Clustering of countries based on the timeline of government interventions: Description of the method

Calculating epidemic age

We used the time-series of the number of COVID-19 cases provided by the Johns Hopkins University Center for Systems Science and Engineering, accessible via
Github: https://github.com/CSSEGISandData/COVID-19.

For calculating the epidemic age, we considered t0 as the day when the number of confirmed cases reaches 10.

Defining variables for the clustering

Government interventions are separated in three groups based on their time of implementation:

- "anticipatory measures": implemented before t0 (day when 10 cases were reported);
- "early measures": implemented between t0 and day when 200 cases were reported;
- "late measures": implemented after day when 200 cases were reported.

Each country is therefore described with three variables:

1. Number of anticipatory measures;

2. Number of early measures;

3. Number of late measures

Our analysis is based on data recorded in the CCCSL dataset as of 12 July 2020 (static version available at: https://github.com/amel-github/CCCSL-Codes/blob/master/COVID19_non-pharmaceutical-interventions_version2_utf8_static_2020-07-12.csv

K-means analysis

We focused on mandatory government interventions (i.e. the theme “Risk communication” was not included) recorded in the CCCSL at level 2 (categories) that appeared in at least 15 countries, leading to a total number of 40 categories.

[1] "Activate case notification"

[2] "Airport health check"

[3] "Border health check"

[4] "Enhance detection system"

[5] "Isolation of cases"

[6] "Quarantine"

[7] "Surveillance"

[8] "Tracing and tracking"

[9] "Environmental cleaning and disinfection"

[10] "Adapt procedures for patient management"

[11] "Enhance laboratory testing capacity"

[12] "Increase availability of PPE"

[13] "Increase healthcare workforce"

[14] "Increase in medical supplies and equipment"

[15] "Increase isolation and quarantine facilities"

[16] "Increase patient capacity"

[17] "Personal protective measures"

[18] "Research"

[19] "Activate or establish emergency response"

[20] "Crisis management plans"

[21] "Measures to ensure security of supply"

[22] "Police and army interventions"

[23] "The government provide assistance to vulnerable populations"

[24] "Actively communicate with healthcare professionals."

[25] "Actively communicate with managers."

[26] "Educate and actively communicate with the public."

[27] "Travel alert and warning"

[28] "Closure of educational institutions"

[29] "Mass gathering cancellation"

[30] "Measures for special populations"

[31] "Return operation of nationals"

[32] "Small gathering cancellation"

[33] "Special measures for certain establishments"

[34] "Airport restriction"

[35] "Border restriction"

[36] "Cordon sanitaire"

[37] "Individual movement restrictions"

[38] "National lockdown"

[39] "Port and ship restriction"

[40] "Public transport restriction"

Results

The optimum number of k, identified using the elbow method[1] is eight.

Cluster	Size (number of countries)	Cluster means			Within cluster sum of squares by cluster
		Anticipatory measures	Early measures	Late measures	
1	9	4.22	8.89	4.11	163.33
2	7	7.00	14.86	3.43	96.57
3	6	4.67	2.00	21.67	134.67
4	6	5.00	9.00	16.00	108.00
5	10	12.90	2.40	1.90	162.20
6	1	26.00	1.00	0.00	0.00
7	6	14.83	7.83	7.17	122.50
8	11	7.54	3.00	12.90	169.64

Measure of the total variance in the data set that is explained by the clustering (between_SS / total_SS) = 82.8 %.

Cluster 1

> countries_with_measures[which(cluster.results$cluster==1)]

[1] "Bosnia and Herzegovina" "Estonia"

[3] "Iceland" "Indonesia"

[5] "Kuwait" "Malaysia"

[1] Yuan, C. & Yang, H. Research on K-value selection method of K-means clustering algorithm. *J* **2**, 226-235 (2019).

[7] "New Zealand" "Serbia"

[9] "Slovenia"

Cluster 2

> countries_with_measures[which(cluster.results$cluster==2)]

[1] "Albania" "Ecuador" "Japan" "Lithuania" "Senegal"

[6] "Taiwan*" "Thailand"

Cluster 3

> countries_with_measures[which(cluster.results$cluster==3)]

[1] "Brazil" "China" "Netherlands" "Norway"

[5] "Spain" "US"

Cluster 4

> countries_with_measures[which(cluster.results$cluster==4)]

[1] "Canada" "Germany" "India" "Portugal"

[5] "Ireland" "Korea, South"

Cluster 5

> countries_with_measures[which(cluster.results$cluster==5)]

[1] "Croatia" "El Salvador" "Greece"

[4] "Honduras" "Kazakhstan" "Liechtenstein"

[7] "Mauritius" "Montenegro" "Slovakia"

[10] "Syria"

Cluster 6

> countries_with_measures[which(cluster.results$cluster==6)]

[1] "Kosovo"

Cluster 7

> countries_with_measures[which(cluster.results$cluster==7)]

[1] "Ghana" "Hungary" "North Macedonia"

[4] "Poland" "Romania" "Singapore"

Cluster 8

> countries_with_measures[which(cluster.results$cluster==8)]

[1] "Austria" "Belgium" "Czechia"

[4] "Denmark" "Finland" "France"

[7] "Italy" "Mexico" "Sweden"

[10] "Switzerland" "United Kingdom”