The Country-specific Determinants of Death Rates by COVID-19

1.0 Graph Objective and Background

1.1 Graph Objective

In this report, Population Structure, Health Care System and Critical Decision-making are three determinants found to analyse the graph objective "The Country-specific Determinants of Death Rates by COVID-19". To further perform the analysis, 16 countries are selected and divided into top level and bottom level based on their death rates.

1.2 Background

1.2.1 Death Rates

Case Fatality Rate (CFR) is usually used to measure the death rate caused by COVID-19 in the media (Roser et al., 2020). It is calculated by dividing the number of people who died from the total number of people diagnosed during the disease (Henriques, 2020). However, there is another calculation method called infection fatality rate (IFR) which is calculated by dividing the number of deaths from COVID-19 from the total number of cases.

It's important to note that the first calculation method is applied in this report because the reported cases will be significantly smaller than the total number of cases. And It is impossible to generate the data from total cases due to the presence of asymptomatic disease (Virology Blog, 2020).

$$\text{Case Fatality Rate (CFR, in \%)} = \frac{\text{Number of deaths from disease}}{\text{Number of diagnosed cases of disease}} \times 100$$

1.2.2 Other Determinants

(1) Population Structure

It is said that the outbreak's progression and its impact are highly related to the population age structure especially the fatality rate which is concentrated at older ages and near zero for young children (University of Oxford, 2020). Specifically, the research further proves this viewpoint that Brazil with 2% population over 80 year-old people has three times higher death rate than Nigeria with 0.2% population over 80 years old (Population Reference Bureau, 2020).

Firstly, this is because that immune system declines with age. As people age, the blood cells in the body find and eliminate disease could decline. The body becomes much harder to fight off new infections like COVID-19. Therefore, the old with weak immune systems become more vulnerable than young people with a robust system (VOXMEDIA, 2020).

Secondly, elder people show the prevalence of increased chronic conditions as age like heart disease or lung disease. Some organs could not function normally. For example, the research shows that two-thirds who have pre-existing conditions have died during covid-19 among 105 people who have died in Italy. The chronic illnesses can make organs degraded and easily infected (VOXMEDIA, 2020).

Finally, the old might be allocated in institutionalized settings like retirement homes and live in a crowded place which could bring more risk of infection (World Economic Forum, 2020).

(2) Health Care System

It's reported that the health care system is also an important determinant of death rates in COVID-19 (Mystery behind Germany, 2020). In addition, the news mentions the number of intensive care beds in German is almost 6 times larger than that in Italy. That's one of the reasons that lead to different death rates in the two countries. Therefore, a sound health system plays a key role in fighting COVID-19.

Health system includes many aspects, for example, the number of hospitals in a country and the number of hospital beds. This report applies the number of hospital beds per 1000 people and employment to bed ratio as the measurement.

(3) Critical Decision-making

The third determinant is COVID-19 related decision-making duration by different countries. As mentioned before, COVID-19 spreads from one person to another. There are risks being infected if one exposes himself to crowded places. Scientists have estimated that daily deaths would come to a peak after three months if people live their

lives as usual, and if some mitigation policies which aim to slow the virus spread are taken, death cases would be reduced by half (Whiting, 2020). As a result, some official decisions should be made to restrict people's lives in order to slow down the coronavirus infection rate, such as social distancing restrictions, and the timeliness and of effective-policy executions would affect the spread (Richter, 2020). In other words, if the controlled policies are not taken properly and promptly, the whole country would fall into a serious situation with high confirmed cases and high death rates due to the rapid spread of the virus. However, it is essential to not only slow down the spreading within the country, but also prevent the imported cases abroad. It is known that the first outbreak of COVID-19 begins at Wuhan, Hubei, China (Wang et al., 2020). For other countries, it is of highly important to execute some related restrictions in time to stop the spread inside their territories as well.

2.0 Data Management

2.1 Data Generating Process

(1) Death Rates

The data of death rates used in this report are available in a GitHub repository (GitHub, 2020). After pivoting the original data in Tableau, it has been loaded into R to do the further processing. Accumulated confirmed cases and deaths for each country are generated through grouping by country and date. A new column has been added by dividing accumulated deaths by accumulated confirmed cases. In this report, the date of 21/04/2020 is filtered, which means the data is collected as of 21/04/2020.

(2) Population Structure

The data is generated from PopulationPyramid.net and it illustrates the population structure in different age levels in the year of 2019. Proportion calculation is applied to show the proportion in different age levels based on given numbers to eliminate the scale impact. According to the news from WHO, it is said that 95% of death rate occurs among the people aged over 60 (WHO Regional Office for Europe, 2020). Therefore, the population proportion above 60 is used to investigate the relationship with death rate.

(3) Health Care System

The data is generated from OECD.Stat (OECD.Stat, 2019), and it contains health system figures from 2000 to 2019. The figures of hospital beds per 1000 people and employment to bed ratio are extracted. The number of hospital beds includes general hospitals, mental health hospitals, and other specialised hospitals. The figures are generated from official data from various countries.

(4) Critical Decision-making

The factor in this section would contain two parts, the timelinesses and the kinds of policies. Firstly, In order to quantify the timelinesses of selected countries, The duration is calculated between the execution date of the first policy and the date of the first confirmed case both in each country using this formula: "Duration = Policy Execution Date – Confirmed Case Date".

Secondly, to better standardise the policies, countries will impose some constraints on the policies. Firstly, some policies like *lockdowns*, *shutting down airports/ suspending flights*, *travel restrictions*, *sealing the borders*, and *shutting down facilities/schools* are delivered. These policies announced by governments have stronger impacts than basic recommendations. These policies are usually relatively simple to monitor the executing process and can force people to comply with the restrictions. Additionally, some of the policies would be considered as methods to slow down the outbreak within the countries, and others are able to restrain the infected travelers from coming from the high-risk area. Also, the policies do not need to be country-wide restrictions. For example, locking down one region inside the country or restricting the entry of travelers from Wuhan would both be taken into account.

2.2 Data ValidationValidate existence

Every country has a death rate. In health care data, hospital employment to bed ratio of China, Brazil, Russia and Singapore are missing. For decision making duration, usually the calculated durations would be non-negative numbers, but the negative numbers are allowed and would indicate as prompt preventing decisions as a result of the foresight (if appear).

(1) Validate data type

Data types are concluded in the following chart.

Variable	Data Type
Country	String
Date	Date
Accumulated Confirmed	Number (Whole)
Accumulated Deaths	Number (Whole)
Global Confirmed	Number (Whole)
Global Deaths	Number (Whole)
Death Rate	Number (Decimal)
Daily Deaths	Number (Whole)
Death Rate Level	String
Confirmed case date	Date
Policy Duration	Number (Whole)
Policy	String
Hospital Beds/1000 Person	Number (Decimal)
Hospital Employment To Bed Ratio	Number (Decimal)
Aging Population Propottion	Number (Decimal)

(2) Validate uniqueness

The data in this report are all unique.

(3) Validate composition

Each country has its own death rate, where there is no expected structure in all the data.

(4) Validate range

Both death rate and aging population proportion ratio are located between 0 and 1 which proves the data is valid. As for the health system and decision making duration, there is no specific value range and extreme values. Meanwhile, the negative duration number could be accepted.

(5) Validate relation

Each country's death rate is determined by its accumulated deaths and accumulated confirmed cases. It is calculated by dividing accumulated deaths by accumulated confirmed cases. Also, the decision making duration is calculated by "Duration = Policy Execution Date – Confirmed Case Date", and all the calculation results would be considered valid.

2.3 Limitation

One overall limitation of this report is the small sample size of selected countries, which may result in some bias in the analysis.

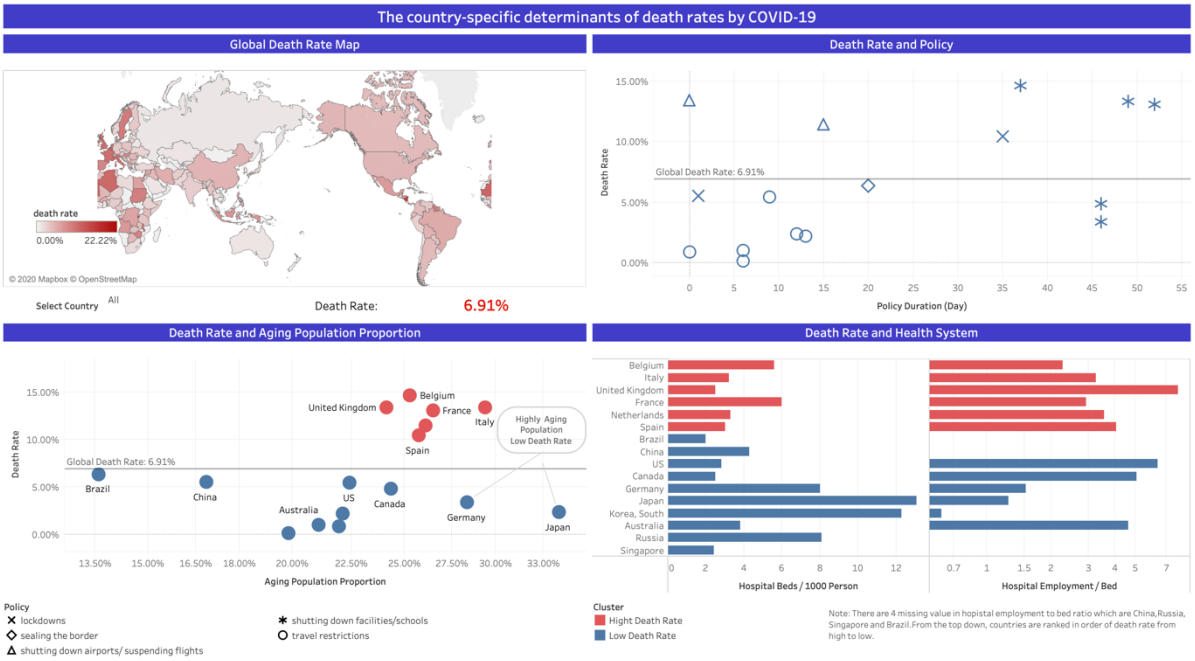
Death Rates: The first limitation of death rates is the calculation method, which may construct different results in the analysis. Except CFR, there are some other ways to calculate death rates such as infection fatality rate -- the number of deaths from a disease divided by the total number of cases (Verity et al., 2020) and crude mortality rate -- the probability that any individual in the population will die from the disease (CDC, 2019). The second limitation is timeliness because the death rate analysed in this report is downloaded on 21/04/2020. Another limitation is the accuracy of the data in GitHub. The test method of COVID-19 differs among countries. Also there may be some people who have died but not been detected.

Health Care System: The first limitation is the missing value of hospital employment to bed ratio, but values are kept because after analysis, these four values are not for main comparison.

The second one is values are not from the same year, but the year differences between all the values are no more than 5 years. The figures are considered to be comparable. Another limitation is that there are two methods to calculate the employment to bed ratio which are headcount and Full-time equivalent (FTE). Both measures are used to compare the values of the same country and it is found the difference is about 1 person. Also most of the countries use the headcount method so this report assumes the two methods are the same.

Critical Decision-making: As for the information which could not be found in official websites, it would be collected from the news instead, and may exist with a slight but negligible bias. Moreover, some execution dates of the policies would be ambiguous, and would use the announcing dates or the news dates instead if no further information is provided. Besides, because it is only considered the dates of the first policy and neglects subsequent ones, it may not completely account for the death rates in recent days. But this factor still indicates the influences to some extent, which would be discussed in the report carefully.

3.0 Data Visualization



4.0 Visual Implantations and Retinal Variables

4.1 Visual Implantations

Death Rates: In the map, the death rate of each country is presented in the area of each country.

Population Structure: The plots are applied to highlight the location of different countries with the measurement of death rate and aging population proportion.

Health Care System: A bar chart is used in this part to show the amount of each country. From the top down, countries are ranked in order of death rate from high to low.

Critical Decision-making: A scatter graph with markers is used to perform the relationship between policy durations and death rates of each country. Also, markers are utilised here indicating the different kinds of policies and every point stands as countries.

4.2 Retinal Variables

In the dashboard, the highly contrasted colors are applied to encode the level of death rate while the darker red stands for higher death rate. In the policy graph, shapes are utilized to reveal different types of policies. Also, in the second graph, the size is avoided among the bubbles to avoid the distortion illusions.

5.0 Graph Identification and Graph Enhancement

5.1 Graph Identification

External identification consists of a clear and brief title to address the graph objective and informative axe label with the application of Sans Serif font.

Death Rates: The legends of the colour of death rates are shown in the dashboard. Also, the death rate is presented in a percentage with 2 decimal numbers under the map.

Population Structure: The legend is used to show the meaning of color encoding.

Health Care System: The legend is used for easier decoding and the title can illustrate the graph objective. In addition, a note telling the missing value in the graph is added.

Critical Decision-making: Title and legend are used to show the single plot objective and distinguish different markers with corresponding policies. And the axes labels are presented well to demonstrate the used variables, death rates and durations counted by days.

5.2 Graph Enhancement

The global death rate has been shown as a reference line in the dotted charts, which would give the readers better understanding of the overall circumstances in the world and how the selected countries are divided into top ones and bottom ones. To maintain the informativeness of the overall graph, the axes range of the death rate are the same in the related graph. Also, in the population structure graph**,** {0,0} in axes range is abandoned in the x-axes this case because the plots will be too clustered and could not be observed clearly with the {0,0}.

6.0 Insights and Conclusion

In the dashboard, a map is utilized to reveal the overall situation in the world with a global death rate 6.91% (until 21/04/2020). Their degrees of death rates are also shown in the map. Using the filter, it can also be seen that the death rate of the selected countries is 7.78%. Based on previous analysis, there are three determinants affecting death rates caused by COVID-19 in different levels, their relations to death rates are shown in the rest graphs.

Firstly, the timeliness of policy executions would affect death rates. The policies executed promptly (less than 30 days) would have different influences on death rates based on their contents. Policies like *lockdowns* and *travel restrictions* would cause low death rates because both of them could effectively avoid the severe spread of COVID-19 in the early stage. But it is not valid enough to execute the policy of *shutting down airports or suspending flights*, even in the beginning of the situation. However, it is considered that no relations exist between death rates and decision-makings with durations in more than 30 days, because most of the countries perform the same restrictions but the death rates vary. In this situation, death rates may be explained more on other determinants.

Next, on the one hand, it can be seen that the countries with top-level death rates would have high aging population proportions over 23%, and this conclusion is consistent with the research. It also helps to explain the high death rates of countries which carry out policies more than 30 days. On the other hand, countries with fewer aging population problems have death rates under the global level. However, two outliers, Germany and Japan, sharing the high aging population but low death rates. That is because these two countries have health care systems in good condition with high ratios of hospital beds per 1000 people. And Canada has a similar situation with Germany and Japan but with an upper level of hospital employment. Moreover, regardless of the missing values, nearly all the countries with low death rates are equipped with sound medical support, no matter what it is accounted for, hospital beds or hospital employment.

To sum up, no single determinant affects the death rates of COVID-19 completely in a country specific. It is the result of a combination of factors and they all contribute themselves to death rates to some extent.

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