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Geographical Disparities in COVID Mortality: Regression Findings

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Abstract:

Purpose: *After almost four years of the COVID pandemic, there remain significant differences in its effect on the death rate (death per 1M population) and the fatality rate (death/case ratio) among different regions of the world, especially between Eastern and Western countries, according to the cumulative figures found in Worldometers. For example, the death rate and the fatality rate for Japan are 595 and 0.221% respectively, whereas those for the US are 3,519 and 1.082% respectively. The aim of this research is to examine and determine what factors can explain these regional differences in the COVID death and fatality rates for some 150 countries around the world.*

Design/Methodology/Approach: *First, we overview the geographical patterns of those cumulative figures, particularly international differences between the East and the West as well as between the North and the South by the regression analysis using the longitude and the latitude numbers for some 150 countries. Second, we introduce key economic, demographic and health factors as explanatory variables in our regression analysis to explain the regional differences revealed in our longitude-latitude approach. Finally, we present our hypothesis regarding the degree of immunity for corona viruses to explain what is left unexplained by the key socio-economic factors.*

Findings: *Our results show that the representative economic factor, that is, per capita income, is the only consistently significant variable among various other social and health factors which could, in theory, affect the regional differences in COVID cases, deaths and fatality rates. Our analysis also shows that per capita income cannot fully explain the regional differences and the longitude variable remains significant in our regressions with the per capita income variable included. This result has led us to the hypothesis regarding the degree of immunity.*

Practical implications: *Our study implies that we should be more careful about adopting globally uniform anti-corona virus policies which are often recommended by international organizations on the basis of data and/or observations in certain countries or regions, mostly the Western world. What we need is a more localized, or regionalized policy making and adoption approach toward a "pandemic" like COVID, based on data and observations in each region, as there might well be significant regional differences in the death and fatality rates remaining over several years.*

Originality/Value: *This is the first empirical study to highlight and analyze the regional differences, particularly the East-West differences, in COVID cases, death, and fatality rates. It is also significant that this study is the first attempt to comprehensively use the worldwide*

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data listed in the Worldometer table, which is often cited but never fully utilized to do empirical studies.

Keywords: *Regional differences, COVID mortality, per capita income, longitude*.

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1. Introduction

It should be noticed that, after almost four years of the COVID pandemic, there remain significant differences in its effect on the death rate (death/population ratio) and the fatality rate (death/case ratio) among different regions of the world. For example, according to the cumulative figures found in Worldometers' data table (https://www.worldometers.info/coronavirus/), the differences among six major countries are as in Table 1 (as of Oct. 7, 2023).

Table 1. *Deaths and Fatality rate in regions*

Regions	Cases per 1M pop	Deaths per 1M pop	Fatality rate (%)
[East] Australia	451,754	875	0.193
Japan	269,169	595	0.221
S. Korea	673,523	700	0.103
[West] USA	325,043	3,519	1.082
UK	360,826	3,348	0.927
France	612,013	2,556	0.417

Source: *Worldometers' data table.*

There appear no systematic differences in total cases per 1M population between the East (Australia, Japan, and S. Korea) and the West (US, UK, and France), but surprising is such huge differences remaining in the death rate and the fatality rate between the East and the West.

In this paper, we examine what factors can explain these regional differences in the COVID death and fatality rates in terms of cumulative figures over the past three and a half years.

First, we overview the geographical patterns of those cumulative figures, particularly international differences between the East and the West as well as between the North and the South by using the longitude and the latitude numbers for some 150 countries.

Second, we introduce key economic, demographic and health factors as explanatory variables for the regional differences revealed in our longitude-latitude analysis.

Finally, we present our hypothesis regarding the degree of immunity for corona viruses to explain what is left unexplained by the key socio-economic factors.

1.1 Dr. Yamanaka's X-Factor and the Genetic Inheritance from Neanderthals

Despite apparent differences in the number of COVID cases and deaths between the East and the West, very few studies have been done to analyze such a phenomenon to find the reasons for the East-West differences.

One notable exception is the study by Dr. Sinya Yamanaka, Nobel Laureate in physiology, who emphasize some unknown factor that he called "X-factor" which might have made a difference between Japan and the rest of the world regarding the effects of COVID (https://asia.nikkei.com/Business/Science/Yamanaka-on-COVID-19/Uncovering-Japan-s-coronavirus-X-factor-matters-to-the-world).

As it turned out, this difference is not really between Japan and the rest of the world but rather between East Asia and Oceania on one hand and Western Europe and America on the other (Table 1). Note that Australia and New Zealand have been similar to East Asian countries and very different from the Western countries in terms of COVID cases and deaths, implying that the difference is regional and not genetic or racial in nature.

This fact is also shown by the time series profile of excess deaths in Australia and New Zealand as compared to that of other East Asian countries in contrast to that of typical Western countries (https://ourworldindata.org/excess-mortality-covid).

As indicated, those representative Oceanian countries have been following the same pattern of other East Asian countries with an initial low excess death rate followed by an increasing number of excess deaths over time. In contrast, most Western European countries have shown an almost opposite trend with a very high excess death rate in the first year of the pandemic followed by a decreasing number of excess deaths over time.

It should be noted that these results seem to contradict the COVID-related implications of the recent studies by a group of notable scientists including Nobel Laureate Svante Saabo that some genetic factors inherited from Neanderthals are responsible for severe symptoms of COVID, possibly leading to a higher death rate among the people with the risky genetic heritage.

Here again, Australia and New Zealand offer definite counterexamples. According to those recent studies, Australians and New Zealanders are likely to have a distinctly riskier factors than East Asians, but in reality those two representative Oceanian countries have been exhibiting very similar patterns to most East Asian countries, rather than to most Western European countries, in terms of the rates of cases and deaths over time (Ref: https://www.nature.com/articles/s41586-020-2818-3 and https://www.oist.jp/news-center/news/2020/9/30/ancient-neanderthal-hand-severe-covid-19).

2. Geographical Patterns of COVID Cases and Deaths

Since our study focuses on geographical differences in the effects of COVID, we adopt the "inductive" approach. We thereby start with actual, stylized observations for analysis, rather than the "deductive" approach with a certain theoretical model to explain the effects of COVID based on previous model analyses in the literature.

We, therefore, examine how different the COVID case and death rates are among some 150 countries as listed in the Worldometers' data table in terms of world geography, particularly on the east-west axis and on the north-south axis.

We use the "longitude" number for the capital city of each country to represent the distance from the International Date Line (IDL) in the westward direction all the way around (360 degrees) back to IDL. We also use the "latitude" numbers to present the distance from the equator in the northern direction up to the North Pole in the Northern Hemisphere, and the distance from the equator in the southern direction down to the South Pole in the Southern Hemisphere.

This way we treat the Northern and the Southern Hemispheres in a symmetric fashion. For example, we properly take account of temperature differences for different countries in order of distance from the equator regardless of their hemisphere.

The following are the results from our regressions of the total number of COVID cases (L) and the total number of COVID deaths (M) per 1M population, respectively, in Table 2 and Table 3 below, on the longitude (G) and the latitude (H) to overview their regional distribution in the world.

Table 2. *Total COVID cases per 1M population.*

$L = aG + bH + k$

Where: L = Total number of COVID cases per 1M pop, G = longitude, and H = latitude.

G (longitude):	a = -76.275	(t = -0.3288; Not significant)
H (latitude):	b = 3,345.127	(t = 6.2589; Significant)
Constant:	k = 107,233.500	(t = 2.6535; Significant)

$R^2 = 0.203$ (Adjusted $R^2 = 0.193$), Total number of observations = 157

Source: *Own study.*

Table 3. *Total COVID deaths per 1M population.*

$M = aG + bH + k$,

Where: M = Total number of COVID deaths per 1M pop, G = longitude, and H = latitude

G (longitude):	a = 7.048	(t = 4.0787; Significant)
H (latitude)	b = 18.877	(t = 4.7417; Significant)
Constant:	k = -156.635	(t = -0.5210; Not significant)

$R^2 = 0.206$ (Adjusted $R^2 = 0.196$), Total number of observations = 157

Source: *Own study.*

(Ref: https://www.worldometers.info/coronavirus/ as of August 10, 2023)

First, we find from Table 2, regarding COVID "cases," the coefficient for the "longitude" is positive but NOT significant, whereas the coefficient for the "latitude" variable is positive and significant. This means that "the farther away from the equator the country (its capital city) is located, the more COVID cases it tends to have." On the other hand, we cannot make any definite statement about the "longitude" variable, since its coefficient is insignificant in explaining COVID cases.

Second, as seen in Table 3 regarding COVID "deaths," the coefficients for both the longitude and the latitude variables are positive and significant, which means that "the farther away in the westward direction from the International Date Line (IDL) the country is located, the greater number of COVID deaths it tends to register." And, just as for COVID cases, we note that "the farther away from the equator the country (its capital city) is located, the more COVID deaths appear."

Now that we have overviewed the patterns of geographical distribution of COVID cases and deaths, we explain why such certain patterns tends to emerge by focusing on key social factors like economic, demographic, and health conditions.

3. Economic, Demographic and Health Factors

Now consider some economic, demographic and health factors, which can possibly explain the differences in the COVID case and death rates among different countries. Actually, an economic factor stands out as "the representative index" to indicate the level of socio-economic development. That variable is "per capita income," which is closely correlated with the level of economic activities as well as the level of nutrition, hygiene, health care, and medical services in general, thus possibly making a difference in the COVID cases and/or deaths.

Another factor, which is especially important in relation to COVID, is a demographic factor, that is, the degree of "aging," as it has widely been reported that older people, particularly those who are 60 or above, are more susceptible and vulnerable to COVID than younger people are.

Although the degree of aging can be correlated with the level of per capita income, it may be worthwhile to consider it an independent explanatory variable to influence the COVID case and/or death rates.

The third factor is a health-related one, that is, the obesity rate, which can affect the COVID death rate significantly, at least in the case of the alpha and delta variants. In addition, it is well known that the obesity rate, that is, the percentage of obese people in total population, is much higher in the Western countries like the US and Europe than in the Asian countries like Japan and Korea. So, this factor is a good candidate to explain why the death rate is higher in the West than in the East.

Below are the results of our regressions of both COVID case and death rates with respect to five independent variables, per capita income (Y), the aging rate (I), and the obesity rate (J) in addition to the longitude (G) and the latitude (H) variables. In Table 4, the number of COVID cases is regressed on all the five variables, and in Table 5, the number of COVID deaths is regressed on those five variables.

Note that we use the per capita income, aging, and obesity data for 2019, since the dependent variables, the COVID case and death rates, are "cumulative figures" for 2020-2023.

From Tables 4 and 5, we find that "per capita income" and "aging" are both significant for COVID cases as well as for COVID deaths. On the other hand, the obesity rate is not significant for cases, although it is significant for deaths.

As expected, the coefficient for aging is positive, which means that the higher the aging rate, the greater the number of cases and deaths. Interestingly, the coefficient for per capita income is "positive" for cases, but "negative" for deaths. This is really puzzling.

Table 4. *Total "cases" per 1M population.*

$L = aY + bI + cJ + dG + eH + k$

Where: L = Total number of COVID cases per 1M pop, Y = per capita income, I = aging rate, J = obesity rate, G = longitude and H = latitude.

Y (per capita income):	a = 3.485	(t = 6.2010; Significant)
I (aging):	b = 15,442.600	(t = 8.3519; Significant)
J (obesity):	c = 1,519.190	(t = 1.3191; Not significant)
G (longitude):	d = -220.125	(t = -1.4017; Not significant)
H (latitude):	e = -289.895	(t = -0.6780; Not significant)
Constant:	k = -17,928.130	(t = -0.6185; Not signif0.icant)

$R^2 = 0.676$ (Adjusted $R^2 = 0.665$), Total number of observations = 157

Source: *Own study.*

Table 5. *Total "deaths" per 1M population.*

$M = aY + bI + cJ + dG + eH + k$

Where: M = Total number of COVID deaths per 1M pop, Y = per capita income, I = aging rate, J = obesity rate, G = longitude and H = latitude.

Y (per capita income):	a = -0.021	(t = -5.250; Significant)
I (aging):	b = 167.515	(t = 11.5991; Significant)
J (obesity):	c = 45.813	(t = 5.0931; Significant)
G (longitude):	d = 4,818	(t = 3.9266; Significant)
H (latitude):	e = -3.769	(t = -1.1287; Not significant)
Constant:	k = -1,422.948	(t = -6.2851; Significant)

$R^2 = 0.645$ (Adjusted $R^2 = 0.633$), Total number of observations = 157

Source: *Own study.*

A possible explanation for these rather conflicting income effects is that the number of cases tends to increase, as a country becomes richer and the socio-economic activities and human interactions are increasing accordingly.

But the number of deaths may well decrease, as hospital care and medical conditions (including the availability of COVD vaccines) tend to improve with per capita income. But this is only a possible explanation, and it remains puzzling.

Regarding the "latitude" variable, we should notice in Table 4 that the latitude variable is no longer significant for cases after controlling for per capita income and aging.

This means that the North-South difference in the number of COVID cases can be explained by the income and aging factors only, and not by other factors, like temperature or climate, related to the latitude difference.

On the other hand, as far as the death rate is concerned, in Table 5, the "longitude" variable is still significant even after controlling for income, aging, and even obesity, which can only partially explain the East-West difference in the COVID death rate.

4. Adjustment for the Number of Tests

Let's take a second look at the conflicting effects of per capita income on COVID cases and deaths. It all amounts to the question why the number of cases tends to "increase," rather than decrease, with per capita income. Here we should notice that the number of cases naturally tends to increase with the number of tests on COVID, and the number of tests tends to be greater for countries with a higher income.

Therefore, the positive effects of per capita income on the number of cases may be simply due to the result of an increasing number of tests with a higher income.

To see if this is indeed the case, we have first found from our Worldometer data that the number of tests is almost proportional to the per capita income level. And then we have regressed per capita income and other variables on the number of cases and deaths "per test," instead of the number of cases and deaths "per population" in order to adjust for the number of COVID tests.

It appears from our regression results that the effect of per capita income on the number of "cases per test" is no longer significant, whereas it was positively significant on the number of "cases per population" before.

On the other hand, the effect of per capita income on the number of "deaths per test" remains negative and significant, just like it was on the number of "deaths per population." In addition, the longitude variable is still positive and significant on the number of deaths per test, just as before.

All this means that the puzzle of having the opposite effects of per capita income on the number of cases and deaths may now be resolved. The positive effect of per capita income on the number of cases may simply be apparent because it is a result of the number of tests, whereas the negative effect of per capita income on the number of deaths is "robust" since it holds for both "deaths per test" and "deaths per population."

5. Factors Affecting the Fatality Rate

Finally, we consider the "fatality" rate (the death/case ratio) to see a possible change in the significance of the key socio-economic variables, as some of those variables

could become insignificant by affecting both the numerator (death) and denominator (case) in more or less the same way, although they are significant for each (or either) of the case and the death regressions. Notice that unlike previous cases, it does not matter if it is per test or per population, since the fatality is the "ratio" of deaths to cases.

The following is the result of our regression of the "fatality" rate with respect to the same five independent variables as before. In Table 6, the fatality rate (F), that is the ratio of deaths (M) to cases (L), is regressed on per capita income (Y), the aging rate (I), and the obesity rate (J) as well as the longitude (G) and the latitude (H) variables.

Table 6. *Fatality Rate.*

$F = aY + bI + cJ + dG + eH + k$

Where: F = COVID fatality rate, Y = per capita income, I = aging rate, J = obesity rate, G = longitude and H = latitude.

Y (per capita income):	a = -0.0000076020	(t = -4.102; Significant)
I (aging):	b = -0.00007779	(t = -0.467; Not significant)
J (obesity):	c = -0.00008529	(t = -0.822; Not significant)
G (longitude):	d = 0.00005349	(t = 3.782; Significant)
H (latitude):	e = -0.000006889	(t = -0.179; Not significant)
Constant:	k = 0.01142	(t = 4.375; Significant)

$R^2 = 0.2505$ (Adjusted $R^2 = 0.2257$), Total number of observations = 157

Source: *Own study.*

Interesting enough, according to this regression result, only two variables are significant, that is, "per capita income" and "longitude," whereas the obesity rate, which is significant for the death rate, becomes insignificant in explaining the fatality rate difference between the East and the West, probably because obesity affects both numerator (death) and denominator (case) in more or less the same way.

The question, therefore, is whether other factors than economic, demographic, and health variables can explain the remaining East-West difference in the death rate and the fatality rate.

Actually, this is a question very much related to what Japanese stem cell researcher and Nobel Prize laureate Shinya Yamanaka called "X-Factor," that is an unknown factor, which could explain the significant difference in COVID mortality between the West and the East, particularly, Japan, which Dr. Yamanaka focused on in the early days of the pandemic period.

6. Past Exposure to Corona Viruses

A possible cause for the East-West difference in the COVID death/fatality rate is the

intensity and frequency of the exposure to corona viruses prior to the COVID-19 pandemic, likely resulting in the different level of "immunity" for COVID acquired by the time when COVID-19 arrived.

This "immunity" hypothesis seems consistent with various data and observations that have been reported in the past studies on corona viruses, including recent studies on the effect of COVID vaccines, which have raised the level of immunity, resulting in a significant reduction in the death and mortality rates, but not necessarily in the number of cases per population.

First, according to WHO's study on SARS, which was the first major corona virus outbreak (https://www.who.int/publications/m/item/summary-of-probable-sars-cases-with-onset-of-illness-from-1-november-2002-to-31-july-2003), a total of 29 countries reported some SARS cases, in which COVID deaths were registered in 11 countries.

There, the greatest number of cases and deaths per population was reported in Hong Kong, followed by Taiwan and other Asian countries such as China and Singapore, whereas Western countries like UK, France, Germany, Spain, Italy, etc., had very few cases with virtually no death registered at least during the year of 2003.

What this means is that many people in Asian countries may have been exposed to a kind of corona viruses due to the SARS outbreak two decades ago, and possibly acquired some kind of immunity for corona viruses including COVID-19.

If that is the case, however, there should be a question whether the immunity acquired two decades ago can possibly remain effective for such a long time, especially in East Asia. Actually, some recent studies gave at least partial answers to these questions.

The research results recently obtained from the SARS studies by researchers in Singapore and Germany independently have shown that the exposure to SARS two decades ago seemed to create the kind of immunity strong enough to remain effective and neutralize the Alpha and the Delta variants of COVID-19 in some cases

(Ref: Fighting the Variants of Corona Viruses, 2022, authored by Toshio Kuroki, President of Gifu University and the Chairman of the Japan Cancer Association).

Furthermore, it turns out that the "corona virus" families are so extensive as to include not only SARS and COVID-19 but also some regular colds as well as the extremely deadly MERS virus. For evidence, see Table 7 (provided by Tokiko Watanabe and Masayuki Miyasaka at Osaka University, and referred to by Toshio Kuroki at Gifu University).

Table 7. *Families of Corona Viruses*

•	A-Family:	HCoV-229E	(regular cold)
•		HCoV-NL63	(regular cold)
•	B-Family:	HCoV-OC43	(regular cold)
•		HCoV-HKU1	(regular cold)
•		SARS-CoV-1	(SARS)
•		SARS-CoV-2	(COVID-19)
•	C-Family:	MERS-CoV	(MERS)

Source: *Study by Tokiko Watanabe and Masayuki Miyasaka cited in Toshio Kuroki.*

So, the story goes as follows. Many people in the East, especially in East Asia, were infected by SARS two decades ago and also have been exposed to regular colds with corona viruses, resulting in the strong immunity to neutralize COVID-19 and the relatively low rates of COVID deaths, at least due to the earlier (the Alpha and the Delta) variants of COVID, in the East, as compared to the West.

Needless to say, this remains to be a hypothesis, however plausible it might look, until some empirical work is done with reliable data. Unfortunately, there does not seem to exist any such data on either SARS or regular colds to use for our empirical studies, as seen in the SARS case, where only about 30 observations are available in the WHO report for our study of some 200 countries around the world.

Hopefully, some new sets of data will be discovered and made publicly available in the near future.

7. Concluding Remarks

In this study, we have shown that such key economic, demographic, and health factors as per capita income, the aging rate, and the obesity rate seem quite important in explaining regional (international) differences in COVID cases and deaths among some 150 countries as listed in Worldometer's data base.

However, some significant East-West difference in the rate of COVID deaths (per population) remains unexplained by those key socio-economic factors, as we can clearly see that many of the Western countries have significantly higher COVID death and fatality rates than most of East Asian and Asian Pacific countries over the past three and a half years.

Then we have offered a hypothesis that may be most plausible to explain the East-West difference in the COVID death and fatality rates, that is, the degree of immunity for COVID, which resulted from the past exposure to some kind of corona viruses like SARS originating from somewhere in East Asia and also from regular colds in Asia containing some mild variants of corona viruses.

An important implication of our study is that we should be more careful about adopting globally uniform anti-corona virus policies which are often recommended by international organizations on the basis of data and/or observations in certain countries or regions, mostly the Western world.

What we need is a more localized, or regionalized policy making and adoption approach toward a "pandemic" like COVID, based on data and observations in each region, as there might well be significant regional differences in the death and fatality rates remaining over several years.

We also might draw the implication that it may be counterproductive, especially in the East, to adopt anti-COVID policy measures to restrict people's behavior and interaction, attempting to reduce the number of positive cases, since the COVID death rate is relatively low, mostly limited to the elderly and those who have basic illnesses, especially in East Asia, and restrictive policies tend to reduce economic activities and thus lower per capita income, which in turn might well increase rather than decrease the death rate due to a reduced level of health and other social services that each individual could receive.

A better policy is to protect the elderly and sick people more directly, separate from younger people who should be encouraged rather than discouraged to be more active to contribute to the improvement of economic and social services, especially related to public health.

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