y, Poletto C, Colizza V. Novel coronavirus (2019-nCoV) early-stage importation risk to Europe, January 2020. *Eurosurveillance*. 2020;25(4):2000057.

Siu, A., & Wong, Y. C. R. Economic impact of SARS: the case of Hong Kong. *Asian Economic Papers*. 2004; 3(1): 62–83.

Sohrabi C, Alsafi Z, O'Neill N, et al. World Health Organization declares global emergency: A review of the 2019 novel coronavirus (COVID-19). *Int J Surg*. 2020;76:71-76.

Sun D, Ahn H, Lievens T, Zeng W. Evaluation of the performance of national health systems in 2004-2011: An analysis of 173 countries. *PLoS ONE*. 2017;12(3):e0173346.

Team EE. Note from the editors: World Health Organization declares novel coronavirus (2019-nCoV) sixth public health emergency of international concern. *Eurosurveillance*. 2020;25(5):200131e.

Van Kerkhove MD, Vandemaele KAH, Shinde V, et al. Risk factors for severe outcomes following 2009 influenza A (H1N1) infection: a global pooled analysis. *PLoS Med*. 2011;8(7):e1001053.

Velavan TP, Meyer CG. The COVID-19 epidemic. *Trop Med Int Heal*. 2020;25(3):278.

Wang D, Hu B, Hu C, et al. Clinical characteristics of 138 hospitalized patients with 2019 novel coronavirus–infected pneumonia in Wuhan, China. *Jama*. 2020;323(11):1061-1069.

Wu C, Chen X, Cai Y, et al. Risk factors associated with acute respiratory distress syndrome and death in patients with coronavirus disease 2019 pneumonia in Wuhan, China. *JAMA Intern Med*. 2020. https://jamanetwork.com/journals/jamainternalmedicine/article-abstract/2763184.

World Development Report. New York, Oxford University Press; 1988

World Development Report. New York, Oxford University Press; 1991

World Health Organization. What is a pandemic? https://www.who.int/csr/disease/swineflu/frequently_asked_questions/pandemic/en/. Published 2010. Accessed 7 June, 2020.

World Health Organization. Novel Coronavirus (2019-nCoV): situation report, 3. World Health Organization. https://www.who.int/docs/default-source/coronaviruse/situation-reports/20200123-sitrep-3-2019-ncov.pdf?sfvrsn=d6d23643_8. Published 2020.Accessed 7 June, 2020

Yang Y, Lu Q, Liu M, et al. *Epidemiological and Clinical Features of the 2019 Novel Coronavirus Outbreak in China*. Cold Spring Harbor Laboratory Press; 2020. https://www.medrxiv.org/content/10.1101/2020.02.10.20021675v2.

Yin Y, Wunderink RG. MERS, SARS and other coronaviruses as causes of pneumonia. *Respirology*. 2018;23(2):130-137.

Zhou F, Yu T, Du R, et al. Clinical course and risk factors for mortality of adult inpatients with COVID-19 in Wuhan, China: a retrospective cohort study. *Lancet*. 2020;395(1022):1054-1062.

Zhou P, Yang X-L, Wang X-G, et al. A pneumonia outbreak associated with a new coronavirus of probable bat origin. *Nature*. 2020;579(7798):270-273.

Zu ZY, Jiang M Di, Xu PP, et al. Coronavirus disease 2019 (COVID-19): a perspective from

China. Radiology. https://pubs.rsna.org/doi/10.1148/radiol.2020200490. Published 2020.

TABLES

Table 1. Data and Variables

Variable	**Definition/description**	**Measurement**	**Sources**
numcase	Number of positive cases (as of 14 April 2020)	unit	World Health Organization
numdeath	Number of death (as of 14 April 2020)	unit	World Health Organization
health_gdp	Domestic general government health expenditure (% of GDP)	per cent	World Health Organization Global Health Expenditure database
health_gexp	Domestic general government health expenditure (% of current health expenditure)	per cent	World Health Organization Global Health Expenditure database
pop65plus	Population ages 65 and above (% of total population)	per cent	World Development Indicators
bsan	People using at least basic sanitation services (% of population)	per cent	World Development Indicators
gdppc	GDP per capita (constant 2010 US$)	US$	World Bank and OECD National Accounts data files

Table 2. Descriptive Statistics of Variables

Variable	N	Minimum	Maximum	Mean	Standard deviation	Skewness	Kurtosis
numcase	118	106	582594	16272.76	60516.51	7.538	66.884
numdeath	118	0	23649	1014.339	3697.076	4.730	22.640
health_gdp	116	0.188	10.475	4.017	2.304	0.594	-0.196
health_gexp	114	5.095	94.823	56.638	20.202	-0.399	-0.520
pop65plus	116	1.034	27.109	10.595	6.462	0.323	-1.140
bsan	116	10.506	100	85.470	22.453	-1.950	2.898
gdppc	116	393.662	109453	19293.11	22072.92	1.581	2.354

Table 3. Quantile regression results 1

Independent variables	Quantile regression Dependent variable: *numcase* **OLS**	**10th quant**	**25th quant**	**50th quant**	**75th quant**	**90th quant**
Constant	-8832.05 (22846.3)	-9.862 (106.63)	52.85 (161.36)	-252.48 (411.8)	497.13 (2020.6)	-900.4 (15907)
health_gdp	9710.65** (4143.5)	35.690 (42.37)	44.43 (87.46)	92.51 (300.3)	1145.9 (2190.60	12203.7 (13014.1)
pop65plus	-576.05 (1399.7)	1.964 (20.66)	6.431 (24.72)	173.20 (114.2)	336.7 (520.3)	3002.7 (3503.0)
bsan	-135.3 (312.9)	0.434 (2.139)	-1.046 (4.266)	-4.408 (9.511)	-45.53 (56.44)	-310.4 (288.5)
gdppc	0.249 (0.330)	0.280*** (0.008)	0.0494** (0.023)	0.118 (0.072)	0.295 (0.453)	0.091 (2.255)
N	110	110	110	110	110	110
Adj. R^2	0.088					
Pseudo R^2		0.0213	0.0253	0.0381	0.0683	0.1957
	Slope equality test					
	$\tau_{0.25,0.50,0.75,0.90}$		**$\tau_{0.10,0.25}$**		**$\tau_{0.25, 0.50,0.75}$**	
	F-statistic	***p-value***	***F-statistic***	***p-value***	***F-statistic***	***p-value***
health_gdp	0.85	0.4671	0.01	0.9316	0.13	0.8783
pop65plus	0.96	0.4148	0.03	0.8732	1.25	0.2896
bsan	0.54	0.6527	0.17	0.6833	0.33	0.7194
gdppc	0.35	0.7885	2.08	0.1521	0.60	0.5488

Note: 1. Standard errors are in parentheses; ***statistically significant at the 1% level; **5% level; *10% level.
2. For quantile regressions, standard errors are bootstrap (100) standard errors

Table 4. Quantile regression results 2

Independent variables	Quantile regression Dependent variable: *numcase* **OLS**	**10th quant**	**25th quant**	**50th quant**	**75th quant**	**90th quant**
Constant	6306.4 (25109.7)	-118.2 (212.87)	209.22 (202.54)	204.88 (621.91)	748.64 (3016.4)	-5383.3 (14705.1)
health_gexp	-495.6 (415.14)	5.049 (5.297)	-3.486 (6.29)	-17.658 (18.41)	-45.327 (66.125)	-46.656 (357.7)
pop65plus	1744.3 (1210.6)	-4.293 (16.332)	8.738 (27.182)	239.55 (120.14)	614.50 (496.63)	4453.4 (2918.8)
bsan	97.96 (342.38)	0.6029 (2.888)	1.064 (3.999)	-3.033 (9.915)	-11.764 (26.51)	-133.23 (115.42)
gdppc	0.633* (0.335)	0.0273*** (0.0097)	0.0487*** (0.0186)	0.1223** (0.0573)	0.3042 (0.4746)	1.218 (2.215)
N	108	108	108	108	108	108
Adj. R^2	0.0524					
Pseudo R^2		0.0214	0.0250	0.0386	0.0677	0.1810
	Slope equality test					
	$\tau_{0.25,0.50,0.75,0.90}$		$\tau_{0.10,0.25}$		$\tau_{0.25,0.50}$	
	F-statistic	***p-value***	***F-statistic***	***p-value***	***F-statistic***	***p-value***
health_gexp	0.21	0.8904	3.08	0.0824	0.43	0.5126
pop65plus	1.49	0.2213	0.25	0.6180	4.05	0.0468
bsan	0.25	0.8587	0.02	0.8878	0.38	0.5375
gdppc	0.7	0.5568	1.85	0.1768	2.00	0.1604

Note: 1. Standard errors are in parentheses; ***statistically significant at the 1% level; **5% level; *10% level.
2. For quantile regressions, standard errors are bootstrap (100) standard errors

Table 5. Quantile regression results 3

Independent variables	Quantile regression					
	Dependent variable: *numdeath*					
	OLS	**10th quant**	**25th quant**	**50th quant**	**75th quant**	**90th quant**
Constant	-591.7 (1380.2)	-1.4017 (4.245)	2.671 (7.777)	3.722 (14.098)	-32.07 (112.8)	153.04 (799.36)
health_gdp	538.06** (250.32)	0.1758 (1.781)	3.041 (4.167)	4.944 (12.55)	8.375 (173.19)	1359.3** (621.7)
pop65plus	38.663 (84.56)	0.3011 (0.6239)	1.540 (1.032)	4.884 (4.085)	11.511 (41.94)	230.71 (267.34)
bsan	-12.953 (18.90)	0.00081 (0.0886)	-0.187 (0.115)	-0.414 (0.426)	-0.103 (5.108	-38.01 (23.002)
gdppc	0.01006 (0.0199)	0.00012 (0.00015)	0.00045 (0.0003)	0.0022 (0.0025)	0.0121 (0.0187)	0.0079 (0.1189)
N	110	110	110	110	110	110
Adj. R^2	0.1084					
Pseudo R^2		0.0015	0.0044	0.0120	0.0348	0.2003
	Slope equality test					
	$\tau_{0.25,0.50,0.75,0.90}$		$\tau_{0.25,0.50,0.75}$		$\tau_{0.75,0.90}$	
	F-statistic	***p-value***	***F-statistic***	***p-value***	***F-statistic***	***p-value***
health_gdp	1.88	0.1381	0.02	0.9772	5.42	0.0218
pop65plus	0.59	0.6234	1.14	0.3234	0.77	0.3815
bsan	1.34	0.2659	0.29	0.7487	3.84	0.0527
gdppc	0.15	0.9290	0.38	0.6863	0.00	0.9704

Note: 1. Standard errors are in parentheses; ***statistically significant at the 1% level; **5% level; *10% level.
2. For quantile regressions, standard errors are bootstrap (100) standard errors

Table 6. Quantile regression results 4

Independent variables	Quantile regression					
	Dependent variable: *numdeath*					
	OLS	**10^{th} quant**	**25^{th} quant**	**50^{th} quant**	**75^{th} quant**	**90^{th} quant**
Constant	27.76 (1517.9)	-0.9888 (5.758)	0.0718 (8.247)	15.365 (39.02)	-7.886 (2017.8)	1185.4 (1483.4)
health_gexp	-16.616 (25.096)	-0.0003 (0.1348)	-0.0276 (0.2577)	-0.523 (1.125)	-0.651 (4.368)	-44.13 (37.32)
pop65plus	159.09** (73.184)	0.3005 (0.6447)	1.824* (1.0085)	6.669** (3.382)	15.256 (47.70)	359.56 (299.8)
bsan	-2.948 (20.690)	0.0008 (0.0849)	-0.0634 (0.1293)	-0.236 (0.261)	-0.105 (2.069)	-12.712 (9.4870
gdppc	0.0285 (0.0202)	0.00012 (0.0002)	0.0005 (0.0004)	0.0026 (0.0027)	0.0115 (0.0345)	0.1941 (0.1399)
N	108	108	108	108	108	108
Adj. R^2	0.0718					
Pseudo R^2		0.0015	0.0040	0.0123	0.0341	0.1772
	Slope equality test					
	$\tau_{0.25,0.50,0.75,0.90}$		**$\tau_{0.25,0.50,0.75}$**		**$\tau_{0.10,0.50}$**	
	F-statistic	***p-value***	***F-statistic***	***p-value***	***F-statistic***	***p-value***
health_gexp	0.62	0.6066	0.30	0.7395	0.65	0.4210
pop65plus	1.37	0.2556	1.14	0.3240	3.04	0.0843
bsan	0.44	0.7281	0.13	0.8775	0.83	0.3650
gdppc	0.68	0.5656	0.31	0.7323	0.79	0.3751

Note: 1. Standard errors are in parentheses; ***statistically significant at the 1% level; **5% level; *10% level.
2. For quantile regressions, standard errors are bootstrap (100) standard errors

FIGURES

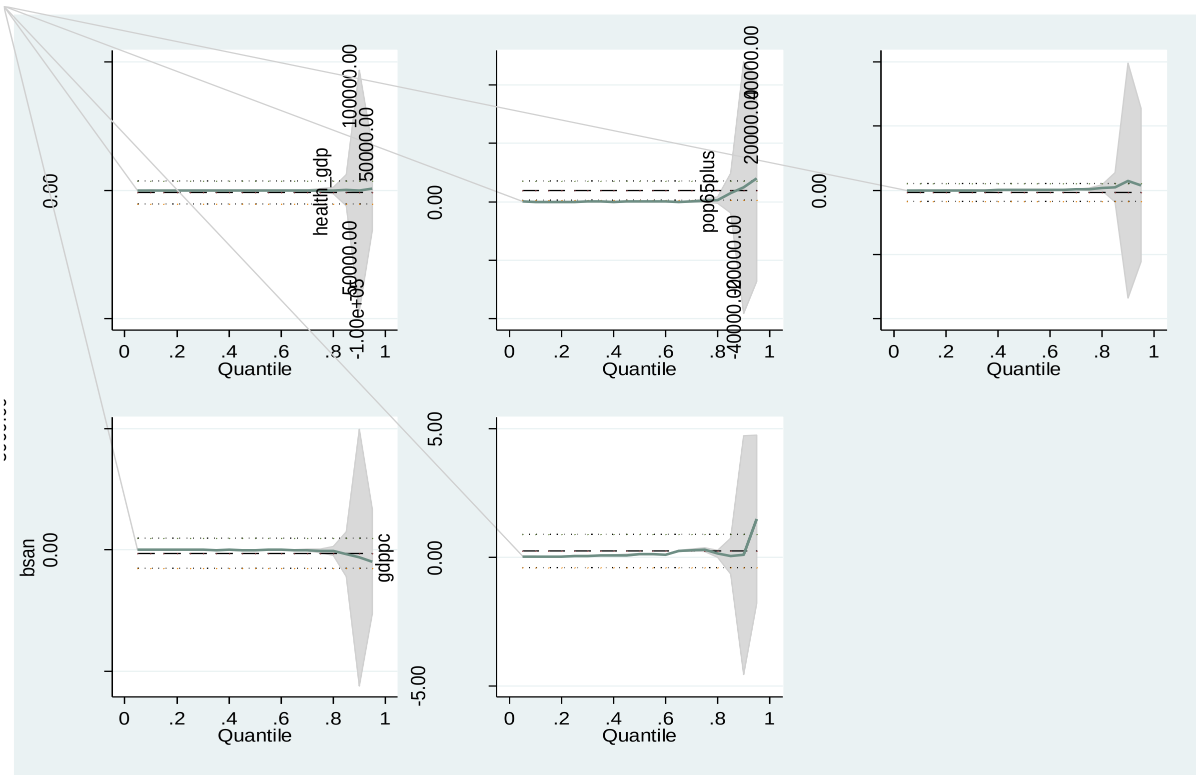

Figure 1. The trend of coefficients of exploratory variables on dependent variable by quantiles (equation 2)

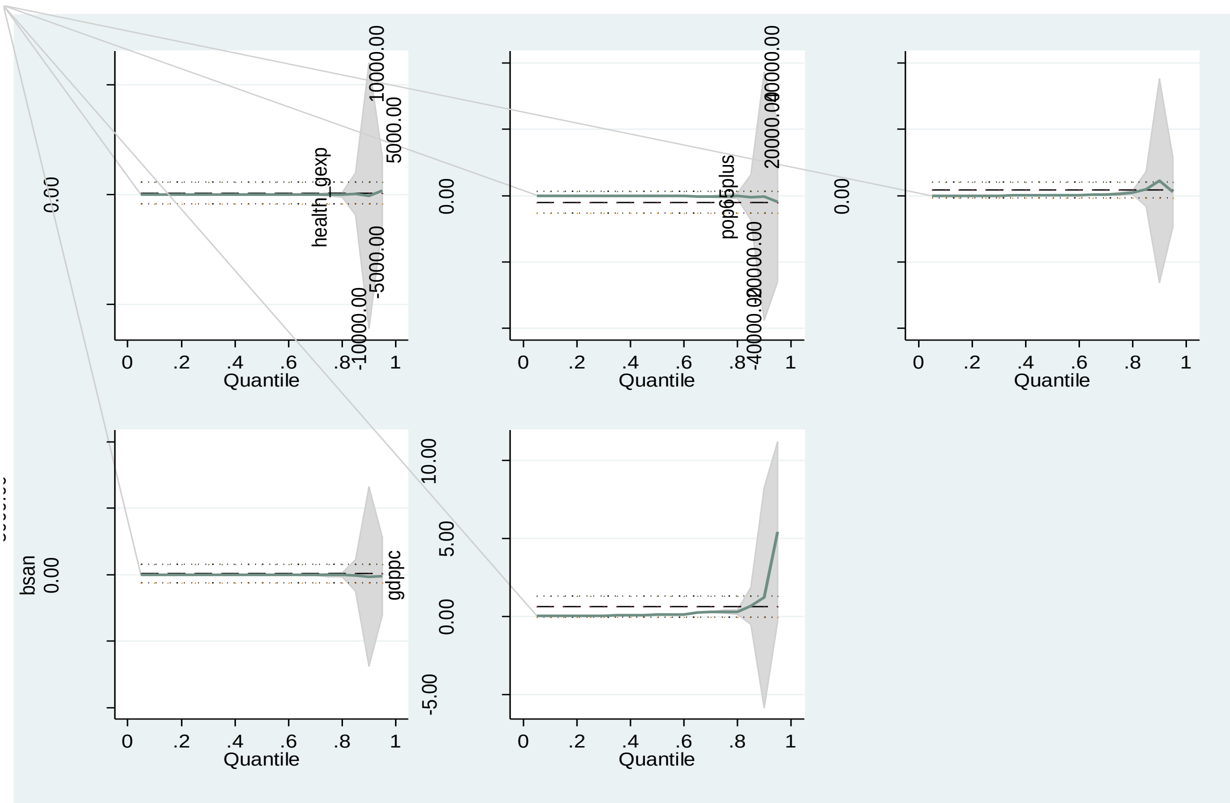

Figure 2. The trend of coefficients of exploratory variables on dependent variable by quantiles (equation 3)

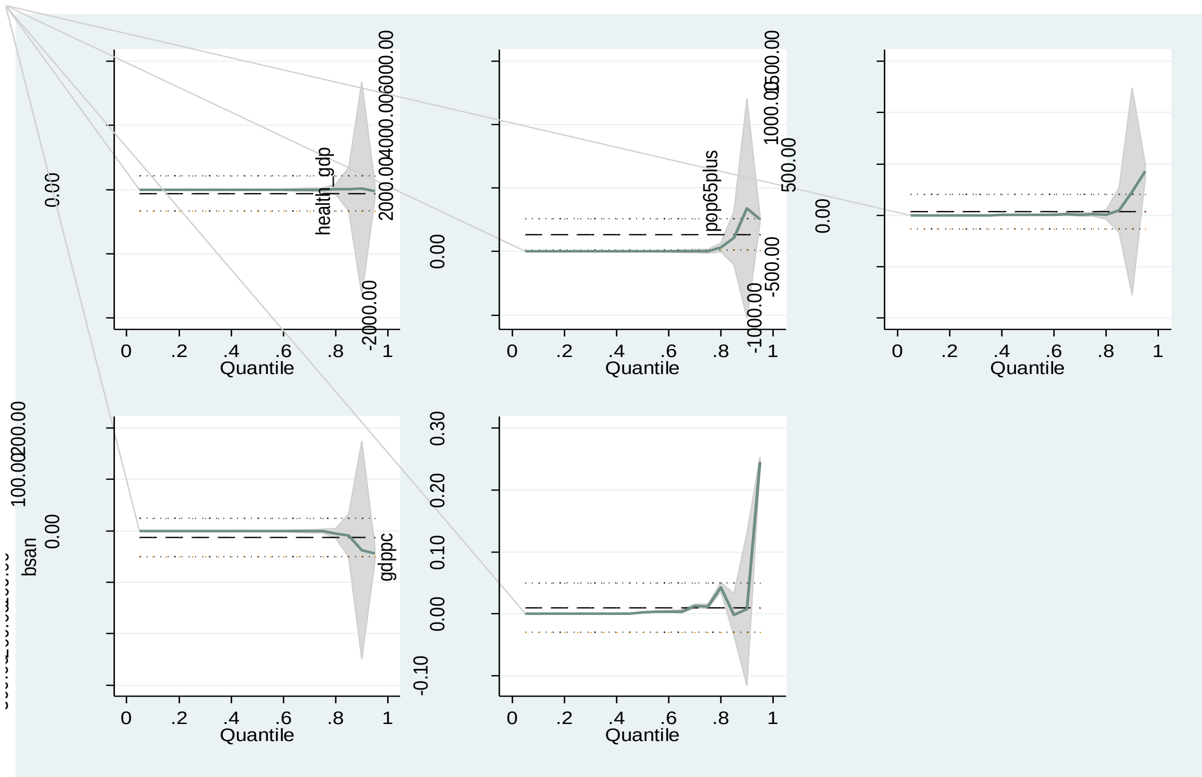

Figure 3. The trend of coefficients of exploratory variables on dependent variable by quantiles (equation 4)

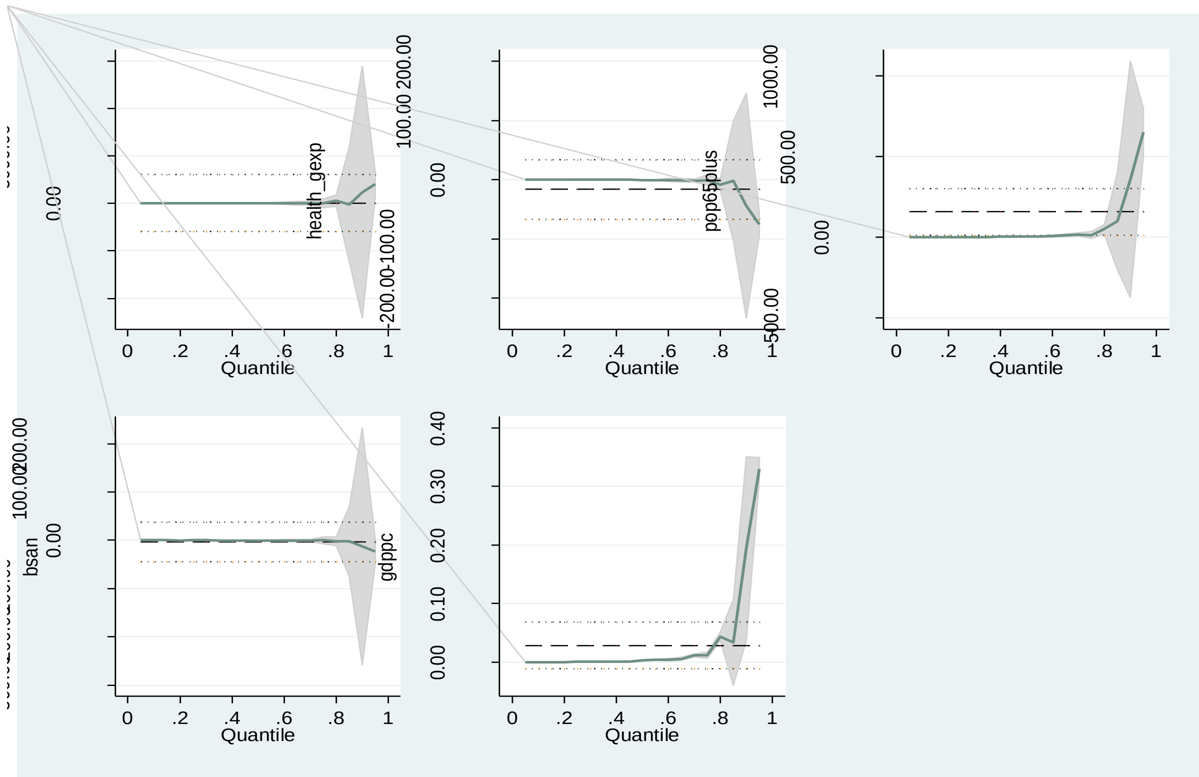

Figure 4. The trend of coefficients of exploratory variables on dependent variable by quantiles (equation 5)

APPENDIX

List of countries in study

Afghanistan	Denmark	Lebanon	San Marino
Albania	Djibouti	Lithuania	Saudi Arabia
Algeria	Dominican rep	Luxembourg	Senegal
Andorra	Ecuador	Madagascar	Serbia
Argentina	Egypt	Morocco	Singapore
Armenia	El Salvador	Malaysia	Slovakia
Australia	Estonia	Mali	Slovenia
Austria	Finland	Malta	South Africa
Azerbaijan	France	Mauritius	South Korea(rep)
Bahrain	Georgia	Mexico	Spain
Bangladesh	Germany	Moldova	Sri Lanka
Belarus	Ghana	Montenegro	Sweden
Belgium	Guatemala	Netherland	Switzerland
Bolivia	Guinea	New Zealand	Thailand
Bosnia Heregovina	Honduras	Niger	Trinidad & Tobago
Brazil	Hungary	Nigeria	Tunisia
Brunei	Iceland	North Macedonia	Turkey
Bulgaria	India	Norway	UAE
Burkina Faso	Indonesia	Oman	UK
Cambodia	Iran	Pakistan	Ukraine
Cameroon	Iraq	Palestine (West bank gaza)	Uruguay
Canada	Ireland	Panama	US
Chile	Israel	Paraguay	Uzbekistan
China	Italy	Peru	Venezuela
Colombia	Japan	Phillipines	Vietnam
Congo(rep)	Jordon	Poland	
Costa Rica	Kazakhstan	Protugal	
Crotia	Kenya	Qatar	
Cuba	Kuwait	Romania	
Cyprus	Kyrgyzstan	Russia	
Czech Republic	Latvia	Rwanda	