Introduction

The novel coronavirus outbreak caused by 'severe acute respiratory syndrome coronavirus 2' (SARS-CoV-2) originated from Wuhan City of Hubei Province in Mainland China back in early December 2019. It initially hit the neighbouring regions and countries in Asia and then rapidly spread across the continent over to the US, Europe, and then now the rest of the world, especially several less developed and less wealthy countries. On the 11th of March 2020 the World Health Organisation declared it a global pandemic and officially named the disease as 'COVID-19'. So far this pandemic has not only brought to the entire world public health crisis which has taken 292,085 lives (as of this submission made on 13/05/2020), overwhelmed the healthcare system of numerous countries and has put 103 states into nation-wide lockdown restrictions as an emergency measure to curb the uncontrolled large contagion of the disease. The subsequent impacts and consequences are unprecedented in modern history and have become tremendously destructive to the global economy and people's livelihood.

Notably, different regions at different stages of infection course responded to the threat remarkably differently in terms of the speed of decision making, stringency, and approach. Even countries within Europe which are experiencing similar stages of the pandemic, no cohesion can be seen and lack of solidarity has been constantly on the table. Profound level of cutback in public well-being, economic downturn, and social unrest within the community have even imposed extra crisis on everyone under those strict mobility restrictions. Arguably such disparity in government responses and the effectiveness of these measures could be attributed to the past experience in tackling with similar public health crisis, political agenda and diplomatic strategies of the nation, traditional and cultural values in society, healthcare capacity and infrastructure development, economic situation, population constitution and so on.

The situation has put the entire world under the greatest test. Every individual, household, business, government is so desperate to get their life back to normality. Countries which are currently suffering in paused economy cannot wait till then and have started easing the lockdown as soon as they have successfully 'flattened the curve'. By that, epidemiologists mean to keep the 'basic reproduction number' (aka. R0) of the virus below 1. However, until an effective and safe to use vaccine has been invented and has become globally available, the virus will never stop spreading and no one can be fully off their guard. In fact, second waves of infection have already emerged in a number of regions which originally succeeded in keeping the crisis at bay at the onset of the pandemic outbreak, such as Singapore, South Korea, Iran, and even China.

Therefore, we will look into the current situations of several selected countries and major cities which have been under the spotlight in the media and examine why, what, when and how their country authorities respond to the disease. This study hopefully can help the general public and decision makers to get some questions answered and learn from what we have already been through for a better grip on the battle with the invisible enemy COVID-19.

Data

The data to lay the groundwork of our analysis involve both direct and indirect links to COVID-19. Data quality from different sources even large international institutions might not be so straightforward in a cleaned, consistent, accurate, and timely manner. WHO, the leading organisation for centralised guidance to the entire world on the pandemic, was the first place where we reached out to retrieve the latest daily number of cases and deaths. However, it was found within their data a few underlying abovementioned issues. As the same information shared by European Centre for Disease Prevention and Control adequately meet those essential requirements, it has been adopted for use in our analysis.

The disparity of government responses to the pandemic is a crucial part to be examined in this work, with particular focus on the effectiveness of intervening the spread of illness and what determines policy maker's choice from a variety of responsive measures. The Blavatnik School of Government at Oxford University has published 'COVID-19 Government Response Tracker' and has shared the underlying daily time series data with the public, which plays a fundamental role to help our analysis complete the jigsaw puzzle.

Of the interest of this project, demographics, healthcare capacity and development, the level of public health, population, economic output and migration dynamics of affected nations have also been collected, but not with fewer challenges. These country aggregated data in fact are not frequently updated as coronavirus statistics. Additionally, they are neither widely available or easily accessible even in large global bodies. Therefore, the figures presented here is the latest available information from the web and should be interpreted with such limitation in mind. The pertinent sources range from Worldmeters, The United Nations, Our World In Data, and Wikipedia.

Two separate datasets have been created from both Google COVID-19 Community Mobility Reports and Foursquare API. These two pieces of information look at five of the hardest hit cities by the coronavirus disease, namely, New York, London, Paris, Madrid, and Berlin. The data presents how Google user daily footprints have been affected by restrictions on internal movements and how much impact has been on those local businesses and public venues.

Upon completion of data acquisition, a series of data cleaning processes carried out includes setting data types, standardising country names, treatment of missing values, correcting misinformation, data reshaping, transformation, aggregation and normalisation for further analysis, updating column headers, and imputation of lost information for Taiwan and Singapore, two of the selected countries on the focus in this study. The final prepared data constitutes the following four corresponding datasets:

1) daily_covid_govresponse_df
2) country_master_df
3) goog_mob_df
4) five_city_venues_df

The meaning and origin of each variable on the four datasets above are specified in the tables as follow.

1) daily_covid_govresponse_df

Variable Name	Variable Description	Data Source
country	Country names cleaned and standardised from multiple data sources	Derived
date_reported	Dates when cases were reported	European Centre for Disease Prevention and Control: https://www.ecdc.europa.eu/en/publications-data/download-todays-data-geographic-distribution-covid-19-cases-worldwide
day_reported	Day element of *date_reported*	Ditto
month_reported	Month element of *date_reported*	Ditto
year_reported	Year element of *date_reported*	Ditto
covid_cases	Number of reported cases on the corresponding date	Ditto
covid_deaths	Number of reported deaths related to COVID-19 on the corresponding date	Ditto
first_case_date	Date of first reported case	Derived
first_death_date	Date of first death	Derived
days_1st_case	Number of days after first reported case	Derived
days_1st_death	Number of days after first death	Derived
R0	Reproduction rate of infections, calculated from the ratio of moving average of reported cases of the last 3 days (aka. ma3) over the ma3 value for 14 days ago	Derived
c1_school_closing	Record closing of schools and universities (Defined in the Codebook section of BSG Working Paper 'BSG-WP-2020-032-v5.0_0.pdf' which can be downloaded from https://covidtracker.bsg.ox.ac.uk/)	Oxford University: https://oxcgrtportal.azurewebsites.net/api/CSVDownload
c1_flag	Flag for general nation-wide implementation	Ditto
c2_workplace_closing	Record closings of workplaces	Ditto
c2_flag	Flag for general nation-wide implementation	Ditto
c3_cancel_public_events	Record cancelling public events	Ditto
c3_flag	Flag for general nation-wide implementation	Ditto
c4_restrictions_on_gatherings	Record the cut-off size for bans on private gatherings	Ditto
c4_flag	Flag for general nation-wide implementation	Ditto
c5_close_public_transport	Record closing of public transport	Ditto
c5_flag	Flag for general nation-wide implementation	Ditto
c6_stay_at_home_requirements	Record orders to 'shelter-in-place' and otherwise confine to home	Ditto
c6_flag	Flag for general nation-wide implementation	Ditto
c7_restrictions_on_internal_movement	Record restrictions on internal movement	Ditto
c7_flag	Flag for general nation-wide implementation	Ditto
c8_international_travel_control	Record restrictions on international movement	Ditto

Variable Name	Variable Description	Data Source
s		
e1_income_support	Record if the government is covering the salaries or providing direct cash payments, universal basic income, or similar, of people who lose their jobs or cannot work. (Includes payments to firms if explicitly linked to payroll/ salaries)	Ditto
e1_flag	Flag for general nation-wide implementation	Ditto
e2_debt/contract_relief	Record if govt. is freezing financial obligations (eg stopping loan repayments, preventing services like water from stopping, or banning evictions)	Ditto
e3_fiscal_measures	What economic stimulus policies are adopted? (USD)	Ditto
e4_international_support	Announced offers of COVID-19 related aid spending to other countries (USD)	Ditto
h1_public_information_campaigns	Record presence of public info campaigns	Ditto
h1_flag	Flag for general nation-wide implementation	Ditto
h2_testing_policy	Who can get tested?	Ditto
h3_contact_tracing	Are governments doing contact tracing?	Ditto
h4_emergency_investment_in_healthcare	Short-term spending on, e.g, hospitals, masks, etc	Ditto
h5_investment_in_vaccines	Announced public spending on vaccine development	Ditto
m1_wildcard	Record policy announcements that do not fit anywhere else	Ditto
stringencyindex	Index of stringency for national governments' responses to contain infection population	Ditto

2) country_master_df

Variable Name	Variable Description	Data Source
country	Country names cleaned and standardised from multiple data sources	Derived
longitude	Longitude value of country location	The World Health Organisation: https://www.who.int/data/gho or https://data.humdata.org/dataset/coronavirus-covid-19-cases-data-for-china-and-the-rest-of-the-world
latitude	Latitude value of country location	Ditto
total_cases	Accumulated number of reported reported cases	Worldometers: https://www.worldometers.info/coronavirus/
total_deaths	Accumulated number of reported deaths related to COVID-19	Ditto
total_recovered	Accumulated number of reported cases discharged from hospitalisation or	Ditto

Variable Name	Variable Description	Data Source
	quarantine	
total_tests	Accumulated number of tests for the presence of COVID-19 virus carried out	Ditto
active_cases	Accumulated number of reported cases under hospitalisation or quarantine	Ditto
serious_critical	Accumulated number of hospitalised cases in need of intensive critical care	Ditto
cases_per_m	Accumulated number of reported reported cases per million of population	Ditto
deaths_per_m	Accumulated number of reported deaths related to COVID-19 per million of population	Ditto
tests_per_m	Accumulated number of tests for the presence of COVID-19 virus carried out per million of population	Ditto
tests_per_case	Ratio of *total_tests* over *total_cases*	Derived
recovery_rate	Ratio of *total_recovered* over *total_cases*	Derived
critical_rate	Ratio of *serious_critical* over *total_cases*	Derived
population_2020	Country population estimated in 2020	Worldometers: https://www.worldometers.info/world-population/population-by-country/
density_p_km2	Number of population per square kilometre of country area	Ditto
migrants_net	The difference between the number of immigrants and the number of emigrants throughout the year	Ditto
med_age	Median value or midpoint of population age	Ditto
urban_pop_%	Percent of country residents living in urban areas	Ditto
world_share_%	Country population in proportion of world population	Ditto
life_exp_both_sex	The average length of time that people of the country are normally likely to live, regardless of gender	Worldometers: https://www.worldometers.info/demographics/life-expectancy/#countries-ranked-by-life-expectancy
life_exp_female	The average length of time that the female population of the country are normally likely to live	Ditto
life_exp_male	The average length of time that the male population of the country are normally likely to live	Ditto
old_dep_ratio_2020	Old-age dependency ratio (age 65+ / age 15-64) de facto population	The United Nations: https://population.un.org/wpp/Download/Standard/Population/
hospital_beds_per_100k	Total number of hospital beds per 100	Our World In Data:

Variable Name	Variable Description	Data Source
	thousand of country population	blob:https://ourworldindata.org/562c6cd1-8da3-4dfc-8d70-8a80ed4f9cad
physicians_per_k	Total number of physicians per thousand of country population	Our World In Data: blob:https://ourworldindata.org/bc19aa7c-bf6b-419f-9d06-d3101310dd5d
gdp_capita_usd	2019 estimates of nominal GDP per capita from IMF	Wikipedia: https://en.wikipedia.org/wiki/List_of_countries_by_GDP_(nominal)_per_capita
gross_publicdebt_pct_of_gdp	Latest available figures for public debt in % of GDP from CIA	Wikipedia: https://en.wikipedia.org/wiki/List_of_countries_by_public_debt
days_1st_case	Maximum value from *daily_covid_govresponse_df*	Derived
days_1st_death	Maximum value from *daily_covid_govresponse_df*	Ditto
R0	Last value from *daily_covid_govresponse_df*	Ditto
c1_school_closing	Maximum value from *daily_covid_govresponse_df*	Ditto
c1_flag	Ditto	Ditto
c2_workplace_closing	Ditto	Ditto
c2_flag	Ditto	Ditto
c3_cancel_public_events	Ditto	Ditto
c3_flag	Ditto	Ditto
c4_restrictions_on_gatherings	Ditto	Ditto
c4_flag	Ditto	Ditto
c5_close_public_transport	Ditto	Ditto
c5_flag	Ditto	Ditto
c6_stay_at_home_requirements	Ditto	Ditto
c6_flag	Ditto	Ditto
c7_restrictions_on_internal_movement	Ditto	Ditto
c7_flag	Ditto	Ditto
c8_international_travel_controls	Ditto	Ditto
e1_income_support	Ditto	Ditto
e1_flag	Ditto	Ditto
e2_debt/contract_relief	Ditto	Ditto
e3_fiscal_measures	Ditto	Ditto
e4_international_support	Ditto	Ditto
h1_public_information_campaigns	Ditto	Ditto
h1_flag	Ditto	Ditto
h2_testing_policy	Ditto	Ditto
h3_contact_tracing	Ditto	Ditto
h4_emergency_investment_in_healthcare	Ditto	Ditto
h5_investment_in_vaccines	Ditto	Ditto
m1_wildcard	Ditto	Ditto

Variable Name	Variable Description	Data Source
stringencyindex	Ditto	Ditto

3) goog_mob_df

Variable Name	Variable Description	Data Source
sub_region_1	City	Google COVID-19 Community Mobility Reports: https://www.google.com/covid19/mobility/index.html?hl=en
date	Date of visits of users who have opted-in to Location History for their Google Account	Ditto
retail_and_recreation_percent_change_from_baseline	Mobility trends for places like restaurants, cafes, shopping centers, theme parks, museums, libraries, and movie theaters	Ditto
grocery_and_pharmacy_percent_change_from_baseline	Mobility trends for places like grocery markets, food warehouses, farmers markets, specialty food shops, drug stores, and pharmacies	Ditto
parks_percent_change_from_baseline	Mobility trends for places like local parks, national parks, public beaches, marinas, dog parks, plazas, and public gardens	Ditto
transit_stations_percent_change_from_baseline	Mobility trends for places like public transport hubs such as subway, bus, and train stations	Ditto
workplaces_percent_change_from_baseline	Mobility trends for places of work	Ditto
residential_percent_change_from_baseline	Mobility trends for places of residence	Ditto

4) five_city_venues_df

Variable Name	Variable Description	Data Source
station	Metro station of the city	Foursquare Places API
stn_latitude	Latitude value of the metro station	Ditto
stn_longitude	Longitude value of the metro station	Ditto
venue	The best known name for this venue	Ditto
venue_lat	Latitude value of the venue	Ditto
venue_lon	Longitude value of the venue	Ditto
venue_categories	Place category of the venue	Ditto
venue_categories_id	pID of the Place category	Ditto
city	City	Derived