# WORKING PAPER

# A COVID-19 SEVERITY INDEX

Moubarack LO[1] and Amaye Sy [2]

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## Abstract

On March 11, 2020, the World Health Organisation (WHO) qualified the Covid-19 virus, which originated in China in December 2019, as a pandemic, since on that date it had circulated across all continents and to the vast majority of countries worldwide.

Since January 2020, some countries have experienced a favourable trend (concomitantly recording a slowdown in new infections, a continuous increase in recoveries and a decrease in deaths linked to the disease), whilst others are still struggling to control the propagation of the virus and its negative consequences on the lives of the sick.

It seemed necessary to us, therefore, to build a synthetic index, which summarises the respective performances of countries in their strategy for fighting the virus. This index will make it possible at any time, to instantly estimate the severity of the pandemic in different countries. The index is calculated on a weekly frequency for 169 countries.

As of 10 May 2020, the average score for the countries in the sample is 0.74, corresponding to a globally moderate severity. Europe has an average score of 0.77 and has seen a significant decrease in severity in recent weeks. For Africa, the scores are between 0.99 and 0.30, with an average of 0.70. In America, scores range from a low of 0.34 to 0.98, with an average of 0.69, the highest level of severity in the world. Asia averages a score of 0.74. Oceania performs the best, with an average score of 0.98.

**Keywords**: severity, Covid-19, index, resilience, survival.

[1] Economist and Statistician, Director General of the Economic Prospective Bureau of Senegal

[2] Economist and Statistician, Economic Prospective Bureau of Senegal

## Introduction

In late December 2019, China officially recognised the existence of the virus, called Covid-19, on its soil. In January 2020, the virus spread rapidly, reaching a peak in China in mid-February 2020. In January and February 2020, other neighbouring countries or those trading with China, particularly in Asia and Europe, were affected by the epidemic.

On January 30, 2020, the World Health Organisation (WHO) declared a public health emergency of international scope. On March 11, 2020, the Covid-19 epidemic was reclassified by the WHO as a pandemic, since by that date it had circulated on all continents and throughout the vast majority of countries worldwide.

The human cost of the COVID-19 pandemic continues to rise with, as of mid-May 2020, more than four million four hundred officially confirmed cases worldwide by the WHO with nearly three hundred thousand reported deaths from the disease.

At the beginning of March 2020, Asia accounted for more than 60% of coronavirus-related deaths. Attention then turned to Europe, with Italy, Spain, Great Britain and France being the new global hot spots. Although Europe still accounts for more than half of worldwide deaths, attention is now turning to the United States, where the number of fatalities rose rapidly in April. The United States now has the highest number of new cases in the world. In Africa, there are nearly 81,000 confirmed cases of coronavirus and close to 2,700 deaths as of May 17, 2020.

All this data comes from the WHO database, which publishes daily the pandemic situation in each country where the virus is circulating, using all available official statistics.

An examination of the available figures shows that some countries are experiencing a favourable trend (with a concomitant slowing down of new infections, a continuous increase in recoveries and a decrease in disease-related deaths), whilst others are still struggling to control the development of the virus and its negative consequences on the lives of the sick.

We felt it necessary, therefore, to construct a synthetic index that summarizes the respective performances of countries in their strategy for fighting the virus. The approach adopted in this document can be applied to any epidemic. It is, therefore, a universal index.

This index will make it possible to assess the situation of countries concerning the disease, at any time, to estimate instantaneously the severity of the pandemic in different countries and to identify groups of performing countries, in order to draw up a severity assessment at the end of the pandemic. It will then be possible to study, using robust statistical methods, the factors of resilience that may have been at the root of the successes achieved by some countries, in order to draw lessons from the conduct of Covid-19 response strategies and for the development of public health policies throughout the world.

The document is divided into three parts. The first part defines and details the main steps in the construction of the index, as well as the methodological choices that were made. The second part presents the results of the severity index and classifies countries according to their score on the index. The third part discusses the potential causes that may explain why some countries are showing more resilience to the virus than others. The way forward is presented in the conclusion.

# 1. Methodology

This section presents the methodology for constructing the Covid-19 severity index. It follows the steps defined in the Handbook on Constructing Composite indicators (Nardo et al., 2008) that are necessary for the proper construction of a composite or synthetic index. The construction of the index thus follows the following steps: (i) selection of the indicators that make up the index; (ii) data processing; (iii) choice of the method for standardising the indicators; (iv) selection of the weighting to be assigned to each of the indicators; (v) choice of the method for aggregating the indicators. These different points are analysed below.

Beforehand, an analysis of the concept of severity is carried out.

## 1.1 The concept of Disease Severity

### *1.1.1 What severity means*

An illness is an integral part of all human, animal and plant life. It can be caused by a virus and may affect, episodically, a few individuals or a large part of society. It can be limited to a given territory in a country, cover the whole country or spread rapidly throughout the world, due to its novelty and the lack of adequate immune protection measures (such as a vaccine). In the latter case, the disease is qualified as a pandemic by the WHO. Notwithstanding its spread across the surface of the earth, the emerging pandemic is only a source of real concern if it is accompanied by negative consequences in the short and medium term. In other words, it is the degree of severity that characterises the level of severity of a pandemic. According to the WHO, the severity of a viral pandemic has three elements: (i) the transmissibility of the virus, (ii) the severity of the disease, and (iii) its impact (see Box 1).

The severity varies from country to country and changes continuously during the period of disease transmission.

**BOX 1: WHAT THE SEVERITY OF A DISEASE MEANS (FROM THE WHO GUIDE TO ASSESSING THE SEVERITY OF INFLUENZA DURING SEASONAL EPIDEMICS AND PANDEMICS)**

*The Severity of the illness describes the extent of the illness in people infected with the influenza virus. It describes the frequency of clinical symptoms, complications of influenza, and the outcome of influenza infection. The severity of the illness depends on the virus; for example, an influenza virus associated with a high rate of severe clinical symptoms may result in a disproportionate number of severely ill people, some of whom will be hospitalized and some of whom will die. The severity of the disease also depends on the host; for example, the presence of an underlying illness that predisposes people to develop severe symptoms, previous vaccinations that may have a protective effect (e.g., influenza vaccination and pneumococcal vaccination), the age of the person, and the availability of health care. It is likely that the infection will be much more severe in certain segments of the population, and the description of risk groups will form an important part of this indicator. During seasonal influenza, the severity of illness is measured by routine hospital surveillance; for example, the case-fatality rate among people hospitalized or admitted to intensive care for influenza.*

***Source** :* OMS (2017), Évaluation de la sévérité de la grippe pandémique (PISA), Mai 2017 «https://apps.who.int/iris/bitstream/handle/10665/272872/WHO-WHE-IHM-GIP-2017.2-fre.pdf?ua=1

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L'analyse de l'indice GHS révèle qu'aucun pays n'est pleinement préparé pour les épidémies ou les pandémies. Collectivement, la préparation internationale est faible. De nombreux pays ne montrent pas des preuves de capacités de sécurité sanitaire et les capacités nécessaires pour prévenir, détecter et répondre aux flambées importantes de maladies infectieuses. Le score global moyen de l'indice SGH parmi les 195 pays évalués est de 40,2 sur un score possible de 100. Parmi les 60 pays à revenu élevé, la moyenne de l'indice GHS est de 51,9. En outre, 116 pays à revenu élevé et intermédiaire n'obtiennent pas un score supérieur à 50. Dans l'ensemble, l'indice du SGH révèle de graves faiblesses dans les aptitudes des pays à prévenir, détecter et répondre aux urgences sanitaires; de graves lacunes dans les systèmes de santé; vulnérabilités à risques politiques, socio-économiques et environnementaux ; et un manque d'adhésion aux normes internationales.

### *1.1.2 Selection of indicators*

The work undertaken in this paper aims to measure and monitor the severity of the COVID-19 virus worldwide. It is based on the WHO approach presented above. It covers all countries (169 in total) for which the WHO publishes daily data on the disease's progression.

Given the availability of regular data for a large sample of countries, six variables, grouped into three dimensions (infections, recoveries and deaths) were selected to make up the severity index (see Table 1 below). These are: (i) the infection rate; (ii) the progression of new infections in the recent period; (iii) the cure rate; (iv) the disease control rate; (v) the case-fatality rate; (vi) the flow of new deaths.

Therefore, the severity index combines elements of stocks (which have a lasting impact on society) and elements of flows (which must be controlled to stop the disease) (see Table 1).

## 1.2 Stock indicators

The **rate of infection** is equal to the cumulative number of people infected since the onset of the disease, relative to the size of the population. It is a measure of what the WHO calls the transmissibility of the virus; that is, how easily it circulates amongst individuals and communities. In the case of COVID-19, the actual rate of infection is difficult to determine. The highly asymptotic nature of the disease makes it invisible to 80.9 percent of people who develop a mild form, according to the results of a major study conducted last February on a sample of 72,000 people by the China Centre for Disease Control and Prevention. The same study found that 13.8% of sufferers develop severe forms (requiring hospitalisation or special care) and only 4.7% of cases become critical and eventually lead to death. For the purposes of this paper, therefore, we rely on the data published by the WHO in its COVID-19 daily situation reports, which covers all affected countries. In addition, case detection methods differ from one country to another. Some do massive tests, possibly generating more recognised cases, whilst others include in their official statistics only those patients who are treated in their healthcare facilities once they have experienced symptoms related to the coronavirus. Nevertheless, we have included the variable – the cumulative number of infected people - pending better estimates in the future as countries make progress in managing the pandemic. Infected people recover more or less quickly and some of them die. Those who do recover may eventually have sequelae that impact on their future health. The infection rate variable must therefore be monitored over time, in order to consider strategies for the proper management of patients who have recovered from COVID-19.

The number of active infections (the cumulative number of infected persons from which are deducted recoveries and deaths) puts more or less pressure on the bed capacity of the country's hospitals, as well as on the personnel and healthcare equipment available. It also has an impact on the labour force and on the activities of the healthcare sector.

The **case-fatality** rate is the ratio of the number of deaths to the number of confirmed cases. It is an impact indicator that can be disaggregated, within countries, by geographical area, gender, age or occupational category.

The **cure rate** is the ratio of the number cured to the number infected in the previous period. It provides information on the ability of the country's healthcare system and the people affected to recover from the disease.

## Flow indicators

The variable "**progression of new infections in the recent period**" (two weeks in our study) provides information on the speed of transmission of the virus and the appearance of new cases. It is expected to trend towards zero as the country emerges from the epidemic.

The **disease control rate** (new recoveries over a period of time relative to new infections over a period of time) is the best indicator of a reversal in the evolution of the disease. If the ratio is continuously above unity, the country eventually cures all its patients and can, in a relatively short period of time, declare itself free of the virus.

The **flow of new deaths** measures new deaths that have occurred over a two-week period as a proportion of the number of active infected persons at the beginning of that period. It is a speed indicator that can detect a decline in the overall case-fatality rate and demonstrate the degree of disease control.

**Table 1 : Dimensions of the Severity Index**

| Dimensions | Indicateurs | Description | Use |
|---|---|---|---|
| **Infection** | Infection rate | Cumulative infections relative to population size | This indicator is used to assess the extent of the disease in the population of a given country. |
| | Progression of new cases | Growth rate of new infections over two weeks | This indicator shows how fast the virus is spreading in the country. |
| **Recovery** | Cure rate | Ratio of the number of recoveries to the number of infections in the previous period (two weeks) | This indicator shows the performance of a given country taking into consideration the recovery from the infection. It targets the period of infections from the preceding two weeks |

| | | | |
|---|---|---|---|
| | | | because the infection is not instantaneous. |
| | Disease control rate | Ratio of newly cured to newly infected people over two weeks | This indicator helps to detect whether the country has reversed the trend and is now registering more new cured than new patients. |
| **Deaths** | Case-fatality rate | Ratio of the number of deaths to the number of confirmed cases | This indicator provides information on deaths caused by the disease. |
| | Flow of new deaths | Ratio of the flow of new deaths over the period (two weeks) to the number of people infected at the beginning of that period | This indicator is used to detect a decrease in the overall case-fatality rate. |

In the future, other variables of the lasting impact of the virus could be added, including the consequences on health indicators (morbidity rates, mortality rates, post-pandemic life expectancy, for example), in addition to the geopolitical, economic, social, cultural and psycho-sociological sequelae that can be studied elsewhere.

National (or even regional and local) severity indices could also be developed, with a greater number of variables that can be easily collected at a given country level (e.g. intensive care admissions that provide information on risk of deaths).

The index is published on a weekly basis for all 169 countries. The data is taken from the WHO's daily databases of country-level data, as well as data from the African Union Centre for Disease Control and Prevention, the European Centre for Disease Prevention and Control, and John Hopkins CSSE.

## 1.3 Processing and Standardisation of Indicators

The COVID-19 severity index aggregates the information contained in several indicators. In order to allow the indicators to be compared and, thus, to avoid the problem of heterogeneity in their units of measurement, a transformation is required before they can be aggregated. It is necessary, therefore, to place the variables on a common scale (from 0 to 1, for example) using various standardisation methods in order to be able to aggregate them. The Min-Max transformation has been used to standardise the indicators (see Box 2).

**BOX 2 : THE APPROACH OF THE MIN-MAX METHOD**

This method centers the index between the extreme values of the sample. Algebraically the Min-Max method is given by following formula:

- For the case of "positive indicators", that is to say those that are positively correlated with the index,

$$\boldsymbol{Indicateur\ Norm}_{country=i}^{périod=t} = \frac{\boldsymbol{indic\ value}_{country=i}^{période=t} - \mathbf{Min}\left(\boldsymbol{indic\ value}^{période=réf}\right)}{\mathbf{Max}\left(\boldsymbol{indic\ value}^{période=réf}\right) - \mathbf{Min}\left(\boldsymbol{indic\ value}^{période=réf}\right)}$$

- For the case of "negative indicators", ie those which are negatively correlated with the index

$$\boldsymbol{Indicateur\ Norm}_{country=i}^{période=t} = \frac{\mathbf{Max}\left(\boldsymbol{indic\ value}^{période=réf}\right) - \boldsymbol{indic\ value}_{country=i}^{période=t}}{\mathbf{Max}\left(\boldsymbol{indic\ value}^{période=réf}\right) - \mathbf{Min}\left(\boldsymbol{indic\ value}^{période=réf}\right)}$$

By definition, the indicator thus normalized $\boldsymbol{Indicateur\ Norm}$ is between 0 and 1 and the rankings of all the entities are made with reference to the relative positions of the indicator in this range.

Once this standardisation is completed, weights are assigned to the indicators before they are aggregated into a single index.

## 1.4 Weighting and Aggregation of Indicators

The weights associated with the indicators are derived from the structure of the data through the implementation of a Principal Component Analysis (PCA) on the sample (see Box 3).

 

**BOX 3 : WEIGHTING OF INDICATORS**

The most common methods are multiple factor analysis (AFM) and principal component analysis (PCA). In this study, by retaining the first thre factorial axes, the calculation of the weights of the indicators is carried out as follows:

The weight of the variable V is obtained by the following formula:

$$W_{Var=V} = \frac{(Contrib_{axe1}^{V} * \delta_{axe1} + Contrib_{axe2}^{V} * \delta_{axe2} + +Contrib_{axe3}^{V} * \delta_{axe3})}{(\delta_{axe1} + \delta_{axe2} + \delta_{axe3})}$$

Where :

$\delta_{axei}$ si the eigenvalue associated with axis i=(1,2 3)

$Contrib_{axei}^{V}$ is the contribution of indicator V to the formation of axis i =(1,2 3)

$$Index = \sum_{V=1}^{6} \frac{W_{Var=V} * Value(Var = V)}{W_{Var=V}}$$

With respect to the Kaiser criterion (eigenvalue associated with the axis greater than or equal to 1), the first three axes (or factors) of the PCA are retained (see Table 2).

**Table 2: Eigenvalues associated with CPA axes**

| | F1 | F2 | F3 | F4 | F5 | F6 |
|---|---|---|---|---|---|---|
| **Eigenvalue** | 2,42 | 1,37 | 1,12 | 0,60 | 0,36 | 0,13 |
| **Explained Variance (%)** | 40,26 | 22,88 | 18,69 | 10,02 | 5,93 | 2,22 |
| **Cumulative Explained Variance %** | 40,26 | 63,14 | 81,83 | 91,85 | 97,78 | 100,00 |

**Source**: Authors' calculations

Table 2 shows the coordinates of the indicators on each of the first three factors. The weight of a given indicator corresponds to the average (weighted by the eigenvalues of the axes selected) of its contributions to the formation of the axes.

Table 3 presents the weights calculated and associated with each indicator.

**Table 3: Weighting of indicators in the calculation of the Severity Index**

| Indicator | Weight |
|---|---|
| **Case-fatality rate** | 18% |
| **Cure rate** | 19% |
| **Disease control rate** | 20% |
| **Progression of new cases** | 16% |
| **Infection rate** | 17% |
| **Flow of new deaths** | 10% |

**Source:** Authors' calculations

Hence, the index is given by the following formula:

**Index = 18% * Case-fatality_rate + 19% * Cure_rate + 20%* Disease_control_ rate + 16% * Progression_of_new_cases + 17% * Infection_rate + 10%* Flow_of_new_deaths**

## 1.5 Robustness Analysis and Validation of the Index

We test the robustness of the severity index by calculating several synthetic indices using different weighting methods, using aggregation by the arithmetic mean. From these indices, we conduct sensitivity tests to the weighting assumptions. This analysis aims to capture the qualitative and quantitative variation of the index, following a change in the weighting assumptions. There are various methods for conducting this analysis. The one that will be used is the calculation of the Spearman correlation between the calculated indices. The Spearman coefficient is given by the following formula:

$$\rho = \frac{\frac{1}{n}\sum_{i=1}^{n}(R(x_i) - \overline{R(x)}) * (R(y_i) - \overline{R(y)})}{\sqrt{(\frac{1}{n}\sum_{i=1}^{n}(R(x_i) - \overline{R(x)})^2 * \frac{1}{n}\sum_{i=1}^{n}(R(y_i) - \overline{R(y)})^2)}}$$

This measure assesses the correlation not between the values taken by the various indices, but between the ranks of these values.

The following three indices, which differ only in their weighting system, were calculated and compared with the severity index:

- **Index A**: uniform weighting
  - Equal weighting is assigned to indicators

- **Index B**: weighting which retains all the axes of the PCA
  - The weights are derived from the PCA on the data by retaining all the axes (instead of 3)

**Table 4: Correlations between the Severity Index and the A and B indices built using other weighting systems**

| | 14 April 2020 | 25April 2020 | 10 May 2020 |
|---|---|---|---|
| **Index A** | 99,69% | 99,86% | 99,84% |
| **Index B** | 99,90% | 99,93% | 99,95% |

**Source**: Authors' calculations

## 2. COVID-19 Severity Index Results

### 2.1 Country and Continent Scores

The index is constructed in such a way that the countries with the highest scores are those that are most resistant to the disease, at the precise time the index is calculated. A very high score, therefore, corresponds to a very low severity of the disease in the country. Conversely, a very low score means that the severity of the disease is very high in the country.

Considering that data on the disease is collected differently from one country to another, with varying degrees of rigour in terms of the completeness of the census of cases of infection and deaths (especially those recorded outside health facilities), and that country rankings on the index change from week to week, we have favoured two approaches:

- Conduct an analysis of index scores at the continent level, thereby mitigating collection shortfalls;
- Study the comparative trajectories of a number of countries, to analyse the evolution of severity in these countries since their onset of the disease.

As of 10 May 2020, New Caledonia displays the highest score (of 0.99 out of a possible total of 1 in a sample of 170 countries around the world), followed by Cambodia (0.99) and New Zealand (0.99). The lowest scores are held by Yemen (0.33), Sao Tome (0.30) and the Maldives (0.29). The average score for the countries in the sample is 0.74, corresponding to a globally moderate severity. Compared to May 3, 2020, the largest increases in the index (largest decreases in severity) are displayed by Panama, Mozambique and Estonia. Tajikistan, Gambia and Sao Tome recorded the largest decreases in the index (largest increases in severity) in one week.

The analysis by continent shows that Europe has an average score of 0.77. With such a score, Europe has seen a significant decrease in severity in recent weeks. The best score on this continent is 0.99 (Iceland) and the worst-performing country is United Kingdom (0.37). Estonia, Serbia and Sweden show the largest increases in the index (largest decreases in severity) in one week on the European continent. Russia, Armenia and Azerbaijan had the largest decreases in the index (largest increases in severity) in one week in Europe.

For Africa, the scores are between 0.99 (Eritrea) and 0.30 (Sao Tome) with an average of 0.70. Mozambique, Zimbabwe and Morocco show the largest increases (largest decreases in severity) in the index in one week in Africa. Chad, The Gambia and Sao Tome report the largest decreases (largest increases in severity) in one week in Africa.

In America, scores range from a low of 0.34 (for Ecuador, the most severely affected country on the continent) to 0.98 (Saint Kitts and Nevis), with an average of 0.69, the highest level of severity in the world. Panama, the Bahamas and Jamaica show the largest increases in the index (largest decreases in severity) in one week on this continent. Honduras, Chile and Paraguay show the largest decreases in the index (largest increases in severity) in one week on this continent.

Asia has an average score of 0.74. The highest score (and thus the lowest severity) is obtained by Cambodia (0.99), followed by Brunei (0.99) and Thailand (0.98). Japan, Myanmar and Sri Lanka show the largest increases in the index (largest decreases in severity) in one week in Asia. Kuwait, Yemen and Tajikistan reported the largest decreases in the index (largest increases in severity) in one week in Asia.

In Oceania, New Caledonia achieved the best performance for the Covid-19 severity index, as of 10 May 2020 (with a score of 0.99), followed by New Zealand (0.99), French Polynesia (0.96) and Australia (0.97). In one week, Australia, French Polynesia and New Caledonia show an increase in their score whilst New Zealand and Fiji stabilise their scores.

**Table 4: Scores by continent (as of 10 May 2020)**

| Continent | Number of countries | Minimum | Maximum | Average |
|---|---|---|---|---|
| Index \| Africa | 51 | 0,30 | 0,99 | 0,70 |
| Index \| America | 29 | 0,34 | 0,98 | 0,69 |
| Index \| Asia | 40 | 0,29 | 1,00 | 0,74 |
| Index \| Europe | 45 | 0,37 | 0,99 | 0,77 |
| Index \| Oceania | 5 | 0,96 | 1,00 | 0,98 |

**Source**: Authors' calculations

In the following lines we analyse, by way of illustration, the trajectories of disease severity in 11 countries (see table 5 and graph 1): China, South Korea, the United States, France, Germany, Spain, Italy, New Zealand, Morocco and South Africa.

As of 28 February, South Korea had the highest severity amongst the selected countries. From 28 February to 10 May, the country continuously improved its performance from a score of 0.43 to 0.97; the second best score amongst the 11 countries behind New Zealand.

In New Zealand, severity has been continuously decreasing since 18 March, after a rapid increase between 28 February and 18 March (the index score falling from 0.8 to 0.45). As of May 10, the New Zealand has the lowest severity (highest score) amongst the selected countries.

In China, the score ranged from a high of 0.98 on April 1 and May 10 to a low of 0.63 on April 25. The country shows an increase in its score between 28 February and May 10, except the period between April 14 and April 25.

The severity in France and Germany began to decline (i.e. the score in their index rose) as of April 1, whilst the decline in Italy and Spain did not occur until after April 14.

In the United Kingdom and the United States, the decrease in severity (i.e. an increase in the score) does not occur until 25 April 2020. Since 1 April, these two countries have had the highest severity amongst the selected countries.

In Morocco and South Africa, the severity decreased between 28 February and 18 March and then increased again between 18 March and 1 April. Since that date, both countries have seen a decrease in severity (corresponding to an increase in their score in the index).

**Graph 1: Trend in scores for selected countries between 14 February and 10 May 2020**

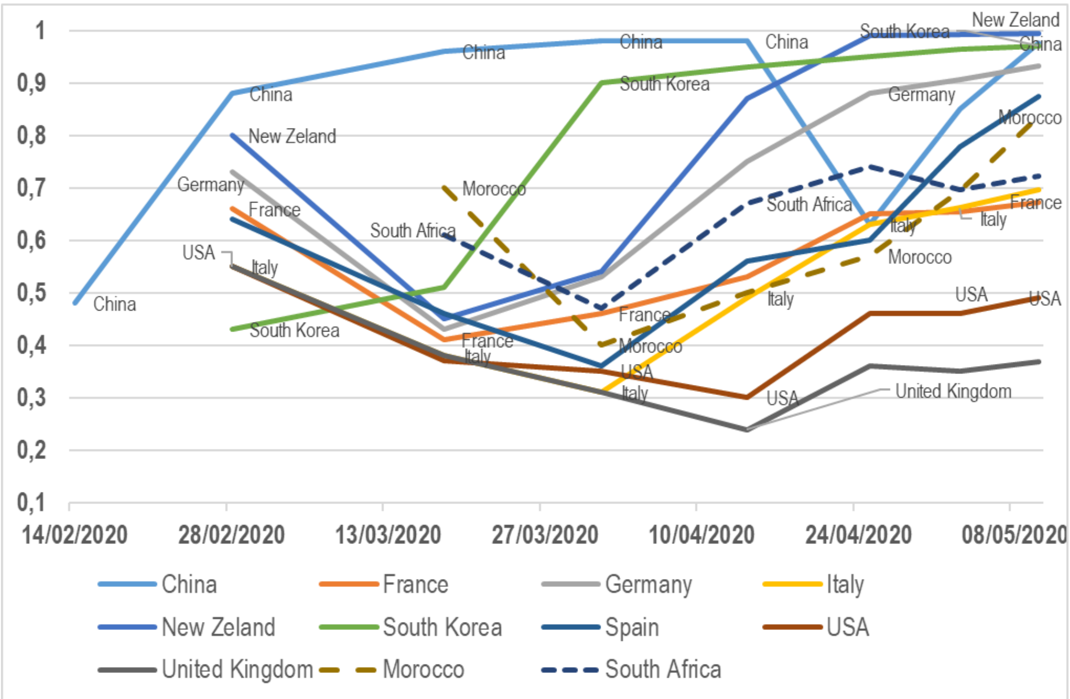

**Table 5: Change in scores of selected countries between 14 February and 10 May 2020**

| Country | 14/02 2020 | 28/02 2020 | 18/03 2020 | 01/04 2020 | 14/04 2020 | 25/04 2020 | 03/05 2020 | 10/05 2020 |
|---|---|---|---|---|---|---|---|---|
| China | 0,48 | 0,88 | 0,96 | 0,98 | 0,98 | 0,63 | 0,85 | 0,98 |
| France | | 0,66 | 0,41 | 0,46 | 0,53 | 0,65 | 0,65 | 0,67 |
| Germany | | 0,73 | 0,43 | 0,53 | 0,75 | 0,88 | 0,91 | 0,93 |
| Italy | | 0,55 | 0,38 | 0,31 | 0,49 | 0,63 | 0,66 | 0,70 |
| New Zeland | | 0,8 | 0,45 | 0,54 | 0,87 | 0,99 | 0,99 | 0,99 |
| South Korea | | 0,43 | 0,51 | 0,9 | 0,93 | 0,95 | 0,96 | 0,97 |
| Spain | | 0,64 | 0,46 | 0,36 | 0,56 | 0,6 | 0,78 | 0,87 |
| USA | | 0,55 | 0,37 | 0,35 | 0,3 | 0,46 | 0,46 | 0,49 |
| United Kingdom | | 0,55 | 0,38 | 0,31 | 0,24 | 0,36 | 0,35 | 0,37 |
| Morocco | | | 0,7 | 0,4 | 0,5 | 0,57 | 0,69 | 0,84 |
| South Africa | | | 0,61 | 0,47 | 0,67 | 0,74 | 0,70 | 0,72 |

## 2.2 Segmetation

This section proposes a breakdown of the Covid-19 Severity Index into five classes and, thus, an identification of optimal bounds (see Table 6). This breakdown is done in two steps: first, a first segmentation of the sample using the Ascending Hierarchical Classification (AHC) method is performed. As a second step, thresholds of the Index limiting severity classes are identified from the result of the first step.

Intuitively, the second segmentation corresponds to discretising the Index (see Box 4) in such a way that the resulting qualitative variable is the "closest" possible to the categorical variable derived from the first segmentation (or AHC segmentation). The second discretisation is, thus, "supervised" by the first. This can be solved by an algorithm that sets a measure of distance between two qualitative variables and initial thresholds and iteratively updates the previous thresholds, so as to reduce the distance between the segmentation associated with the thresholds and the AHC segmentation. This is done by the algorithm of Cheng-Jung Tsai , al (2007) presented in Box 4.

**BOX 4: SUPERVISED DISCRETISATION APPROACH**

Discretisation is a technique for partitioning continuous attributes into a finite set of adjacent intervals to generate attributes with a small number of distinct values. There are five different axes along which the proposed discretisation algorithms can be classified: supervised or unsupervised, static or dynamic, global or local, top-down or bottom-up, and direct or incremented. For the case of the index, the discretisation algorithm will generate a new variable characterised by n discrete intervals {[d0, d1], (d1, d2], . . . , (dn_1,dn]}, with d0 corresponding to the minimum value of the severity index and dn the maximum value assigned to the index. The new variable thus generated by the algorithm is the "discretisation scheme of the indicator" (Cheng-Jung Tsai, al 2007). The next contingency table may, therefore, be well defined and the next step will consist of maximising the interdependence between the two variables, i.e. the variable whose modalities are the classes and the discretisation scheme of the indicator whose modalities are the different intervals (n intervals).

**Tableau de contingence entre la variable classe et le schéma de discrétisation**

| CLASSE | Intervalle | | | | | | Total |
|---|---|---|---|---|---|---|---|
| | [d0, d1] | ] d1, d2] | . | . | . | ] dn-1, dn] | |
| **C1** | q11 | q12 | | | | q1n | **M1+** |
| **C2** | q21 | q22 | | | | q2n | **M2+** |
| . | . | . | | | | | |
| **Cn** | qn1 | qn2 | | | | Qnn | **Mn+** |
| **Total** | M+1 | M+2 | | | | M+n | **M** |

**Source :** Calculs des auteurs

To maximize the dependency, the contingency coefficient used in the article "A discretization algorithm based on Class-Attribute Contingency Coefficient" (Cheng-Jung Tsai, al 2007) is as follows:

$CACC = \sqrt{\frac{y}{y+M}}\ avec\ y = \frac{M\left[\left(\sum_{i=1}^{S}\sum_{r=1}^{n}\frac{{q_{ir}}^2}{M_{i+}M_{+r}}\right)-1\right]}{log(n)}$, $M$ is the size of the base, S is the number of class and finally q_in which corresponds to the number of elements initially belonging to class i and which is found in the interval (dn-1,dn] . For practical reasons, the method used in this study is that of supervised discretization.

 

**Table 6: Descriptive statistics of the classes obtained**

| Classes | Number of countries | Minimum | Maximum | Median | Mean |
|---|---|---|---|---|---|
| **Severity \| very low** | 22 | 0,90 | 0,99 | 0,94 | 0,94 |
| **Severity \| low** | 24 | 0,80 | 0,89 | 0,85 | 0,85 |
| **Severity \| moderate** | 29 | 0,65 | 0,79 | 0,70 | 0,70 |
| **Severity \| high** | 41 | 0,50 | 0,64 | 0,58 | 0,58 |
| **Severity \| very high** | 16 | 0,33 | 0,47 | 0,44 | 0,42 |

**Source**: Authors' calculations

## 2.3 Characterisation of the Classes Resulting from Segmetation

The previous section allowed the construction of severity classes, hierarchised by the Index. In what follows, the aim is to identify, amongst the index indicators, those that distinguish between two adjacent classes. The approach is as follows: for each pair of adjacent classes (very high/high severity, high/moderate severity, etc.), the 6 basic variables of the Index will be identified, those that on average characterise the best performing class.

Table 7 summarises the characterisation of the different classes of the Index.

**Table 7: Summary of characterisations**

| | Very low or low vs. moderate | Moderate vs high or very high |
|---|---|---|
| **Progression of new cases** | **Yes** | **Yes** |
| **Case fatality rate** | | |
| **Cure rates** | **Yes** | **Yes** |
| **Disease control rate** | **Yes** | **Yes** |
| **Infection rate** | | **Yes** |
| **Flow of new death** | **Yes** | |

**Source**: Authors' calculations

It is noted that countries with "very low or low" severity have a significantly better performance than countries with "moderate" severity on all indicators, except case-fatality and infection rates. The class of "moderate" severity countries stands out from "high or very high" severity countries on all indicators, except case-fatality and death rates.

Countries with "very low or low" severity are the best performers, in terms of recovery and control of both new cases and new deaths. Countries with "moderate" severity trail countries with "very low or low" severity on infection and case-fatality rates, whilst performing less well on the other indicators. High and very high severity countries perform as well as moderate severity countries on case-fatality rates and death rates, but perform less well in terms of infection rates, progression of infections, cure rates and cure control.

In general, the ability to heal patients quickly and to control new infections and deaths is proving to be a critical asset for the best performing countries in the Covid-19 Severity Index. In other words, these countries, even if severely affected at one point, have been able to very quickly reverse the trend and halt the progression of the disease and its negative impact on the health of their populations.

# 3. Additional Line of Research: Covid-19 Resilience Factors

The construction of the Severity Index opens up several prospects for future research, the most important of which seems to us to be the identification of relevant factors of resilience, both structural and cyclical. To do this, it is first necessary to identify all the potential candidate levers (socio-economic, medical and health, governance, etc.) and then to identify those that have a significant impact on the performance of countries in terms of resilience. This analysis will make it possible to orient policies towards the implementation of effective combinations of measures to mitigate or stop the spread of the disease.

Another avenue of research could be the assessment of the presence of potential persistent effects (sequelae). Indeed, a country may suffer sequelae in terms of mortality and morbidity, for example, long after the mitigation of the shock linked to the disease. An analysis of these persistent effects could be carried out after a few months using proxy variables.

## 3.1 Identification of Potential Determinants of Resilience

### 3.1.1 What resilience means:

According to the WHO (2016), "resilience in health refers to the capacity of the system to cope with and manage health risks while maintaining its core functions, identity and structure".

A resilient country must, therefore, before and during the course of a pandemic, similar to COVID-19, possess and/or develop the assets to limit the spread of the virus and recover quickly with minimal loss of life. The components of this resilience can be both structural (intrinsic quality of the healthcare system, size and generational structure of households, age pyramid, climate, etc.) and/or linked to disease governance measures (screening strategies, population protection strategies, patient management strategies).

### 3.1.2 Structural causes of resilience:

**The intrinsic quality of the healthcare system**

The capacity of healthcare systems to respond to the sharp increase in demand for care associated with COVID-19 cases is one of the main challenges facing countries. The growing demand could put particular pressure on access to consultations, diagnosis, hospitalisation and intensive care for the most complex cases. The quality of healthcare systems can be assessed in terms of its ability to mobilise: (i) personnel (to diagnose and manage patients), (ii) equipment (to safely diagnose patients and provide acute treatment when needed), and (iii) space (to diagnose quickly and safely, to isolate suspected and confirmed cases and to treat patients in hospital or at home).

The intrinsic quality of the healthcare system is assessed through the Global Health Security Index (see Box 5).

Countries with a good quality healthcare system are, at first glance, more likely to cope with the severity of the virus in a sustainable manner. But this is only one asset that needs to be combined with other factors, related to disease management, to give the country full capacity to cope with the virus. In fact, as of 14 April 2020, the correlation between the GHS Index (described in Box 5 below) and the Severity Index of Covid-19 is almost zero (-4%). It is expected to improve (positively) over time, thanks to the opportunities for adjustment to the challenges posed by the virus available to countries with a good GHS Index, many of which have been caught off guard by the disease.

**BOX 5: THE GLOBAL HEALTH SECURITY INDEX (GHS)**

The Global Health Security Index (GHS) is the first comprehensive assessment and comparative analysis of health security and related capacities in the 195 countries that make up the member states of the International Health Regulations (IHR [2005]). The GHS Index is a project of the Nuclear Threat Initiative (NTI) and the Johns Hopkins Center for Health Security (JHU) and was developed with The Economist Intelligence Unit (EIU).

It is based on a detailed and comprehensive framework of 140 questions, divided into 6 categories (prevention, detection and reporting, rapid response, health system, compliance with international standards, environment at risk), 34 indicators and 85 sub-indicators to assess a country's capacity to prevent and mitigate epidemics and pandemics.

As of October 2019, the results of the GHS Index reveal that no country in the world is fully prepared for epidemics or pandemics. Collectively, international preparedness is low. Many countries do not demonstrate the health security and safety capabilities needed to prevent, detect and respond to major infectious disease outbreaks. The overall average index score, among the 195 countries assessed, is 40.2 out of a possible score of 100. Among the 60 high-income countries, the average index score is 51.9. In addition, 116 high- and middle-income countries score no higher than 50. Overall, the GHS Index reveals serious weaknesses in countries' abilities to prevent, detect and respond to health emergencies, serious gaps in health systems, vulnerabilities to political, socio-economic and environmental risks, and a lack of adherence to international standards. The top three countries on the GHS Index for 2019 are the United States, the United Kingdom and the Netherlands.

*The WHO IHR (2005) is the fundamental international standard for health. The IHR (2005) is a binding legal instrument to combat cross-border public health risks. The objective of the IHR (2005) is to prevent, protect, control and respond* *without disrupting international trade and traffic. The IHR (2005) provided the guiding regulations behind many of the indicators included in the GHS Index.*

L'analyse de l'indice GHS révèle qu'aucun pays n'est pleinement préparé pour les épidémies ou les pandémies. Collectivement, la préparation internationale est faible. De nombreux pays ne montrent pas des preuves de capacités de sécurité sanitaire et les capacités nécessaires pour prévenir, détecter et répondre aux flambées importantes de maladies infectieuses. Le score global moyen de l'indice SGH parmi les 195 pays évalués est de 40,2 sur un score possible de 100. Parmi les 60 pays à revenu élevé, la moyenne de l'indice GHS est de 51,9. En outre, 116 pays à revenu élevé et intermédiaire n'obtiennent pas un score supérieur à 50. Dans l'ensemble, l'indice du SGH révèle de graves faiblesses dans les aptitudes des pays à prévenir, détecter et répondre aux urgences sanitaires; de graves lacunes dans les systèmes de santé; vulnérabilités à risques politiques, socio-économiques et environnementaux ; et un manque d'adhésion aux normes internationales.

### Extent of disease coverage

The current crisis shows the importance of universal health coverage as a key element for the resilience of healthcare systems. High levels of out-of-pocket payments can discourage people from seeking early diagnosis and treatment, thus contributing to accelerated transmission rates.

Regarding the extent of standardised national electronic healthcare records and technical and operational capacity to draw on them, beyond the notification of laboratory-confirmed cases to early warning and response systems, countries with standardised national electronic healthcare records, which produce high-quality data, can extract routine data from these systems for real-time surveillance. Technical and operational readiness depends on several factors: electronic healthcare record coverage, information sharing between physicians and hospitals, defined minimum data set, use of structured data, unique record identification, national standardisation of terminology and electronic messaging, legal requirements for the adoption of certification software and incentives for their adoption.

### The distribution of certain risk factors in the population (age, weight, chronic diseases, gender)

Deaths are highly concentrated in the older population (65 and over) and amongst people with severe pre-existing diseases, according to a study by Chinese researchers (Liu et al, 2020) and numerous epidemiological data from South Korea, Italy and France.

**Age**: Elderly people are at greater risk of developing severe cases of coronavirus. According to official data, amongst the 1,325 serious cases hospitalised in intensive care units and reported in France between 16 March and 2 April 2020, the average age of the cases was 64 years (21% were aged 75 years and over). The average age of the deceased was 74 years. Patients aged 65 and over accounted for 57% of patients admitted to intensive care units for COVID-19 and 90% of patients who died in France.

The correlation between the Severity Index and the median age of the countries in the sample was -13% on April 14, 2020.

**Gender**: In all European countries, there are more male than female deaths amongst COVID-19 related deaths, but the extent of the male disadvantage differs from one country to another. At day 28, it is 1.5 in French hospital deaths and 1.7 in Spanish hospital deaths. Deaths by COVID-19 in Italy have a more elevated sex ratio: 2.4.

**Blood group**: Blood group may influence coronavirus resistance, according to a study by Jiao Zhao and Al (2020). The researchers observed the distribution of blood groups in 2,173 Covid-19 infected patients from three hospitals in Wuhan and Shenzhen, comparing it with that of uninfected individuals. They concluded that "blood group A is associated with a higher risk of contracting Covid-19 compared to other blood groups, while blood group O is associated with a lower risk.

**Chronic diseases**: The majority of serious cases of coronavirus in France hospitalised in intensive care units, present at least one co-morbidity. The two most frequently reported co-morbidities are diabetes (24%) and cardiac pathology (21%).

### National culture

Experts say that social and cultural norms that impose self-discipline and obedience towards official advice, encouraging people not to cause problems for others, may be one of the reasons why some Asian countries have so far managed to limit the number of infections. Moreover, in East Asia, the wearing of face masks is often seen as a collective responsibility to reduce disease transmission and can symbolise solidarity.

National culture can play a role in constraining certain policy options. For example, a narrative of strengthening herd immunity, by allowing a majority of the population to pass through the disease in a dosed manner, would be an unthinkable narrative for a culture opposed to uncertainty, such as Italy, for example. On the other hand, leaders in the United Kingdom and the Netherlands (low scores for uncertainty-aversion) initially publicly defended such a strategy.

### Temperature

Mahmoud Arbouch and Uri Dadush of the Policy Centre for the New South (see Box 6) estimate that a 1% increase in temperature above average levels (50 degrees Fahrenheit, or 10 degrees Celsius) could reduce the number of cases per million people by 0.5% (with a margin of error of +/- 0.2%). They also find that the incidence of the disease is lower in very cold weather.

Jingyuan Wang, Kai Feng, Weifeng Lv of Beihang University and Ke Tang of Tsinghua University find that a one-degree Celsius increase in temperature and a one-percent increase in relative humidity lower the average number of people a sick person continues to infect (in a group that has no immunity to the virus) by 2.5% and 1.58% respectively.

**BOX 6: METHOD FOR ESTIMATING THE IMPACT OF TEMPERATURE ON DISEASE INCIDENCE BY MAHMOUD ARBOUCH AND URI DADUSH OF THE POLICY CENTER FOR THE NEW SOUTH**

The authors tested the effect of temperature on the cases of infection per million people. With all variables expressed in logarithms, they estimated regression models with different combinations of the control variables (per capita income, trade with China, population aged over 65, and medical preparedness). The regression of cases per million on all independent variables gives a low level of significance for all variables except per capita income and temperature.

**Source**: Mahmoud Arbouch and Uri Dadush (2020), "Coronavirus and Temperature", Policy Brief, Policy Center for new South, March 20-21, 2020.

L'analyse de l'indice GHS révèle qu'aucun pays n'est pleinement préparé pour les épidémies ou les pandémies. Collectivement, la préparation internationale est faible. De nombreux pays ne montrent pas des preuves de capacités de sécurité sanitaire et les capacités nécessaires pour prévenir, détecter et répondre aux flambées importantes de maladies infectieuses. Le score global moyen de l'indice SGH parmi les 195 pays évalués est de 40,2 sur un score possible de 100. Parmi les 60 pays à revenu élevé, la moyenne de l'indice GHS est de 51,9. En outre, 116 pays à revenu élevé et intermédiaire n'obtiennent pas un score supérieur à 50. Dans l'ensemble, l'indice du SGH révèle de graves faiblesses dans les aptitudes des pays à prévenir, détecter et répondre aux urgences sanitaires; de graves lacunes dans les systèmes de santé; vulnérabilités à risques politiques, socio-économiques et environnementaux ; et un manque d'adhésion aux normes internationales.

**The country's exposure to malaria and the vaccination of children with BCG**

Some postulate that countries exposed to malaria or whose children are vaccinated early with BCG would be less affected by COVID-19 than other countries. This thesis has been put forward, amongst other ideas, to explain the low extent of coronavirus disease in Africa, even though the numbers are increasing. As of 15 April, the African continent officially totalled 17,000 infections and nearly 900 deaths.

### 3.1.3 Intrinsic Quality of Pandemic Governance

COVID-19 has elicited a wide range of responses from governments around the world. In addition, governments have varied considerably in the measures they have taken and the speed with which they have adopted them.

### Global Resilience Strategy: Mitigation/Removal

The Imperial College of London report on the impact of an uncontrolled pandemic describes two main approaches available to contain COVID-19. The first is mitigation: slowing the spread of the epidemic but not completely interrupting transmission, whilst ensuring that the health needs of those at risk of developing severe forms of infection are met. It aims at achieving "herd immunity" to the virus in the population (Netherlands, Sweden). However, "herd immunity" is theoretically only conceivable in countries with sufficiently developed hospital capacities, capable of absorbing a large flow of patients. The United Kingdom initially opted for this strategy, but changed its mind in view of the rapid spread of the virus and growing social protest.

According to the authors, this approach, which includes "social distancing" as well as the isolation and quarantine of cases, is unlikely to contain the pandemic and may lead to the death of thousands of patients, whilst placing a heavy burden on healthcare systems, especially the available intensive care units.

Researchers recommend the second approach - suppression. It refers to reversing the spread of the epidemic by reducing the rate of coronavirus infection and maintaining this approach for up to 18 months. Spread reversal can be achieved through the implementation of non-pharmaceutical interventions. These include strict lock-in measures - social distancing of entire populations, closure of schools and community spaces - and the extension of these measures until vaccines can be developed. This is the approach taken by many countries around the world.

### Screening strategy (selective versus broad-based screening)

Some countries (South Korea, Germany or Australia), in line with WHO recommendations, have launched massive population screening campaigns at an early or earlier stage, whilst other countries (France, Tunisia, Senegal) have chosen to limit testing to a segment of the population (generally people with symptoms or those who have been in contact with confirmed cases of Covid-19).

### Social distancing strategy

Four patterns of social distancing can be identified:

- Zero containment: (South Korea, Taiwan, Sweden, the Netherlands)
- Partial containment: isolation of epidemic outbreaks at the regional level and through the closure of schools/universities and non-essential public places at the national level.
- General containment: in view of the scale of the pandemic, an increasing number of countries have chosen to move to general containment. To date, more than a third of the world's population (circa 2.6 billion) has been affected by this situation.
- General curfew: This is the ultimate form of social distancing. The management of the general confinement is entrusted to the army, movements are forbidden, except in special dispensation or in cases of extreme emergency, and the supply of food and water is tightly controlled during specific time slots.

 

To date, only Jordan has chosen to apply this radical model of crisis management.

**Therapeutic methods**

The availability of a vaccine will make it possible to immunise the world population against COVID-19. In the absence of such a vaccine, countries have developed various strategies to manage patients at different stages of their exposure to the disease. One particular theme that is the subject of intense discussions concerns the use of chloroquine, promoted by Dr Raoult of Marseille, France. According to him, the rapid use of chloroquine makes it possible to treat the disease before it takes on a more severe form.

## 3.2 Methodology for Identifying Relevant Levers

The identification of the causes of good performance in terms of resilience will be based on a double selection.

**First selection**

A concern for completeness will guide the first selection. Efforts will be made to collect all available data on potential determinants that are both structural and governance-related to the disease.

**Second selection**

An indicator is considered a resilience lever if it characterises the countries with the highest scores on the Severity Index. In other words, this indicator should make it possible, on average, to clearly distinguish a performing country that has "low or very low" severity from a country that is not yet at this stage. On the basis of this principle, a second choice, which only retains the indicators characteristic of "very low or low" severity, is made within the variables resulting from the first selection. The v-test statistic (see Box 7) is used to characterise each modality of the qualitative variable whose modalities are the severity index classes.

This approach, which simply ranks the resilience factors according to their impact, is preferred to the numerical estimation of the impact of each cause through regression models, because of data reliability problems.

**Box 7: Choice of indicators: Principle of the test value method**

The idea is to select the variables that characterise "high" performing countries.

An indicator is relevant to characterise a class if its values within the class are clearly different from the values within other groups. In other words, the hypothesis of a random distribution of the values of this indicator over the different classes cannot be accepted.

Thus, we will proceed as with a classical statistical test.

The hypothesis noted H0 is: the values come from a set of random data independent of the classes.

For each variable, the values held by the countries of the class are drawn randomly amongst all the values. Assuming this working hypothesis of random selection to be true, the probability of observing a configuration of values, at least as extreme as that observed in the sample, will be calculated. This is the critical probability associated with testing the null hypothesis H0. The smaller this probability is, the more one will be led to reject the null hypothesis.

In order to rank the variables in order of importance we will, therefore, rank them according to the critical probabilities. The most typical variable in the group is the one with the smallest probability.

We assume m is the empirical mean of the variable and s2 is the empirical variance. Let m_k be the empirical mean of the group, n_k the class size and X_k the mean random variable after n_k draws on the whole sample (the draw is without discount).

(Under H0), the random variable $\boldsymbol{U} = \frac{(\boldsymbol{X_k} - \boldsymbol{m})}{\boldsymbol{s_k}}$

approximately follows the reduced centred Laplace Gauss law. It is equivalent to selecting the variables corresponding to the largest values taken by the normal variable:

$$\boldsymbol{u} = \frac{(\boldsymbol{m_k} - \boldsymbol{m})}{\boldsymbol{s_k}}$$

This quantity is called the test value.

The most typical variables of the group of individuals are obtained by selecting the smallest critical probabilities.

 

## Conclusion

The purpose of this paper is to construct an index to measure and monitor the severity of covid-19 in different affected countries worldwide and to capture the degree of resilience to the disease.

The index is calculated on a weekly basis for 169 countries, with two weeks of data (to take into account the recognised incubation period of the virus).

As of 10 May 2020, the average score for the countries in the sample is 0.74, corresponding to a globally moderate severity. The analysis by continent shows that Europe has an average score of 0.77. With such a score, Europe has seen a significant decrease in severity in recent weeks. For Africa, the scores are between 0.99 and 0.30 with an average of 0.70. In America, scores range from a low of 0.34 to 0.98 with an average of 0.69, the highest level of severity in the world. Asia averages a score of 0.74.

Continued calculation of the index will allow an assessment of the severity of COVID-19 in the different countries at the end of the pandemic and their respective trajectories throughout the course of the disease. A survival index from the COVID-19 could then be constructed.

The construction of the Severity Index opens up several prospects for future research, the most important of which seems to us to be the identification of relevant factors of resilience, both structural and situational. To do this, it is first necessary to identify all the potential candidate factors: natural (such as climate), socio-demographic (such as the age pyramid), socio-economic (such as income inequalities), medico-sanitary (such as the quality of the healthcare system, the governance of the disease, etc.). Secondly, to identify, through statistical methods, those that have a significant impact on the performance of countries in terms of resilience. This analysis will make it possible to orient policies towards the implementation of effective combinations of measures in order to mitigate or stop the spread of the disease.

Another avenue of research could be the assessment of the presence of potential persistent effects (sequelae of the virus). Indeed, a country may suffer lasting negative impacts in terms of mortality and morbidity, for example, long after the disease shock has been mitigated. An analysis of these persistent effects could be conducted, after a few months, through proxy variables.

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## Annex

**Tableau 8 : Change in scores of countries between 14 April and 10 May 2020**

| Country | Score as of 10 May | Score as of 25 April | Score as of 14 April | Rank as of 10 May | Rank as of 25 April | Rank of as 14 April |
|---|---|---|---|---|---|---|
| New Caledonia | 1,00 | 0,99 | 0,81 | 1 | 4 | 25 |
| Cambodia | 1,00 | 0,99 | 0,95 | 1 | 3 | 3 |
| New Zealand | 0,99 | 0,99 | 0,90 | 3 | 2 | 10 |
| Eritrea | 0,99 | 0,87 | 0,57 | 4 | 42 | 93 |
| Brunei Darussalam | 0,99 | 0,97 | 0,95 | 5 | 8 | 4 |
| Iceland | 0,99 | 0,90 | 0,73 | 6 | 31 | 35 |
| French Polynesia | 0,99 | 0,94 | 0,55 | 7 | 15 | 104 |
| Mauritius | 0,99 | 0,97 | 0,60 | 8 | 7 | 74 |
| Saint Kitts And Nevis | 0,98 | 0,72 | 0,55 | 9 | 75 | 102 |
| Seychelles | 0,98 | 0,90 | 0,80 | 10 | 29 | 31 |
| Thailand | 0,98 | 0,98 | 0,90 | 11 | 6 | 11 |
| China | 0,98 | 0,63 | 0,98 | 12 | 105 | 1 |
| Australia | 0,97 | 0,95 | 0,64 | 13 | 11 | 57 |
| Dominica | 0,97 | 0,92 | 0,88 | 14 | 25 | 15 |
| South Korea | 0,97 | 0,95 | 0,93 | 15 | 10 | 5 |
| Montenegro | 0,97 | 0,85 | 0,52 | 16 | 46 | 122 |
| Taiwan | 0,97 | 0,93 | 0,85 | 17 | 18 | 19 |
| Gibraltar | 0,96 | 0,99 | 0,80 | 18 | 5 | 28 |
| Malta | 0,96 | 0,85 | 0,52 | 19 | 47 | 119 |
| Belize | 0,96 | 0,84 | 0,37 | 20 | 51 | 164 |
| Fiji | 0,96 | 0,91 | 0,58 | 21 | 27 | 83 |
| Austria | 0,95 | 0,92 | 0,81 | 22 | 26 | 26 |
| Vietnam | 0,95 | 0,97 | 0,93 | 23 | 9 | 7 |
| Uzbekistan | 0,95 | 0,78 | 0,50 | 24 | 68 | 132 |
| Burkina Faso | 0,95 | 0,92 | 0,71 | 25 | 20 | 40 |
| Bhutan | 0,95 | 0,79 | 0,89 | 26 | 65 | 14 |
| Croatia | 0,94 | 0,86 | 0,69 | 27 | 43 | 44 |
| Malaysia | 0,94 | 0,92 | 0,88 | 28 | 23 | 16 |
| Niger | 0,94 | 0,88 | 0,54 | 29 | 37 | 108 |
| Namibia | 0,94 | 0,89 | 0,63 | 30 | 32 | 62 |
| Albania | 0,94 | 0,85 | 0,86 | 31 | 48 | 18 |
| Luxembourg | 0,94 | 0,85 | 0,45 | 32 | 49 | 151 |
| Germany | 0,93 | 0,88 | 0,81 | 33 | 39 | 27 |
| Monaco | 0,93 | 0,72 | 0,43 | 34 | 74 | 155 |
| Switzerland | 0,93 | 0,85 | 0,73 | 35 | 50 | 37 |
| Iran | 0,93 | 0,92 | 0,88 | 36 | 24 | 17 |

| | | | | | | |
|---|---|---|---|---|---|---|
| **Uruguay** | 0,93 | 0,92 | 0,89 | 37 | 22 | 13 |
| **Costa Rica** | 0,92 | 0,86 | 0,63 | 38 | 45 | 63 |
| **Kyrgyzstan** | 0,92 | 0,89 | 0,54 | 39 | 34 | 109 |
| **Slovakia** | 0,92 | 0,68 | 0,64 | 40 | 87 | 58 |
| **Syria** | 0,91 | 0,66 | 0,67 | 41 | 91 | 50 |
| **Tunisia** | 0,91 | 0,79 | 0,58 | 42 | 67 | 81 |
| **Denmark** | 0,91 | 0,88 | 0,68 | 43 | 38 | 46 |
| **Cuba** | 0,91 | 0,73 | 0,57 | 44 | 73 | 92 |
| **North Macedonia** | 0,90 | 0,68 | 0,53 | 45 | 86 | 115 |
| **Botswana** | 0,90 | 0,55 | 0,44 | 46 | 139 | 154 |
| **Jordan** | 0,89 | 0,95 | 0,90 | 47 | 13 | 12 |
| **Djibouti** | 0,89 | 0,55 | 0,56 | 48 | 137 | 100 |
| **Grenada** | 0,89 | 0,89 | 0,58 | 49 | 33 | 85 |
| **Lithuania** | 0,89 | 0,80 | 0,61 | 50 | 59 | 70 |
| **Finland** | 0,88 | 0,86 | 0,49 | 51 | 44 | 134 |
| **Greece** | 0,88 | 0,79 | 0,65 | 52 | 64 | 55 |
| **Spain** | 0,87 | 0,65 | 0,59 | 53 | 96 | 76 |
| **Myanmar** | 0,87 | 0,54 | 0,45 | 54 | 140 | 149 |
| **Libya** | 0,87 | 0,61 | 0,71 | 55 | 114 | 42 |
| **Mozambique** | 0,86 | 0,62 | 0,49 | 56 | 110 | 133 |
| **Israel** | 0,86 | 0,75 | 0,54 | 57 | 71 | 113 |
| **Czechia** | 0,86 | 0,80 | 0,59 | 58 | 61 | 78 |
| **Latvia** | 0,86 | 0,83 | 0,56 | 59 | 54 | 96 |
| **Azerbaijan** | 0,86 | 0,92 | 0,63 | 60 | 19 | 64 |
| **Turkey** | 0,85 | 0,58 | 0,40 | 61 | 127 | 160 |
| **Cameroon** | 0,85 | 0,87 | 0,63 | 62 | 40 | 60 |
| **Georgia** | 0,85 | 0,70 | 0,65 | 63 | 81 | 54 |
| **Japan** | 0,85 | 0,59 | 0,52 | 64 | 122 | 118 |
| **Bahamas** | 0,84 | 0,65 | 0,55 | 65 | 97 | 106 |
| **Morocco** | 0,84 | 0,57 | 0,52 | 66 | 131 | 117 |
| **Ethiopia** | 0,83 | 0,69 | 0,62 | 67 | 85 | 68 |
| **Cyprus** | 0,83 | 0,67 | 0,54 | 68 | 89 | 112 |
| **Mongolia** | 0,83 | 0,61 | 0,85 | 69 | 113 | 22 |
| **Guyana** | 0,83 | 0,60 | 0,60 | 70 | 119 | 73 |
| **Venezuela** | 0,83 | 0,69 | 0,90 | 71 | 84 | 9 |
| **Zimbabwe** | 0,82 | 0,57 | 0,48 | 72 | 130 | 137 |
| **Madagascar** | 0,82 | 0,90 | 0,73 | 73 | 30 | 36 |
| **Ireland** | 0,81 | 0,70 | 0,31 | 74 | 83 | 168 |
| **Iraq** | 0,81 | 0,94 | 0,82 | 75 | 17 | 24 |
| **Lebanon** | 0,80 | 0,82 | 0,64 | 76 | 55 | 59 |
| **Bosnia and Herzegovina** | 0,80 | 0,81 | 0,67 | 77 | 57 | 51 |
| **Ivory Coast** | 0,80 | 0,80 | 0,54 | 78 | 62 | 110 |
| **Romania** | 0,79 | 0,67 | 0,56 | 79 | 90 | 97 |

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|---|---|---|---|---|---|---|
| **Estonia** | 0,79 | 0,56 | 0,50 | 80 | 135 | 128 |
| **Mexico** | 0,77 | 0,77 | 0,65 | 81 | 69 | 53 |
| **Mali** | 0,77 | 0,61 | 0,58 | 82 | 117 | 82 |
| **Panama** | 0,77 | 0,45 | 0,42 | 83 | 157 | 158 |
| **Rwanda** | 0,77 | 0,88 | 0,85 | 84 | 36 | 21 |
| **Poland** | 0,76 | 0,65 | 0,55 | 85 | 98 | 105 |
| **Togo** | 0,76 | 0,92 | 0,71 | 86 | 21 | 39 |
| **Liberia** | 0,75 | 0,65 | 0,39 | 87 | 93 | 162 |
| **United Republic of Tanzania** | 0,74 | 0,52 | 0,58 | 88 | 147 | 84 |
| **Algeria** | 0,74 | 0,80 | 0,71 | 89 | 60 | 41 |
| **Uganda** | 0,73 | 0,94 | 0,83 | 90 | 16 | 23 |
| **South Africa** | 0,72 | 0,74 | 0,69 | 91 | 72 | 45 |
| **Zambia** | 0,72 | 0,70 | 0,93 | 92 | 80 | 6 |
| **Mauritania** | 0,72 | 0,95 | 0,63 | 93 | 14 | 61 |
| **Kenya** | 0,72 | 0,72 | 0,67 | 94 | 76 | 49 |
| **Burundi** | 0,71 | 0,70 | 0,56 | 95 | 79 | 101 |
| **Sri Lanka** | 0,70 | 0,68 | 0,73 | 96 | 88 | 38 |
| **Hungary** | 0,70 | 0,63 | 0,51 | 97 | 107 | 127 |
| **Malawi** | 0,70 | 0,59 | 0,36 | 98 | 121 | 167 |
| **Italy** | 0,70 | 0,63 | 0,51 | 99 | 106 | 126 |
| **Kazakhstan** | 0,70 | 0,65 | 0,58 | 100 | 95 | 87 |
| **Angola** | 0,69 | 0,70 | 0,56 | 101 | 82 | 94 |
| **Oman** | 0,68 | 0,57 | 0,52 | 102 | 132 | 120 |
| **Guinea** | 0,68 | 0,58 | 0,51 | 103 | 128 | 124 |
| **Nepal** | 0,67 | 0,59 | 0,52 | 104 | 125 | 116 |
| **France** | 0,67 | 0,65 | 0,56 | 105 | 94 | 95 |
| **Canada** | 0,67 | 0,64 | 0,62 | 106 | 101 | 66 |
| **Moldova** | 0,67 | 0,62 | 0,44 | 107 | 111 | 153 |
| **Argentina** | 0,66 | 0,71 | 0,65 | 108 | 78 | 56 |
| **Philippines** | 0,65 | 0,62 | 0,58 | 109 | 112 | 89 |
| **Serbia** | 0,65 | 0,50 | 0,46 | 110 | 151 | 146 |
| **India** | 0,65 | 0,63 | 0,51 | 111 | 103 | 125 |
| **Slovenia** | 0,65 | 0,63 | 0,59 | 112 | 104 | 75 |
| **Indonesia** | 0,64 | 0,59 | 0,53 | 113 | 126 | 114 |
| **Gambia** | 0,64 | 0,95 | 0,58 | 114 | 12 | 80 |
| **Bulgaria** | 0,64 | 0,61 | 0,63 | 115 | 115 | 65 |
| **Armenia** | 0,63 | 0,81 | 0,74 | 116 | 58 | 34 |
| **Chile** | 0,63 | 0,84 | 0,68 | 117 | 52 | 48 |
| **El Salvador** | 0,63 | 0,71 | 0,57 | 118 | 77 | 90 |
| **Ukraine** | 0,62 | 0,51 | 0,45 | 119 | 149 | 147 |
| **Dominican Republic** | 0,62 | 0,56 | 0,50 | 120 | 134 | 131 |
| **Congo** | 0,62 | 0,50 | 0,58 | 121 | 152 | 88 |

 

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|---|---|---|---|---|---|---|
| **Senegal** | 0,62 | 0,76 | 0,93 | 122 | 70 | 8 |
| **Pakistan** | 0,61 | 0,62 | 0,62 | 123 | 109 | 67 |
| **Jamaica** | 0,61 | 0,47 | 0,75 | 124 | 154 | 33 |
| **Colombia** | 0,61 | 0,65 | 0,56 | 125 | 92 | 99 |
| **Benin** | 0,61 | 0,88 | 0,57 | 126 | 35 | 91 |
| **Nicaragua** | 0,59 | 0,87 | 0,85 | 127 | 41 | 20 |
| **Egypt** | 0,59 | 0,65 | 0,59 | 128 | 99 | 77 |
| **Cape Verde** | 0,57 | 0,43 | 0,61 | 129 | 162 | 69 |
| **Bahrain** | 0,57 | 0,64 | 0,68 | 130 | 100 | 47 |
| **Brazil** | 0,56 | 0,80 | 0,54 | 131 | 63 | 111 |
| **Haiti** | 0,56 | 0,59 | 0,48 | 132 | 123 | 139 |
| **Paraguay** | 0,56 | 0,82 | 0,61 | 133 | 56 | 71 |
| **Democratic Republic of the Congo** | 0,56 | 0,59 | 0,59 | 134 | 120 | 79 |
| **Bangladesh** | 0,55 | 0,45 | 0,45 | 135 | 158 | 148 |
| **Sierra Leone** | 0,55 | 0,52 | 0,45 | 136 | 148 | 150 |
| **Guatemala** | 0,55 | 0,51 | 0,49 | 137 | 150 | 135 |
| **Nigeria** | 0,53 | 0,55 | 0,69 | 138 | 138 | 43 |
| **Belgium** | 0,52 | 0,47 | 0,44 | 139 | 153 | 152 |
| **Sweden** | 0,51 | 0,39 | 0,41 | 140 | 165 | 159 |
| **Gabon** | 0,51 | 0,52 | 0,48 | 141 | 146 | 142 |
| **United Arab Emirates** | 0,51 | 0,53 | 0,52 | 142 | 144 | 123 |
| **Afghanistan** | 0,50 | 0,60 | 0,48 | 143 | 118 | 138 |
| **Portugal** | 0,50 | 0,44 | 0,39 | 144 | 161 | 161 |
| **Kuwait** | 0,49 | 0,61 | 0,48 | 145 | 116 | 141 |
| **Equatorial Guinea** | 0,49 | 0,44 | 0,75 | 146 | 160 | 32 |
| **Somalia** | 0,49 | 0,40 | 0,46 | 147 | 164 | 145 |
| **United States of America** | 0,49 | 0,46 | 0,38 | 148 | 155 | 163 |
| **Ghana** | 0,48 | 0,57 | 0,49 | 149 | 133 | 136 |
| **Saudi Arabia** | 0,48 | 0,84 | 0,56 | 150 | 53 | 98 |
| **Central African Republic** | 0,47 | 0,91 | 0,58 | 151 | 28 | 86 |
| **Sudan** | 0,47 | 0,53 | 0,43 | 152 | 142 | 156 |
| **Bolivia** | 0,47 | 0,53 | 0,46 | 153 | 143 | 144 |
| **Belarus** | 0,47 | 0,46 | 0,47 | 154 | 156 | 143 |
| **Honduras** | 0,47 | 0,63 | 0,55 | 155 | 108 | 103 |
| **Chad** | 0,47 | 0,79 | 0,52 | 156 | 66 | 121 |
| **South Sudan** | 0,46 | 0,59 | 0,61 | 157 | 124 | 72 |
| **Norway** | 0,43 | 0,42 | 0,43 | 158 | 163 | 157 |
| **Peru** | 0,43 | 0,58 | 0,67 | 159 | 129 | 52 |
| **Guinea Bissau** | 0,43 | 0,64 | 0,48 | 160 | 102 | 140 |
| **Singapore** | 0,42 | 0,33 | 0,54 | 161 | 169 | 107 |
| **Netherlands** | 0,41 | 0,38 | 0,36 | 162 | 166 | 166 |
| **Russia** | 0,40 | 0,44 | 0,50 | 163 | 159 | 129 |

| | | | | | | |
|---|---|---|---|---|---|---|
| **Qatar** | 0,38 | 0,37 | 0,37 | 164 | 167 | 165 |
| **United Kingdom** | 0,37 | 0,35 | 0,31 | 165 | 168 | 169 |
| **Ecuador** | 0,34 | 0,56 | 0,50 | 166 | 136 | 130 |
| **Yemen** | 0,33 | 1,00 | 0,80 | 167 | 1 | 29 |
| **Sao Tome And Principe** | 0,30 | 0,52 | 0,80 | 168 | 145 | 30 |
| **Maldives** | 0,29 | 0,53 | 0,96 | 169 | 141 | 2 |

**Sources**: calculations with data from the WHO, African Union Centre for Disease Control and Prevention, European Centre for Disease Prevention and Control, John Hopkins CSSE, epidemic-stats.com

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## About EMNES

The Euro-Mediterranean Network for Economic Studies (EMNES) is a network of research institutions and think tanks working on socio-economics policy in the Euro-Mediterranean. EMNES is coordinated by the Euro-Mediterranean Economists Association (EMEA).

The research conducted by EMNES Researchers, Associates and Fellows aims to design sound and innovative socio-economic models that are inclusive, sustainable and employment creative, to devise new models for regional integration and to provide policy recommendations towards this goal.

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- Private sector, micro, small and medium –sized enterprises development, entrepreneurship and social business;
- Digital economy;
- Healthcare policy;
- Human capital development, education, innovation, skill mismatch and migration;
- Labor markets, employment and employability;
- Finance, financial inclusion and the real economy;
- Sustainable development;
- Regional integration;
- Euro-Mediterranean economic partnership;
- Scenarios analysis and foresight.

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