An Investigation of COVID-19 Spreading Factors with Explainable AI Techniques

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BACKGROUND:

Since COVID-19 was first identified in December 2019, various public health interventions have been implemented across the world. As different measures are implemented at different countries at different times, we conduct an assessment of the relative effectiveness of the measures implemented in 18 countries and regions using data from 22/01/2020 to 02/04/2020.

METHODS:

We compute the top one and two measures that are most effective for the countries and regions studied during the period. Two Explainable AI techniques, SHAP and ECPI, are used in our study; such that we construct (machine learning) models for predicting the instantaneous reproduction number (\(R_t\)) and use the models as surrogates to the real world and inputs that the greatest
influence to our models are seen as measures that are most effective.

FINDINGS:

Across-the-board, city lockdown and contact tracing are the two most effective measures. For ensuring $R_t < 1$, public wearing face masks is also important. Mass testing alone is not the most effective measure although when paired with other measures, it can be effective. Warm temperature helps for reducing the transmission.

INTERPRETATION:

After a period of city lockdown, the transmission of COVID-19 has been slowed. However, as countries are considering lifting city lockdown in the next a few weeks or months, to prevent resurgent disease, effort should be put to developing privacy preserving, practical and effective contact tracing techniques.

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Research in Context

Evidence before this study  Since COVID-19 was first identified in December 2019, various public health interventions have been implemented across the world. Wuhan has been locked down since Jan 23, 2020; France closed its schools on March 16, 2020; South Korea banned international travelers from Hubei on Feb 02, 2020; Singapore started contact tracing on January 23, 2020, etc. As for mid of April 2020, it seems countries that have implemented some of these measures are seeing a reduced rate of number of confirmed cases growth. Yet, the different
countermeasures implemented by different countries at different time still pose the questions: which countermeasures are effective? Moreover, the effectiveness of mass use of face masks has been a controversial issue, with claims that mass use face mask being ineffective and essential both exist. Lastly, the impact of temperature and humidity is also not entirely clear. Thus, we present a comprehensive study that examines data from 18 countries and regions to understand the effectiveness of such measures. We have used the *Time Series Covid 19 Confirmed* data set from [https://www.kaggle.com](https://www.kaggle.com) for the number of confirmed cases, *COVID 19 Containment measures* data set also from [https://www.kaggle.com](https://www.kaggle.com) together with Wikipedia and Google search with keywords containing country name and control measures such as “South Korea International Travel Ban” to find the dates of measure implementation, and data from [https://rp5.ru/Weather_in_the_world](https://rp5.ru/Weather_in_the_world) to find the temperature and humidity.

**Added value of this study** As of mid-April 2020, most countries in eastern Europe and Africa are still in the early stage of the pandemic, with relatively small number of confirmed cases; understanding the effectiveness of countermeasures are important for controlling the spread. Countries in western Europe, Australasia and North America which have implemented strict control measures for a few weeks are discussing relaxing such measures including lifting lockdown; understanding the effectiveness of measures could help governments in these countries adjust their policies so they do not risk resurgent disease while saving healthcare and social resources.

**Implications of all the available evidence** We identify city lockdown and contact tracing as the most effective countermeasures. Mass testing, mask use by the public, and warm weather are also useful for controlling transmission. For countries that are implementing city lockdown, once that is lifted, contact tracing has been most successfully implemented with technology based approaches such as tracking mobile phones, developing policies along with technolo-
gies that support such contact tracing while providing privacy protection should be seriously considered; promoting mask use and ensuring its supplies should also be considered.

**Introduction**

COVID-19 has spread globally for more than three months since it was first identified in December 2019. Shortly after its initial identification, various control measures have been implemented in different countries for the purposes of containing and delaying the pandemic; at the moment, some of the less affected countries are considering implementing these measures. Thus, a major question to be answered is that: among these control measures, what are the more effective ones, at different stages of the disease development?

Thus, the overarching goal of this work is to identify factors that are most influential in controlling the spread of the disease. $R_t$, the average number of secondary cases generated by one primary case with symptom onset on day $t$, is one of the most important quantities used to measure the epidemic spread. If $R_t > 1$, then the epidemic is expanding at time $t$, whereas if $R_t < 1$, then it is shrinking at time $t$. We want to identify factors that are most influential for controlling $R_t$.

Explainable AI (XAI) is a rising field in AI. In addition to developing AI systems that making accurate predictions, XAI systems “explain” their predictions (1–3, 9, 12, 13). The development of XAI is motivated by building trustworthy systems and revealing insights from data. Still in its infancy, several XAI techniques such as Shapley additive explanations (SHAP) (8) and Explainable Classification with Probabilistic Inferences (ECPI) (4), have been developed in recent years for identifying decisive features in prediction tasks. These techniques are data-driven; they “explain” a prediction by pointing out factors that are “most significant” for the prediction purely based on the data provided.

Much effort has been put into COVID-19 data collection by the global community. As of
early April 2020, time series data containing daily confirmed cases in more than 100 countries are made publicly available at online repositories. With help of Internet search engines, one can identify control measures implemented in different countries and their respective implementation time. Using such data, with Machine Learning (ML) techniques, we construct classification models that predict $R_t$. We then apply XAI techniques to examine the developed ML models and identify key factors that are most influential to their predictions. In this way, the constructed ML models serve as surrogates to the real world; and identifying effective factors in controlling $R_t$ becomes explaining the classifications given by the developed ML models.

**Methods**

**Data Preparation.** Our analysis is based on the following information:

- Implementation dates of control measures as shown in Table 1.
- The daily reported number of confirmed cases from 22/01/2020 to 02/04/2020 in countries and regions shown in Table 1.
- Temperature and humidity during our study period at these countries and regions.

From daily reported number of confirmed cases, we apply a method of estimating $R_t$ as reported in Flaxman, et al. (5). We start by introducing a serial interval distribution, which models the time between a person getting infected and he/she subsequently infecting another people, as a Gamma distribution $g$ with mean 7 and standard deviation 4.5 (these two parameters are reported in (14)); we also assume this serial interval distribution is the same for all countries and regions studied in this work. The number of new infections $c_t$ on a given day $t$ is given by the following discrete convolution function:

$$c_t = R_t \sum_{\tau=0}^{t-1} c_\tau g_{t-\tau},$$  \hspace{1cm} (1)
Table 1: Implementation dates of control measures at 18 countries and regions.

| Countries and Regions | Government Advocation (GA) | Mask Use (MU) | School Closure (SC) | City Lockdown (CL) | Mass Testing (MT) | International Travel Ban (ITB) | Contact Tracing (CT) |
|-----------------------|-----------------------------|---------------|---------------------|-------------------|-------------------|-------------------------------|---------------------|
| Australia             | 13/03/2020                  |               |                     |                   |                   | 01/02/2020                     |                     |
| France                | 12/03/2020                  | 16/03/2020    | 17/03/2020          |                   |                   | 16/03/2020                     |                     |
| Germany               | 28/01/2020                  | 26/02/2020    | 16/03/2020          |                   |                   | 28/01/2020                     |                     |
| Italy                 | 31/01/2020                  | 04/03/2020    | 08/03/2020          |                   |                   | 31/01/2020                     |                     |
| Japan                 | 24/01/2020                  | 22/01/2020    | 02/03/2020          |                   |                   | 01/02/2020                     | 25/02/2020          |
| Singapore             | 22/01/2020                  | 01/02/2020    |                     |                   |                   | 24/01/2020                     | 29/01/2020          | 23/01/2020          |
| South Korea           | 22/01/2020                  | 22/01/2020    | 22/01/2020          |                   | 31/01/2020         | 02/02/2020                     | 22/01/2020          |
| Spain                 | 14/03/2020                  | 12/03/2020    | 14/03/2020          |                   |                   | 10/03/2020                     |                     |
| United Kingdom        | 01/03/2020                  | 20/03/2020    | 21/03/2020          |                   |                   |                               |                     |
| Beijing               | 24/01/2020                  | 07/02/2020    | 22/01/2020          | 24/01/2020        | 24/01/2020        | 28/03/2020                     | 24/01/2020          |
| California            | 04/03/2020                  |               |                     | 24/01/2020        | 24/01/2020        | 28/03/2020                     | 02/02/2020          |
| Guangdong             | 23/01/2020                  | 26/01/2020    | 22/01/2020          | 24/01/2020        | 23/01/2020        | 28/03/2020                     | 23/01/2020          |
| Hong Kong             | 04/01/2020                  | 08/01/2020    | 22/01/2020          | 24/01/2020        | 04/01/2020        | 27/01/2020                     | 04/01/2020          |
| Hubei                 | 20/01/2020                  | 22/01/2020    | 22/01/2020          | 23/01/2020        | 05/02/2020        | 23/01/2020                     | 03/02/2020          |
| Macau                 | 31/12/2019                  | 03/02/2020    | 22/01/2020          | 23/01/2020        |                   | Macau 20/02/2020               | 03/02/2020          |
| New York              | 07/03/2020                  | 15/03/2020    | 20/03/2020          | 13/03/2020        |                   | 13/03/2020                     | 02/02/2020          |
| Taiwan                | 20/01/2020                  | 31/01/2020    | 22/01/2020          | 23/01/2020        | 01/02/2020        | 23/01/2020                     | 27/01/2020          |
| Washington            | 29/02/2020                  | 13/03/2020    | 23/03/2020          | 17/03/2020        |                   | 02/02/2020                     |                     |
where \( g_s = \int_{\tau=s-0.5}^{s+0.5} g(\tau) d\tau \) for \( s = 2, 3, \ldots \) and \( g_1 = \int_{\tau=0}^{1.5} g(\tau) d\tau \), \( c_\tau \) is the number of new infections on day \( \tau \). Thus, new infections identified on day \( t \) depend on the number of new infections in days prior to \( t \), weighted by the discretized serial interval distribution, which is the aforementioned Gamma distribution.

From Equation 1, solve for \( R_t \), we have:

\[
R_t = \frac{c_t}{\sum_{\tau=0}^{t-1} c_\tau g_{t-\tau}}
\]  

(2)

Since \( c_t \) and \( c_\tau \) are available from our data directly, e.g., \( c_t \) is the difference between the confirmed case on day \( t \) and the confirmed case on day \( t - 1 \), and \( g_{t-\tau} \) can be obtained by integrating the Gamma distribution, we now have a way to compute \( R_t \) for all countries on all days between 22/01/2020 and 02/04/2020.

We then compose a data set in a tabular form where each row describes information for one country/region on a day, containing the number of new confirmed cases on that day, days since each of the control measures that have been implemented, and the temperature as well as humidity of that day. \( R_t \) is added to every row in the data set and later used as the target for prediction. Since \( R_t \) calculated as such is sensitive to noise at the number of new infection cases on a given day and the data set we use contains imperfection, e.g., for the United Kingdom, both 14/03/2020 and 15/03/2020 have 1140 confirmed cases so there is no increase on 15/03/2020, we thus run a sliding-window mean filter with radius 1 on the data for noise removal. Moreover, as \( R_t \) calculated in Equation 2 assumes a reasonably large \( t \), (otherwise both \( c_\tau \) and \( g_{t-\tau} \) would be too small, resulting an artificially large \( R_t \)), we drop entries with confirmed case less than 20. In other words, we only use data where there are more than 20 accumulated confirmed cases in that country / region; and as the number of confirmed case is monotonically increasing, there is no “skipped” dates. For instance, our Singapore cases start on 03/02/2020, Japan cases start on 02/02/2020, and Germany cases start on 25/02/2020. Figure 1 illustrates \( R_t \) computed by the
presented method for Japan, Singapore, Australia and Hubei.

A fraction of this data set is shown in Table 2 for illustration. The data in the first row records that \( R_t \) is 1.34, with 4 new confirmed cases, 22 days after government advocation, 12 days after mass use of face mask, school closure, and city lockdown not implemented, 20 days after mass testing, 15 days after international travel ban, 21 days after contract tracing, as well as temperature and humidity 27.825 and 74.37, respectively. The data set contains 800 entries in total.

Table 2: An illustration of the data set with four data entries (Singapore, 12/02/2020, Japan, 26/03/2020, Germany, 26/03/2020, South Korea, 16/03/2020, and Guangdong, 08/02/2020). NC, GA, MU, SC, CL, MT, ITB, CT, T and H are shorthand for New Case, Government Advocation, Mask Use, School Closure, City Lockdown, International Travel Ban, Contact Tracing, Temperature and Humidity, respectively.

| \( R_t \) | NC | GA | MU | SC | CL | MT | ITB | CT | T    | H    |
|----------|----|----|----|----|----|----|-----|----|------|------|
| 1.34     | 4  | 22 | 12 | 0  | 0  | 20 | 15  | 21 | 27.86 | 83.86 |
| 1.91     | 92 | 63 | 65 | 25 | 0  | 0  | 55  | 31 | 17.375| 32.75 |
| 2.14     | 5962| 59 | 0  | 30 | 11 | 0  | 12  | 0  | 6.19  | 39.35 |
| 0.31     | 78 | 55 | 55 | 55 | 0  | 46 | 44  | 55 | 3.73  | 48.47 |
| 0.72     | 53 | 17 | 14 | 18 | 16 | 17 | 0   | 18 | 15.89 | 62.66 |

Since we aim for obtaining easily interpretable qualitative results, we further discretize our data into category intervals as follows:

- NC: \([0,10), [10, 100), [100, \infty)\)

- GA, MU, SC, CL, MT, ITB, CT: \([0,1), [1, 5), [5, 10), [10,15), [15, \infty)\)

- T: \((-\infty, 0), [0, 10), [10, 20), [20, \infty)\)

- H: \([0, 40), [40, 80), [80, \infty)\)

Thus, the number of new cases is put into 3 categories, represented with integers 0...2, respectively. Each of GA, MU, SC, CL, PTC, MT, ITB and CT is discretized into 5 categories,
Figure 1: Daily new cases and computed $R_t$ for selected countries and regions for illustration.
with each category represented with an integer 0...4. Similarly, temperature and humidity are discretized into 4 and 3 categories, respectively. Table 3 shows the result of discretization from data shown in Table 2.

| \( R_t \) | NC | GA | MU | SC | CL | MT | ITB | CT | T | H |
|---|---|---|---|---|---|---|---|---|---|---|
| 1.34 | 0  | 4  | 3  | 0  | 0  | 4  | 3  | 4  | 3  | 2  |
| 1.91 | 1  | 4  | 4  | 4  | 0  | 0  | 4  | 4  | 2  | 0  |
| 2.14 | 2  | 4  | 0  | 4  | 3  | 0  | 3  | 0  | 1  | 0  |
| 0.31 | 1  | 4  | 4  | 4  | 0  | 4  | 4  | 4  | 1  | 1  |
| 0.72 | 1  | 4  | 3  | 4  | 4  | 0  | 4  | 2  | 1  |

**XAI Techniques and Problem Formulation.** Two different XAI techniques for identifying decisive features have been used in this study: Shapley additive explanations (SHAP), and Explainable Classification with Probabilistic Inferences (ECPI). With both SHAP and ECPI, we formulate the factor importance problem as two binary *Explainable Classification* problems: given a data entry (row) as shown in Table 3, classify whether the \( R_t \) (for that row) is greater than some threshold \( \theta \); if an entry is classified as negative (\( R_t \) thus less than or equal to \( \theta \)), then identify the features that are most influential to the classification.

SHAP is based on Shapley value, a game theory concept that assigns a unique distribution of a total surplus generated by the coalition of all players in a cooperative game. In our context, each factor with its value, e.g., NC = 0, GA = 4, MU = 3, etc., is viewed as a “player” in the game where the outcome is in one of the two classes \( R_t \) being either greater than \( \theta \), or not. Shapley value for each feature-value describes its “contribution” to the outcome classification.

ECPI is a probabilistic logic based explainable classification algorithm. ECPI maps a dataset into a knowledge-base in probabilistic logic and performs classification with probabilistic logic inference. ECPI computes explanation by identifying the subset of feature values that gives the same inference result as the full set (or as close as possible to the full set when it is not possible...
to infer the same result). In our context, roughly speaking, from feature value NC = 0, GA = 4, MU = 3, etc., one deduces \( R_t \) is in some class (either \( R_t < \theta \) or not), then the subset of these feature values that also infer \( R_t \) in the same class is the explanation.

Both SHAP and ECPI identify key features for prediction instances with SHAP being a model-agnostic method that computes only feature importance and ECPI an interpretable model that makes the prediction as well. Technically, two major differences between SHAP and ECPI are that (1) SHAP considers features individually when evaluating their “contribution” whereas ECPI considers all coalition among features; (2) SHAP estimates the Shapley characteristic function, the function describing the total expected sum of payoffs the players can obtain by cooperation, from data whereas ECPI does not perform this estimation.

Since our goal is to obtain explanations for cases where \( R_t < \theta \), the entire dataset is used for training the ML models. Then, for each entry in the dataset which has its \( R_t < \theta \), we compute the top \( k \) most influential features with both SHAP and ECPI. For instance, for the entry (Guangdong, 08/02/2020):

| NC | GA | MU | SC | CL | MT | ITB | CT | T | H |
|----|----|----|----|----|----|-----|----|---|---|
| 1  | 4  | 3  | 4  | 4  | 4  | 0   | 4  | 2 | 1 |

we let \( \theta = 1 \), then: SHAP finds CT=4 (CT implemented for more than 15 days) and CL=4 (CL implemented for more than 15 days) being the most and second most influential factors, respectively; whereas ECPI finds CL=4 and MU=3 (MU implemented for 10-15 days) being the top two factors. The identified most influential features from all entries are aggregated and reported in the next section.

**Results**

With SHAP and ECPI, we study the two classification cases for \( \theta = 1, 2 \). For each case, we compute the top \( k \) (\( k = 1, 2 \)) features that are the most influential. There are 228 and 435 entries with \( R_t < 1 \) and \( R_t < 2 \), respectively. The results are shown in Figure 2.
Figure 2: Top $k = 1, 2$ influential factors for $R_t < 1$ and $R_t < 2$. 
From Figure 2, several qualitative interpretations can be obtained. We can see that City Lockdown (CL) and Contact Tracing (CT) are most influential, for all parameter combinations ($\theta = 1, 2$ and $k = 1, 2$). Both measures are effective when they take value 4, meaning they are implemented for more than 15 days. Mask Use (MU) and Mass Testing (MT) both show some influence, although not to the level of CL and CT. School Closure (SC), International Travel Ban and Government Advocation (GA) rank lower in their effectiveness. Humidity plays no role completely whereas warm temperature could be helpful. The bars shown on New Cases (NC) might be interpreted as: when $R_t$ is sufficiently small, it is likely to stay in that case.

Figure 3 and 4 show influential factors for daily new cases in three ranges: 0-10, 10-100, and > 100 for $R_t < 1$ and $R_t < 2$, respectively. For $R_t < 1$, we see that CL is the most effective single measure and CL, CT the most effective pair, regardless the number of new cases, agreed by both SHAP and ECPI. For $R_t < 2$, the top effective measures are CL, CT, MT and MU. The top pairs are harder to select, CL, NC, CL, MT, CT, SC and MT, MU are more effective than others.
Discussion

Since COVID-19 was identified in December 2019, there are a few works which have been dedicated to understanding the effect of non-pharmaceutical countermeasures. Leung et al. (7) estimated $R_t$ in four Chinese cities and ten province between mid January to mid February. They found that though aggressive non-pharmaceutical interventions such as city lockdown have made the first wave of COVID-19 outside of Hubei abated, control measures should be relaxed gradually. Our results, asserting city lockdown being the most effective measure confirms their findings.

In (10), the authors evaluated the effectiveness of surveillance and containment measures for the first 100 patients with COVID-19 in Singapore. The surveillance strategy in Singapore includes applying the case definition at medical consultations, tracing contacts of patients, enhancing surveillance among different patient groups and allowing clinician discretion. It was
found that rapid identification and isolation of cases, quarantine of close contacts, and active monitoring of other contacts have been effective in suppressing expansion of the outbreak. Our results find that contact tracing being the overall second effective measure (after city lockdown) confirms their results.

In (6), the authors studied the real-time mobility data from Wuhan and detailed case data including travel history to investigate the role of travel restrictions in limiting the spread of COVID-19. It was found that travel restrictions are particularly useful in the early stage of an outbreak, while the effect will drop when the outbreak is more widespread. A combination of interventions may be necessary though the individual role of each intervention is yet determined. Our results show that international travel ban, although exactly same as their work on inter-city travel, but also on the effectiveness of restricting travel, is not nearly as effective as other measures such as city lockdown and contact tracing.

In (11), the authors built an age-structured susceptible-exposed-infected-removed (SEIR) model to estimate the effect of physical distancing measures, such as extended school closures and workplace distancing, on the progression of the COVID-19 epidemic. It was found that sustaining these measures are effective in reducing the size of epidemic. Our results, especially the ones from ECPI, show that school closure has a positive effect in lowering $R_t$.

As a data-driven modeling approach, our work is limited by a number of factors. Firstly, all results are based on data collected from the selected 18 countries and regions during the period of 22/01/2020 to 03/04/2020, although results might be generalizable, but are about these regions during the said period. Thus, when applying these results to other regions and other time, they should be viewed indicative. Secondly, the data used is inherently ambiguous, e.g., “contact tracing” and “mass testing” have been implemented at different countries, but it is unlikely the same standard has been applied. Thus, although our methods are quantitative, due to the qualitative nature of the data, one should read our results qualitatively. Thirdly, we
rely on the calculated $R_t$ to label our data, which is then used to construct our models. The calculation used is reported in (5) with parameters found in (14). We are aware that $R_t$ is an estimate that can be approximated with more than one method, some authors such as (7) give a much smaller estimate of $R_t$ for Beijing in January (they estimate $R_t$ being close to 0.5 whereas our calculation shows it is greater than 2; although ours drops to below 0.5 after February 10, same as theirs), different results might be obtained if $R_t$ is estimated differently.

In conclusion, we applied two machine learning and explainable AI methods in studying the influence of factors affecting the spread of COVID-19. We find city lockdown and contact tracing being the two most effective control measures, surpassing mass testing, school closure, international travel ban and mask use. As countries are considering lifting city lockdown, to prevent resurgent disease, effort should be put to developing privacy preserving, practical and effective contact tracing techniques.

**References and Notes**

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Appendix

Classification Performance Since the reliability of our explanation results depends on the quality of our ML models, which depend on the quality of data and the discretization process we used, we first present some classification results. The two datasets are randomly divided into 90% / 10% split with 90% used for training and 10% for testing. We present results using a random forest classifier with 100 trees, neural network with two hidden layers with 12 and 10 nodes each, and ECPI. We measure performance with precision and recall, which are defined as

\[
\text{precision} = \frac{\text{true positive}}{\text{true positive} + \text{false positive}},
\]

and

\[
\text{recall} = \frac{\text{true positive}}{\text{true positive} + \text{false negative}}.
\]

The precision and recalls are shown in Table 4. These results show that effective models can be built with the dataset and our ECPI model gives indicative predictions.

Data Source
Table 4: Classification performance with Random Forest (RF), Neural Network (NN) and ECPI.

|               | $R_t < 1$ |         | $R_t < 2$ |         |
|---------------|-----------|---------|-----------|---------|
|               | RF        | NN      | ECPI      | RF      | NN      | ECPI    |
| Precision     | 0.79      | 0.81    | 0.88      | 0.66    | 0.91    | 0.91    |
| Recall        | 0.79      | 0.77    | 0.94      | 0.77    | 0.69    | 0.79    |

- **Australia**
  - **International Travel Ban (ITB): 01/02/2020**
    * On February 1, Australia banned the entry of foreign nationals from mainland China, and ordered its own returning citizens from China to self-quarantine for 14 days.
    * [https://en.wikipedia.org/wiki/2020_coronavirus_pandemic_in_Australia](https://en.wikipedia.org/wiki/2020_coronavirus_pandemic_in_Australia)
    * Pannett Rachel, “Australia Restricts Travelers From Mainland China as Virus Impact Spreads”, Wall Street Journal. Archived from the original on February 25, 2020. Retrieved on March 17, 2020.
  - **Government Advocation (GA): 13/03/2020**
    * On March 13, the National Cabinet, a form of national crisis cabinet akin to a war cabinet, was created following a meeting of the Council of Australian Governments (COAG).
    * [https://en.wikipedia.org/wiki/2020_coronavirus_pandemic_in_Australia#cite_note-81](https://en.wikipedia.org/wiki/2020_coronavirus_pandemic_in_Australia#cite_note-81)

- **France**
  - **Government Advocation (GA): 12/03/2020**
* On March 12, French President Emmanuel Macron announced on public television that all schools and all universities would close from Monday (March 16) until further notice.

  * [https://en.wikipedia.org/wiki/2020_coronavirus_pandemic_in_France](https://en.wikipedia.org/wiki/2020_coronavirus_pandemic_in_France)

  – School Closure (SC): 16/03/2020

* On March 12, French President Emmanuel Macron announced on public television that all schools and all universities would close from Monday (March 16) until further notice.

  * [https://en.wikipedia.org/wiki/2020_coronavirus_pandemic_in_France](https://en.wikipedia.org/wiki/2020_coronavirus_pandemic_in_France)

  – International Travel Ban (ITB): 16/03/2020

* On March 15, France has announced it will be tightening controls on its border with Germany as of March 16.

  * [https://www.theguardian.com/world/2020/mar/15/coronavirus-causes-french-voters-to-stay-away-from-municipal-elections](https://www.theguardian.com/world/2020/mar/15/coronavirus-causes-french-voters-to-stay-away-from-municipal-elections)

  – City Lockdown (CL): 17/03/2020

* On March 14, French Prime Minister Édouard Philippe ordered the closure of all non-essential public places, including restaurants, cafés, cinemas, and nightclubs, effective at midnight. On March 16, President Emmanuel Macron announced mandatory home confinement for 15 days starting at noon on 17 March.
• Germany

– Government Advocation (GA): 28/01/2020

* On January 28, hotlines were established to calm down worried callers. Experts advise unsettled citizens to follow the usual rules that are also appropriate to protect against a flu infection: regular hand washing, coughing or sneezing in a handkerchief or keeping your arm and distance from other sick people.

– School Closure (SC): 26/02/2020

* On February 26, following the confirmation of multiple COVID-19 cases in North Rhine-Westphalia, Heinsberg initiated closure of schools, swimming pools, libraries and the town hall until March 2. The closures were still effective until the day of the data was collected (April 3).

– International Travel Ban (ITB): 16/03/2020

* https://en.wikipedia.org/wiki/2020_coronavirus_pandemic_in_France
* https://en.wikipedia.org/wiki/2020_coronavirus_pandemic_in_Germany
* https://www.welt.de/wirtschaft/article205424021/Coronavirus-Behoerden-bereiten-sich-auf-hunderte-Infiziertes-vor.html
* On March 15, German Interior Minister Horst Seehofer announced to shut down the borders with France, Switzerland, Austria, Denmark and Luxembourg. The measure would begin on Monday (March 16) and the transportation of goods and commuters would be exempt.

* [https://en.wikipedia.org/wiki/2020_coronavirus_pandemic_in_Germany](https://en.wikipedia.org/wiki/2020_coronavirus_pandemic_in_Germany)

– City Lockdown (CL): 16/03/2020

* On March 16, the Germany federal government and the heads of government of the federal states have reached an agreement in view of the corona epidemic in Germany. They decided on guidelines for a uniform approach to further restrict social contacts in the public sector. According to the agreement of the federal and state governments, bars, clubs, discotheques, pubs and similar facilities are to be closed to the public. In addition, theaters, operas, concert halls, museums, trade fairs, exhibitions, cinemas, leisure and animal parks as well as providers of leisure activities (indoors and outdoors) are to shut down. Sports facilities, gyms, swimming pools and fun pools, playgrounds and other retail outlets are also affected.

* [https://www.bundesregierung.de/breg-de/themen/coronavirus/leitlinien-bund-laender-1731000](https://www.bundesregierung.de/breg-de/themen/coronavirus/leitlinien-bund-laender-1731000)

– Italy

– Government Advocacy (GA): 31/01/2020

* On January 31, Italy declared a six-month state of emergency today after two Chinese tourists tested positive for the coronavirus.
– International Travel Ban (ITB): 31/01/2020

* On January 31, the Italian government suspended all flights to and from China.

* [https://en.wikipedia.org/wiki/2020_coronavirus_pandemic_in_Italy](https://en.wikipedia.org/wiki/2020_coronavirus_pandemic_in_Italy)

– School Closure (SC): 04/03/2020

* On March 4, the Italian government imposed the shutdown of all schools and universities nationwide for two weeks as the country reached 100 deaths from the outbreak. The closures were still effective on the day of the data was collected (April 3).

* [https://en.wikipedia.org/wiki/2020_coronavirus_pandemic_in_Italy](https://en.wikipedia.org/wiki/2020_coronavirus_pandemic_in_Italy)

– City Lockdown (CL): 08/03/2020

* In the night between March 7 and 8, the Italian government approved a decree to lock down Lombardy and 14 other provinces in Veneto, Emilia-Romagna, Piedmont and Marche, involving more than 16 million people. The closures were still effective on the day of the data was collected (April 3).

* [https://en.wikipedia.org/wiki/2020_coronavirus_pandemic_in_Italy](https://en.wikipedia.org/wiki/2020_coronavirus_pandemic_in_Italy)

• Japan
– Mask Use (MU): 22/01/2020

* It is indicted that the use of face masks is ubiquitous in China and other Asian countries such as South Korea and Japan.

* Feng Shuo, Chen Shen, Nan Xia, Wei Song, Mengzhen Fan, and Benjamin J. Cowling. “Rational use of face masks in the COVID-19 pandemic.” The Lancet Respiratory Medicine (2020).

– Government Advocation (GA): 24/01/2020

* On January 24, Japan Prime Minister Abe convened the ”Ministerial Meeting on Countermeasures Related to the Novel Coronavirus” at the Prime Minister’s Office with members of his Cabinet in response to a statement released by the World Health Organization (WHO) that morning which confirmed human-to-human transmission of the coronavirus.

  * [https://en.wikipedia.org/wiki/2020_coronavirus_pandemic_in_Japan](https://en.wikipedia.org/wiki/2020_coronavirus_pandemic_in_Japan).

– International Travel Ban (ITB): 01/02/2020

* On February 1, Japan Prime Minister Abe announced during the Fourth Meeting of the Novel Coronavirus Response Headquarters that he would enact restrictions to deny entry of foreign citizens who had a history of visiting Hubei province within 14 days and those who possess a Chinese passport issued by Hubei province.

  * [https://en.wikipedia.org/wiki/2020_coronavirus_pandemic_in_Japan](https://en.wikipedia.org/wiki/2020_coronavirus_pandemic_in_Japan).

– Contact Tracing (CT): 25/02/2020
On February 25, the Ministry of Health, Labour and Welfare established a “Cluster Response Section” in accordance to the Basic Policies for Novel Coronavirus Disease Control. The purpose of the new section is to quickly identify and contain small-scale clusters of COVID-19 infections before they turn into large-scale ones. It is led by university professors Oshitani Hitoshi and Nishiura Hiroshi and consists of a contact trace team and a surveillance team from the National Institute of Infectious Diseases (NIID), a data analysis team from Hokkaido University, a risk management team from Tohoku University, and an administration team.

https://en.wikipedia.org/wiki/2020_coronavirus_pandemic_in_Japan.

– School Closure (SC): 02/03/2020

On February 27, Japan Prime Minister Abe requested closing all elementary, junior high, and high schools to curb the spread of the infections from March 2 to the end of spring vacations, which usually conclude in early April.

https://en.wikipedia.org/wiki/2020_coronavirus_pandemic_in_Japan

– Singapore

– Government Advocation (GA): 22/01/2020

To combat COVID-19, a multi-ministerial committee was formed on January 22 with Minister for National Development Lawrence Wong and Minister for Health Gan Kim Yong as the co-chairs and Prime Minister Lee Hsien Loong
and Deputy Prime Minister and Minister for Finance Heng Swee Keat as advisors.

* [https://en.wikipedia.org/wiki/2020_coronavirus_pandemic_in_Singapore](https://en.wikipedia.org/wiki/2020_coronavirus_pandemic_in_Singapore)

– Contact Tracing (CT): 23/01/2020

* On January 23, The first case in Singapore was confirmed, involving a 66-year-old Chinese national from Wuhan who flew from Guangzhou via China Southern Airlines flight CZ351 with nine companions. He stayed at Shangri-La’s Rasa Sentosa Resort and Spa. Contact tracing subsequently commenced.

* [https://en.wikipedia.org/wiki/2020_coronavirus_pandemic_in_Singapore](https://en.wikipedia.org/wiki/2020_coronavirus_pandemic_in_Singapore)

– Mass Testing (MT): 24/01/2020

* Temperature screening for travellers arriving at Singapore Woodlands and Tuas checkpoints began at noon on Friday (January 24).

* [https://www.channelnewsasia.com/news/singapore/wuhan-virus-woodlands-tuas-checkpoint-temperature-screening-12319724](https://www.channelnewsasia.com/news/singapore/wuhan-virus-woodlands-tuas-checkpoint-temperature-screening-12319724)

– International Travel Ban (ITB): 29/01/2020

* Travellers from Hubei were denied entry from noon of January 29.

* [https://en.wikipedia.org/wiki/2020_coronavirus_pandemic_in_Singapore](https://en.wikipedia.org/wiki/2020_coronavirus_pandemic_in_Singapore)

– Mask Use (MU): 01/02/2020
• South Korea

  – Government Advocation (GA): 22/01/2020

    * President Moon Jae-in ordered to prevent the spread of the 2019-nCoV during Lunar New Year at an council briefing as of January 22.

    * https://www.cdc.go.kr/board/board.es?mid=a30402000000&bid=0030&act=view&list_no=365844&tag=&nPage=14

  – Mask Use (MU): 22/01/2020

    * It is indicted that the use of face masks is ubiquitous in China and other Asian countries such as South Korea and Japan.

    * Feng Shuo, Chen Shen, Nan Xia, Wei Song, Mengzhen Fan, and Benjamin J. Cowling. “Rational use of face masks in the COVID-19 pandemic.” The Lancet Respiratory Medicine (2020).

  – Contact Tracing (CT): 20/01/2020

    * The COVID-19 outbreak in China occurred on December 8, 2019, and the first case in South Korea was reported on January 20, 2020. In the current epidemiological investigation contact investigation techniques that were used on a limited basis for the Middle East Respiratory Syndrome (MERS) outbreak in 2015, are being used in all confirmed cases of COVID-19.
- COVID-19 National Emergency Response Center, Epidemiology & Case Management Team, Korea Centers for Disease Control & Prevention. “Contact Transmission of COVID-19 in South Korea: Novel Investigation Techniques for Tracing Contacts.” Osong public health and research perspectives vol. 11,1 (2020): 60-63.

- Mass Testing (MT): 31/01/2020
  - Extended regional and local triage check-up centre for Covid19.
  - https://www.kaggle.com/paultimothymooney/covid19-containment-and-mitigation-measures/version/19

- International Travel Ban (ITB): 02/02/2020
  - On February 2, the South Korea government said it will ban the entry into Korea of any foreigners who have visited Hubei Province in China within the past two weeks.
  - https://www.koreatimes.co.kr/www/nation/2020/02/119_282795.html

- School Closure (SC): 07/02/2020
  - According to Korea’s JoongAng Ilbo, there are 450 kindergartens, 77 elementary schools, 29 junior high schools, 33 high schools and 3 special schools shut down till February 7, with a total of 592. on February 23, all kindergartens, elementary schools, middle schools, and high schools were announced to delay the semester start from 2 to 9 March.
  - https://en.wikipedia.org/wiki/2020_coronavirus_pandemic_in_South_Korea
Spain

– International Travel Ban (ITB): 10/03/2020

* On March 10, the Government of Spain decreed the immediate cancellation of all direct flights from Italy to Spain until 25 March. The cancellation was still effective on the day of the data was collected (April 3).

* [https://en.wikipedia.org/wiki/2020_coronavirus_pandemic_in_Spain](https://en.wikipedia.org/wiki/2020_coronavirus_pandemic_in_Spain)

– School Closure (SC): 12/03/2020

* On March 12, most of the autonomous communities in Spain shut down their school systems, initially for two weeks.

* [https://en.wikipedia.org/wiki/2020_coronavirus_pandemic_in_Spain](https://en.wikipedia.org/wiki/2020_coronavirus_pandemic_in_Spain)

– Government Advocation (GA): 14/03/2020

* On March 13, Prime Minister of Spain Pedro Sánchez announced a declaration of a nationwide State of Alarm for 15 days, to become effective the following day after the approval of the Council of Ministers.

* [https://en.wikipedia.org/wiki/2020_coronavirus_pandemic_in_Spain](https://en.wikipedia.org/wiki/2020_coronavirus_pandemic_in_Spain)

– City Lockdown (CL): 14/03/2020

* On March 13, the Government of the Community of Madrid decreed the shutting down of bars, restaurants and "non-alimentary" shops (only allowing the
opening of supermarkets and chemist’s shops. On March 14, Asturias, Catalonia, Cantabria, Galicia, Madrid, Murcia and the Basque Country closed all shops except those selling food and basic necessities. The Mayor of Madrid closed parks and public gardens.

* [https://en.wikipedia.org/wiki/2020_coronavirus_pandemic_in_Spain](https://en.wikipedia.org/wiki/2020_coronavirus_pandemic_in_Spain)

### United Kingdom

- **Government Advocation (GA): 01/03/2020**

  * By March 1, cases had been detected in England, Wales, Northern Ireland and Scotland. Subsequently, Prime Minister Boris Johnson unveiled the Coronavirus Action Plan, and the government declared the outbreak as “level 4 incident”.

  * [https://en.wikipedia.org/wiki/2020_coronavirus_pandemic_in_the_United_Kingdom](https://en.wikipedia.org/wiki/2020_coronavirus_pandemic_in_the_United_Kingdom).

- **School Closure (SC): 20/03/2020**

  * All schools, nurseries and colleges are to join those in the rest of the UK in closing on Friday (March 20) “until further notice”, with the only exception being made for children of key workers and for vulnerable children.

  * [https://www.theguardian.com/world/2020/mar/18/coronavirus-school-colleges-nurseries-england-close-uk-friday](https://www.theguardian.com/world/2020/mar/18/coronavirus-school-colleges-nurseries-england-close-uk-friday)

- **City Lockdown (CL): 20/03/2020**

  * On 20 March, Prime Minister Boris Johnson requested the closure of pubs, restaurants, gyms, entertainment venues, museums and galleries that evening.
Beijing

– School Closure (SC): 22/01/2020

* School Winter Vocation in Beijing was scheduled as from 18/01/2020 to 16/02/2020. The semester start was delayed until the date of the data was collected (April 3).

* https://jw.beijing.gov.cn/tzgg/202004/t20200404_1789233.html

– Government Advocation (GA): 24/01/2020

* On January 24, Beijing launched Level 1 Response Mechanism.

* https://www.thepaper.cn/newsDetail_forward_5622869

– City Lockdown (CL): 24/01/2020

* In China, Chinese New Year Holiday was scheduled as from 24/01/2020 to 02/02/2020. On January 31. Beijing government announced that employees for essential business will resume working on 09/02/2020. Others will remain working from home until April 10.

* http://www.gov.cn/zhengce/content/2020-01/27/content_5472352.htm
* http://www.beijing.gov.cn/zhengce/zhengcefagui/202001/t20200131_1622070.html
* http://www.beijing.gov.cn/zhengce/zhengcefagui/202004/t20200410_1799118.html
Contact Tracing (CT): 24/01/2020

* On January 24, Beijing City Government announced that disease prevention and control institutions should strengthen the epidemiological investigation, investigate the source of infection in detail, determine the spread of the epidemic, assess the impact and possible development trend of the epidemic, and trace the close contacts.

Mass Testing (MT): 24/01/2020

* On January 24, Beijing City Government announced that medical institutions should strengthen the pre-examination and triage work, and guided patients to special fever outpatient clinics based on their symptoms and signs and epidemiological history, and refer the confirmed cases of pneumonia infected by the new coronavirus to designated hospitals for treatment, and strengthen the prevention and control of nosocomial infections.

Mask Use (MU): 07/02/2020

* On February 7, Beijing Municipal People’s Congress Standing Committee agreed on the decision to require people to wear masks in public places.
International Travel Ban (ITB): 28/03/2020

* On March 26, Chinese government decided to temporarily suspend entry of foreigners with the current valid visa and residence permit for entry into China from 0:00 on March 28, 2020.

https://www.fmprc.gov.cn/web/wjbxw_673019/t1761858.shtml

California

International Travel Ban (ITB): 02/02/2020

* On January 31, the United States imposed an entry ban on all foreign nationals who were in the People's Republic of China, excluding Taiwan, Hong Kong, and Macau, in the past fourteen days, effective 5:00 p.m. eastern standard time on February 2, 2020.

https://www.whitehouse.gov/presidential-actions/proclamation-suspension-entry-immigrants-nonimmigrants-persons-pose-risk-transmitting-2019-novel-coronavirus/

Government Advocation (GA): 04/03/2020

* On March 4, Governor Newsom declared a state of emergency after the first death in California attributable to coronavirus occurred in Placer County.

https://en.wikipedia.org/wiki/2020_coronavirus_pandemic_in_California
– School Closure (SC): 13/03/2020

* On March 13, schools were closed in Marin, Sacramento, San Joaquin, San Luis Obispo, Santa Clara, Solano, Placer, and Contra Costa counties, as well as the Oakland, Antioch, Santa Cruz, Los Angeles Unified, Chaffey Unified, Etiwanda, Fontana Unified, Ontario-Montclair, Alta Loma Unified, San Diego, Los Alamitos Unified, and Washington Unified school districts.

https://en.wikipedia.org/wiki/2020_coronavirus_pandemic_in_California

– City Lockdown (CL): 19/03/2020

* On March 19, Governor Newsom announced a statewide stay-at-home order.

* https://en.wikipedia.org/wiki/2020_coronavirus_pandemic_in_California

● Guangdong

– School Closure (SC): 22/01/2020

* School Winter Vocation in Guangdong was scheduled from 19/01/2020 to 16/02/2020. The semester start was delayed until the date of the data was collected (April 3).

* http://edu.gd.gov.cn/zxxz/xwfb/content/post_2968669.html

– Government Advocation (CA): 23/01/2020:

* On Jan 23, Guangdong launched Level 1 Response Mechanism.
– Contact Tracing (CT): 23/01/2020

* On January 23, Guangdong Provincial Health Office required Guandong City Level Health Office to find out close contacts of confirmed cases.

– Mass Testing (MT): 23/01/2020

* On January 23, Guangdong Provincial Health Office required Guandong City Level Health Office to perform new Coronavirus nucleic acid testing for close contacts.

– City Lockdown (CL): 24/01/2020

* In China, Chinese New Year Holiday was scheduled as from 24/01/2020 to 02/02/2020. On January 28, Guangdong Province government announced that employees for essential business will resume working on 10/02/2020. Others will gradually resume working upon situation evaluation.
– Mask Use (MU): 26/01/2020

* On January 26, Guangdong Command Office for the Prevention and Control of the outbreak of new coronavirus infected pneumonia announced that Guangdong residential people are required to wear masks in public places.

* [http://wsjkw.gd.gov.cn/zwyw_gzdt/content/post_2879265.html](http://wsjkw.gd.gov.cn/zwyw_gzdt/content/post_2879265.html)

– International Travel Ban (ITB): 28/03/2020

* On March 26, Chinese government decided to temporarily suspend entry of foreigners with the current valid visa and residence permit for entry into China from 0:00 on March 28, 2020.

* [https://www.fmprc.gov.cn/web/wjbxw_673019/t1761858.shtml](https://www.fmprc.gov.cn/web/wjbxw_673019/t1761858.shtml)

– Hong Kong

– Government Advocation (GA): 04/01/2020

* On January 4, the Hong Kong government declared a "serious response level" to the virus outbreak centred on Wuhan.

* [https://en.wikipedia.org/wiki/2020_coronavirus_pandemic_in_Hong_Kong](https://en.wikipedia.org/wiki/2020_coronavirus_pandemic_in_Hong_Kong)

– Contact Tracing (CT): 04/01/2020

* On January 4, the Hong Kong Government launched Preparedness and Response Plan for Novel Infectious Disease of Public Health Significance, which indicates that at serious response level, Department of Health will put close
contacts of confirmed cases of the novel infection under quarantine/medical surveillance; and other contacts under medical surveillance.

* [https://www.chp.gov.hk/files/pdf/govt_preparedness_and_response_plan_for_novel_infectious_disease_of_public_health_significance_eng.pdf](https://www.chp.gov.hk/files/pdf/govt_preparedness_and_response_plan_for_novel_infectious_disease_of_public_health_significance_eng.pdf)

- Mass Testing (MT): 04/01/2020
  * On January 4, Hong Kong Government launched Preparedness and Response Plan for Novel Infectious Disease of Public Health Significance, which indicates that at alert response level, Department of Health Conduct laboratory testing for the novel pathogen as required, including testing for Hospital Authority and private hospitals to enhance laboratory surveillance on the novel pathogen.

* [https://www.chp.gov.hk/files/pdf/govt_preparedness_and_response_plan_for_novel_infectious_disease_of_public_health_significance_eng.pdf](https://www.chp.gov.hk/files/pdf/govt_preparedness_and_response_plan_for_novel_infectious_disease_of_public_health_significance_eng.pdf)

- Mask use (MU): 08/01/2020
  * On January 8, Hong Kong’s Centre for Health Protection (CHP) added “Severe respiratory disease associated with a novel infectious agent” to their list of notifiable diseases to expand their authority on quarantine. The Hong Kong government also shortened hospital visits and made it a requirement for visitors to wear face masks.

* [https://en.wikipedia.org/wiki/2020_coronavirus_pandemic_in_Hong_Kong](https://en.wikipedia.org/wiki/2020_coronavirus_pandemic_in_Hong_Kong)

- School Closure (SC): 22/01/2020
Most Hong Kong schoolchildren never returned to school following the Chinese New Year holidays (from January 22 to February 1) after the government announced and then, and then the school closures were extended to April 20.

- International Travel Ban (ITB): 27/01/2020
  - On January 27, Mrs Carrie Lam announced that the Steering Committee cum Command Centre has decided to impose restrictions on all Hubei Province residents and people who visited the Hubei Province in the past 14 days from entering Hong Kong until further notice to reduce the chances of infected persons entering the city.

- Hubei
  - Government Advocation (GA): 20/01/2020
    - On January 20, Wuhan City government formed specialized command for epidemic control (CEC) to upgrade measures to cope with the epidemic including enhanced protection over the medical workers.
– School Closure (SC): 22/01/2020

* School Winter Vocation in Hubei was scheduled from 15/01/2020 to 09/02/2020. The semester start was delayed until the date of the data was collected (April 3).

* http://www.cnr.cn/hubei/yaowen/20191224/t20191224_524910001.shtml

– City Lockdown (CL): 23/01/2020

* On January 23, 2020, the central government of the People’s Republic of China imposed a lockdown in Wuhan and other cities.

* https://en.wikipedia.org/wiki/2019-2020_coronavirus_pandemic_in_Hubei

– Mask Use (MU): 22/01/2020

* On January 22, The city authority began to require all citizens to wear a mask in public places.

* https://en.wikipedia.org/wiki/2019-2020_coronavirus_pandemic_in_Hubei

– Public Transport Closure (PTC): 23/01/2020

* On the early morning of January 23, the government of Wuhan City announced a lockdown at around 2 o’clock which said, “Since 10:00 AM on January 23, 2020, the city’s bus, metro, ferry, coach services will be suspended. Without
a special reason, the residents should not leave Wuhan. Departure from the airport and railway stations will be temporarily prohibited. Recovery time of the services will be announced in a further notice.”

∗ https://en.wikipedia.org/wiki/2019-2020_coronavirus_pandemic_in_Hubei

– International Travel Ban (ITB): 23/01/2020

∗ Tianhe International Airport, Wuhan’s only civil airport suspended all commercial flights from 13:00 on January 23.

∗ https://en.wikipedia.org/wiki/2019-2020_coronavirus_pandemic_in_Hubei

– Contact Tracing (CT): 03/02/2020

∗ In the New Coronavirus Prevention and Control Guideline (1st version), it was indicated that the elderly who has been the close contacts with suspected cases should be recorded, and schools should monitor the health conditions of students and report to medical and health institutions for possible tracing of close contacts.

∗ http://wjw.hubei.gov.cn/bmdt/ztzl/yqxxfwxt/jkkp/202002/t20200202_2018199.shtml

– Mass Testing (MT): 05/02/2020

∗ On February 5, a 2000-sq-meter emergency detection laboratory named “Huo-Yan” was opened by BGI which can process over 10,000 samples a day.

∗ https://en.wikipedia.org/wiki/2019-2020_coronavirus_pandemic_in_Hubei
Macau

- Government Advocation (GA): 31/12/2019
  * On December 31 2019, the Health Bureau was notified by the National Health Commission of an outbreak of pneumonia of unknown cause in Wuhan, Hubei. Residents of Macau were asked to avoid excessive panic but to be conscious of personal hygiene and the hygiene of their environment. Those traveling to Wuhan were advised to avoid visiting local hospitals or having contact with sick people.
  * https://en.wikipedia.org/wiki/2020_coronavirus_pandemic_in_Macau

- School Closure (SC): 22/01/2020
  * On January 24, the Education and Youth Affairs Bureau announced that all non-tertiary schools would extend their Chinese New Year holiday (from January 24 to January 29), not resuming classes until February 10 or later. On January 30, the Tertiary Education Bureau announced that the resumption of classes would be delayed further, and that a schedule for resuming classes would be released one week before classes were to resume.
  * https://en.wikipedia.org/wiki/2020_coronavirus_pandemic_in_Macau

- International Travel Ban (ITB): 28/01/2020
  * On January 28, Secretary for Administration and Justice Zhang Yongchun said that in accordance with the decision of the central government, endorsements for mainland Chinese visitors to Macau would be suspended. Effective March
18, the government banned entry of all non-residents, with exceptions for mainland China, Hong Kong, and Taiwan.

* [https://en.wikipedia.org/wiki/2020_coronavirus_pandemic_in_Macau](https://en.wikipedia.org/wiki/2020_coronavirus_pandemic_in_Macau)

- Mask Use (MU): 03/02/2020

  * On February 3, the government of Macau announced that starting at noon, all bus and taxi passengers were required to wear masks.

  * [https://en.wikipedia.org/wiki/2020_coronavirus_pandemic_in_Macau](https://en.wikipedia.org/wiki/2020_coronavirus_pandemic_in_Macau)

- Mass Testing (MT): 20/02/2020

  * On February 19, the government announced that effective February 20, passengers coming from COVID-19 hotspots would need to undergo medical checks upon entering Macau. Medical checks might also be conducted on Macau residents who made multiple trips back and forth to Zhuhai every day.

  * [https://en.wikipedia.org/wiki/2020_coronavirus_pandemic_in_Macau](https://en.wikipedia.org/wiki/2020_coronavirus_pandemic_in_Macau)

- New York

- International Travel Ban (ITB): 02/02/2020

  * On Jan 31, the United States imposed an entry ban on all foreign nationals who were in the People’s Republic of China, excluding Taiwan, Hong Kong, and Macau, in the past fourteen days, effective 5:00 p.m. eastern standard time on February 2, 2020.
On March 7, Governor Andrew Cuomo declared a state of emergency.

On March 13, drive-through testing began in New Rochelle, Westchester County.

On March 15, Governor Andrew Cuomo announced that New York City schools would close the following day through April 20.

On March 20, Governor Andrew Cuomo announced the statewide stay-at-home order with a mandate that all non-essential workers work from home.

Taiwan
– Government Advocation (GA): 20/01/2020

* On January 20, the government deemed the risk posed by the outbreak sufficient to activate the Central Epidemic Command Center (CECC).

* [https://en.wikipedia.org/wiki/2020_coronavirus_pandemic_in_Taiwan](https://en.wikipedia.org/wiki/2020_coronavirus_pandemic_in_Taiwan)

– School Closure (SC): 22/01/2020

* Taiwan School Winter Vocation was scheduled from January 21 to February 11, which was further extended to February 25.

* [https://en.wikipedia.org/wiki/2020_coronavirus_pandemic_in_Taiwan](https://en.wikipedia.org/wiki/2020_coronavirus_pandemic_in_Taiwan)

– International Travel Ban (ITB): 23/01/2020

* On January 23, Wuhan residents are banned to enter Taiwan. Starting from March 19, foreign nationals were barred from entering Taiwan, with some exceptions, such as those carrying out the term of a business contract, holding valid Alien Resident Certificates, diplomatic credentials, or other official documentation and special permits.

* Wang, C. Jason, Chun Y. Ng, and Robert H. Brook. "Response to COVID-19 in Taiwan: big data analytics, new technology, and proactive testing." Jama (2020).

* [https://en.wikipedia.org/wiki/2020_coronavirus_pandemic_in_Taiwan](https://en.wikipedia.org/wiki/2020_coronavirus_pandemic_in_Taiwan)

– Mask Use (MU): 31/01/2020
* On March 31, transportation and communications minister Lin Chia-lung announced that all passengers on trains and intercity buses were required to wear masks, as were people at highway rest stops.

* [https://en.wikipedia.org/wiki/2020_coronavirus_pandemic_in_Taiwan](https://en.wikipedia.org/wiki/2020_coronavirus_pandemic_in_Taiwan)

– Mass Testing (MT): 01/02/2020

* On February 1, Taiwan CDC began monitoring all individuals who had travelled to Wuhan within fourteen days and exhibited a fever or symptoms of upper respiratory tract infections.

* [https://en.wikipedia.org/wiki/2020_coronavirus_pandemic_in_Taiwan](https://en.wikipedia.org/wiki/2020_coronavirus_pandemic_in_Taiwan)

– Contact Tracing (CT): 27/01/2020

* NHIA and NIA integrate patients’s past 14-day travel history into NHIA database.

* Wang, C. Jason, Chun Y. Ng, and Robert H. Brook. “Response to COVID-19 in Taiwan: big data analytics, new technology, and proactive testing.” Jama (2020).

• Washington

– International Travel Ban (ITB): 02/02/2020

* On January 31, the United States imposed an entry ban on all foreign nationals who were in the People’s Republic of China, excluding Taiwan, Hong Kong, and Macau, in the past fourteen days, effective 5:00 p.m. eastern standard time on February 2, 2020.
– Government Advocation (GA): 29/02/2020

- On February 29, Governor Jay Inslee declared a state of emergency.

- [https://en.wikipedia.org/wiki/2020_coronavirus_pandemic_in_Washington_(state)#Government_response](https://en.wikipedia.org/wiki/2020_coronavirus_pandemic_in_Washington_(state)#Government_response)

– School Closure (SC): 13/03/2020

- On March 12, Governor Inslee announced closures for all public and private K-12 schools in King, Snohomish, and Pierce Counties beginning from March 17 through at least April 24. On March 13, Inslee announced K-12 closures until at least April 24 throughout the state.

- [https://en.wikipedia.org/wiki/2020_coronavirus_pandemic_in_Washington_(state)#Government_response](https://en.wikipedia.org/wiki/2020_coronavirus_pandemic_in_Washington_(state)#Government_response)

– Mass Testing (MT): 16/03/2020

- On March 16, the University of Washington has expanded its drive-through coronavirus testing to include first responders and University of Washington Medicine patients with COVID-19 symptoms, as well as the health care system’s staff.

- [https://www.kuow.org/stories/drive-through-virus-testing-expands](https://www.kuow.org/stories/drive-through-virus-testing-expands)

– City Lockdown (CL): 23/03/2020
Governor Inslee announced a statewide stay-at-home order on March 23, to last at least two weeks.

https://en.wikipedia.org/wiki/2020_coronavirus_pandemic_in_Washington_(state)#Government_response