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Government response to COVID-19 using Stringency Index among 151 countries and six regions

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Abstract:	Background: Amidst a global COVID-19 pandemic situation, government adequate preparation and response plays an important role. Therefore, this study aimed to analyze the trend of government response to COVID-19 in six regions, by country, and to identify the national variables affecting the government's response. Method: This study was designed using data from a panel survey in 151 countries across six regions between January 1, 2020 and May 18, 2020, using the Oxford COVID-19 Government Response Tracker Stringency Index and the World Bank Open DATA. This study used linear regression, nonlinear regression model, heat diagrams, and bubble chart to analyze the COVID-19 trends. In addition, between-within model was used to compare the Stringency Index's determinants by country. Findings: The stringency index in six regions increased continuously until the third week of April, and then it began to decline. Four countries - Burkina Faso, Madagascar, New Zealand, South Korea - had relaxed the government response. As a result of analyzing the government response according to the trend of COVID-19 as of April 1st, AFRO is a cautionary stage, EURO is a stable stage, PAHO is an Appropriate response, and WPRO is an overreaction. Among national indicators education was identified as the greatest national indicator with the greatest effect on governments response to COVID-19. Interpretation: The government response to COVID-19 in six regions has been relaxing. However, a total of 42 countries, with AFRO(14), PAHO(8), EURO(6), EMRO(6), WPRO(4), and SEARO(2) are still at the cautionary stage, confirming the high risk of a 2nd wave of COVID-19. In particular, AFRO region being at a high risk of COVID-19 spreading, And also 14 countries in AFRO are still in cautionary stage, thus they need to prepare for the spread of COVID-19. Though other regions' countries are now in relaxing level, they need to prepare for the second wave of covid-19. Finally, active participation of citizen is important to control the COVID-19 while easing the government response. And education at the national level could effectively led the participation of citizens.

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08/June/2020

Editor in Chief

The Lancet Public Health

Dear Chief-in-Editor

I wish to submit a research report for publication in the *The Lancet Public Health*, titled *"**Government responses to COVID-19 using stringency index among 151 countries, six regions.**"* The paper was coauthored by Lee Hocheol, Ji Eon Kim, Seokjun Moon, Ji Ho Lee and Eun Woo Nam.

This study was designed using data from a panel survey in 151 countries across six regions between January 1, 2020 and May 18, 2020. In a press briefing on May 25, WHO warned of the 2^{nd} COVID-19 wave due to relaxation of the government response. This study will be expected to contribute to government response to the COVID-19 pandemic 2^{nd} wave by analyzing data from 151 countries. We hope that this research will provide robust reference data for government guidelines to prevent the spread of COVID-19 worldwide.

This manuscript has not been previously published or presented elsewhere in part or in entirety and is not under consideration by another journal. We have read and understood your journal's p olicies, and we believe that neither the manuscript nor the study violates any of these.

There are no conflicts of interest to declare.

Thank you for your consideration. I look forward to hearing from you.

Sincerely,

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Government response to COVID-19 using Stringency Index among 151 countries and six regions

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Findings: The stringency index in six regions increased continuously until the third week of April, and then it began to decline. Four countries - Burkina Faso, Madagascar, New Zealand, South Korea - had relaxed the government response. As a result of analyzing the government response according to the trend of COVID-19 as of April 1st, AFRO is a cautionary stage, EURO is a stable stage, PAHO is an Appropriate response, and WPRO is an overreaction. Among national indicators education was identified as the greatest national indicator with the greatest effect on governments response to COVID-19.

Interpretation: The government response to COVID-19 in six regions has been relaxing. However, a total of 42 countries, with AFRO(14), PAHO(8), EURO(6), EMRO(6), WPRO(4), and SEARO(2) are still at the cautionary stage, confirming the high risk of a 2nd wave of COVID-19. In particular, AFRO region being at a high risk of COVID-19 spreading, And also 14 countries in AFRO are still in cautionary stage, thus they need to prepare for the spread of COVID-19. Though other regions' countries are now in relaxing level, they need to prepare for the second wave of covid-19. Finally, active participation of citizen is important to control the COVID-19 while easing the government response. And education at the national level could effectively led the participation of citizens.

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Population and Development in Ethiopia” from 2019–2023 (No. P2019-00160-1).

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Research in context

Evidence before this study

COVID-19 has become an important issue that threatens global health and security enough for WHO to officially declare a pandemic for the third time since its inception. In a press briefing on May 25, WHO said, "The current decline in the incidence rate of COVID-19 is due to the strong measures by the governments. In regard to the COVID-19 mitigation policies in many countries, the current pandemic has not ended, and there is a possibility that this will lead directly to the second wave," emphasizing the importance of government response to COVID-19. For this study, references were selected from databases such as Medline, Web of Science, and Google Scholar by searching for keywords using both "and" and "&" ("COVID," "Coronavirus," "2019-Ncov," "Pandemic" & "OxCGRT," "Stringency index," "Government response"). We identified eight related studies, of which two were the global analyses conducted before and in May. However, since January 1, there has been no study analyzing government response to COVID-19 in countries across six regions and around the world.

Added value of this study

This study analyzed COVID-19 trends and government response on a daily basis in 151 countries across six regions from January 1, 2020 to May 18, 2020, and evaluated this response in the last 50 days by dividing it into four stages. Currently, most EURO countries are at a safe stage and most AFRO ones at a dangerous stage. In addition, eight national indicators were used to determine their effects on the response—we found national investment in education most closely related to it. This data is considered to be useful as supporting and validating material to decide on COVID-19 policies.

Implications of all the available evidence

As of May 18, 2020, government response to COVID-19 in countries worldwide is changing according to the progress of each. Policymakers in countries categorized as being at the dangerous stage can refer to this study to review whether their government response is appropriate, and establish a proper policy. Thus, this data may contribute to the prevention of a second global wave of COVID-19 in the corresponding as well as neighboring countries.

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1. Introduction

Following the detection of COVID-19 in Wuhan, China, the World Health Organization (WHO) declared it an epidemic on January 20, 2020 and a pandemic on March 11, 2020.[1,2] As of May 18, 2020, there are 4,618,821 confirmed cases and 311,847 deaths across 214 countries.[3]

The Global Preparedness Monitoring Board (GPMB) of WHO confirmed, based on the H1N1 influenza pandemic in 2009 and Ebola outbreak in 2014–16, that government response to infectious diseases has been insufficient, and that it is difficult to formulate a response adhering to the International Health Regulations (IHR).[4] Therefore, the GPMB discussed continuous monitoring measures with experts to prevent and manage the pandemic, and published a report in preparation of health emergencies.[4] It announced governmental policies responding to infectious diseases, including those complying with IHR, leadership of national and community organizations, building of a strong system and financial preparation by the government, prioritizing community involvement, and increasing funds for the poor. In particular, during a pandemic, countries in one region have relations with each other, and so, the need for mutual cooperation among them was emphasized.

To minimize the spread of epidemics, government preparation and response play an important role[5]—in particular, quick and flexible actions including travel restrictions, Universal Health Coverage (UHC), sharing of data with neighboring countries, responding to community needs, roles of the media, economic stability, and quarantining are crucial in minimizing an epidemic's impact. However, due to differences in economic and national education levels, medical infrastructure, and information accessibility, government response to COVID-19 and the spread of the virus has differed from country to country.[6]

The purpose of this study is three-fold: first, to analyze the trends of government response to COVID-19 on a daily basis from January 1 by country across six regions; second, to evaluate the changes in government response by classifying it into four stages according to the extent of the spread over the last 50 days; and last, to identify the level (variable) of each country that affects its government's response. Thus, the current status of such response in six regions and 151 countries is identified, which serves as a basis for judging the suitability of each country's response to COVID-19.

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2. Method

2.1 Study design

This study was designed using data from a panel survey in 151 countries across six regions between January 1, 2020 and May 18, 2020.

2.2 Data sources

This study employed the Oxford COVID-19 Government Response Tracker (OxCGRT) Stringency Index (hereafter "Stringency Index")[7] and World Bank Open DATA (https://data.worldbank.org/) of 151 countries across six regions.

Stringency Index

The Stringency Index, having values from 0 to 100, evaluates government response policies of 151 countries to COVID-19. Nine response indicators used for its scaling are school closing, workplace closing, cancellation of public events, restrictions on gatherings, public transport closing, stay-at-home requirements, restrictions on internal movements, international travel controls, and public information campaigns, an economic measure. The Stringency Index calculates each government's level of policy response, with a score closer to 100 indicating a higher level of it. This data is updated daily by Oxford.

Countries' data

The eight national indicators used to analyze the data of 151 countries are Health Life Expectancy (HLE), Demographic Index (DI), Out-Of-Pocket Expenditure (OOP), Purchasing Power Parity (PPP), Internet usage rate of population (INT), Population Density per km^2 (PD), UHC Index, and Education Budget Ratio (EDU) (Table 1).

<Table 1> Abbreviations and information on countries' data

Abbreviation	Variables	Min - Max	Data sources
HLE	Health Life Expectancy	0 - 69·7	Institute for Health Metrics and Evaluation

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DI	Demographic Index	1·08 - 9·87	World Bank
OOP	Out-of-Pocket Expenditure	0 - 83·8	World Bank
PPP	Purchasing Power Parity	0 - 116,639	World Bank
INT	Internet using rate of population	0 - 99·6	World Bank
PD	Population Density per km^2	0 - 7,953	World Bank
UHC Index	Universal Health Coverage Index	0 – 89	World Bank
EDU	Education Budget Ratio	0 - 7·9	World Bank

2.3 Statistical analysis

First, the data of 151 countries was divided by region, and the Stringency Index trend from January 1, 2020 to May 18, 2020 analyzed using a nonlinear regression model. Six regions were classified according to WHO offices: African Region (AFRO), Pan American Health Organization (PAHO), South-East Asia Region (SEARO), European Region (EURO), Eastern Mediterranean Region (EMRO), and Western Pacific Region (WPRO).

Second, changes in the Stringency Index from January 1, 2020 to May 18, 2020 were analyzed by country with a heat diagram on a weekly basis.

Third, upward trend in new confirmed COVID-19 cases and changes in the Stringency Index per country were analyzed using a bubble chart as of April 1. The groups were divided in four—from the first quadrant to the fourth—to distinguish between the confirmed cases of each country and response of its government.

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Fourth, the Between-within model was used to compare the Stringency Index's determinants by country. In this analysis, national data was set as the time constant variable (fixed factor) and number of new and cumulative confirmed cases as the time varying variable.

$$E(Y_{it}|X_i, Country\ i) = \beta_0 + \beta_{cc}x_{it} + \beta_{death}x_{it} + \beta_{HLE}x_j + \beta_{SDI}x_j + \beta_{OOP}x_j + \beta_{PPP}x_j + \beta_{UHC\ Index}x_j + \beta_{INT}x_j + \beta_{PD}x_j + \beta_{EDU}x_j + u_i + e_{it} \quad (1)$$

Y_{it} is the government response value of a country for a specific date, where i indicates the country, and t the date. β_{cc} is the coefficient for confirmed COVID-19 cases, and β_{death} for COVID-19 deaths.

3. Results

3.1 Stringency Index by region

The national panel data of the Stringency Index between January 1, 2020 and May 18, 2020 of 151 countries was divided by region, and a linear regression model was employed (Figure 1).

Results showed that WPRO topped with a high Stringency Index from January 1, followed by SEARO, EURO, PAHO, EMRO, and AFRO. This indicates the order of the governments' response. <Figure 1> shows that government response to COVID-19 began on January 17 for SEARO, January 22 for EURO, January 23 for PAHO, January 25 for EMRO, and January 27 for AFRO.

As of May 18, EMRO has the highest Stringency Index, followed by SEARO, EURO, PAHO, AFRO, and WPRO.

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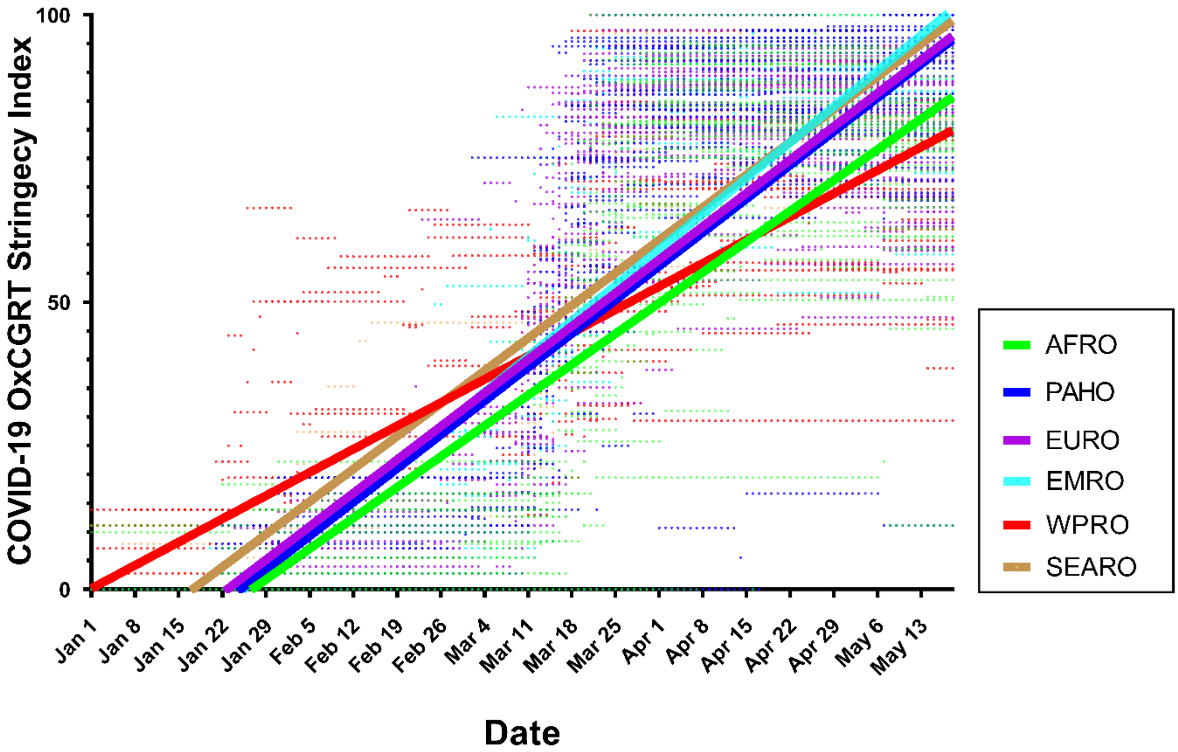

<Figure 1> The Stringency Index by region using a linear regression model

A nonlinear regression model was employed to see the changes in the Stringency Index over time—for all six regions, it increased continuously till the third week of April, after which, it began to decline. As of May 18, EMRO has the highest Stringency Index, followed by PAHO, SEARO, AFRO, EURO, and WPRO. Variation in the Stringency Index has been the highest in EMRO and lowest in WPRO.

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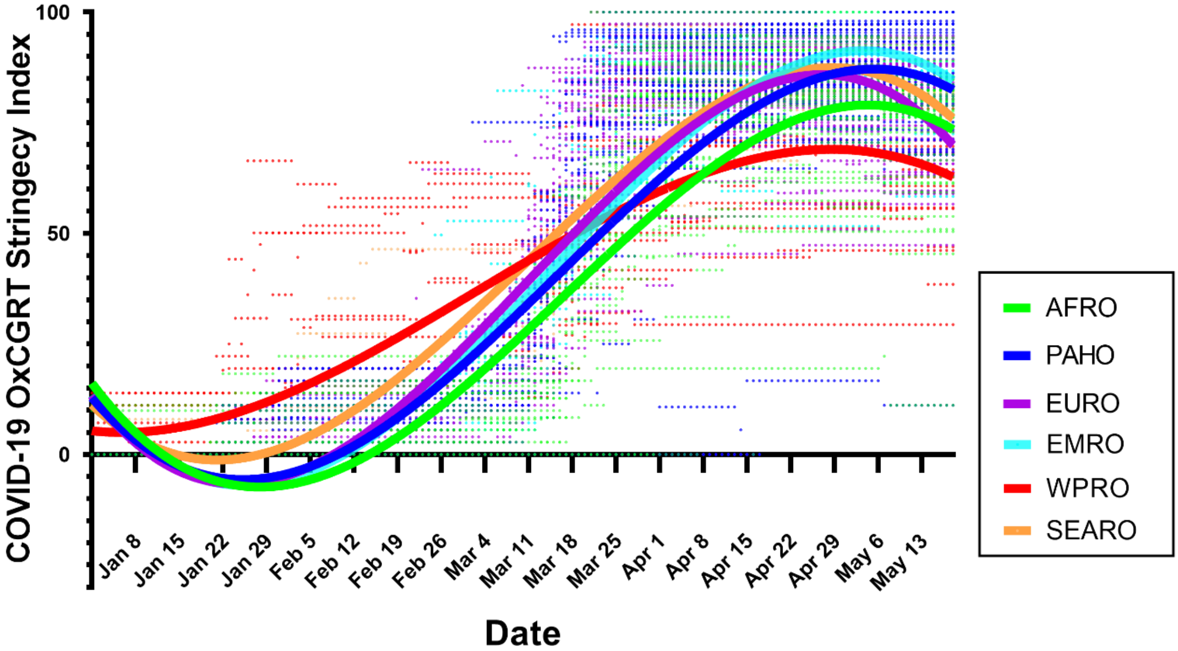

<Figure 2> The Stringency Index by region using a nonlinear regression model

3.2 Stringency Index by country

<Figure 3> shows the changes in the Stringency Index of 151 countries on a weekly basis from January 1, 2020 to May 18, 2020. The time it took China, Hong Kong, and Mongolia to cross 50 on the Stringency Index was the lowest—in the fourth week of January; Macau and Korea (WPRO), Italy (EURO), and Vietnam (SEARO) crossed 50 in February.

In March first week, 147 of the 151 countries had crossed 50 on the Stringency Index; the four below 50 were Burundi, Nicaragua, Sweden, and Taiwan. In the second, third, fourth, and fifth weeks, the number of countries crossing 50 was 32, 99, 124, and 130, respectively.

In April and May, 146 countries crossed 50—137, 140, 146, 146, 146 in the first, second, third, fourth, and fifth weeks (April), respectively, and 146, 145, 145 in the first, second, and third weeks (May), respectively; in other words, the number of countries was 146 for four weeks (third week of April–first week of May).

The four countries that have gone from over 80 to below 60 on the Stringency Index as of May are Burkina Faso, Madagascar, New Zealand, and South Korea.

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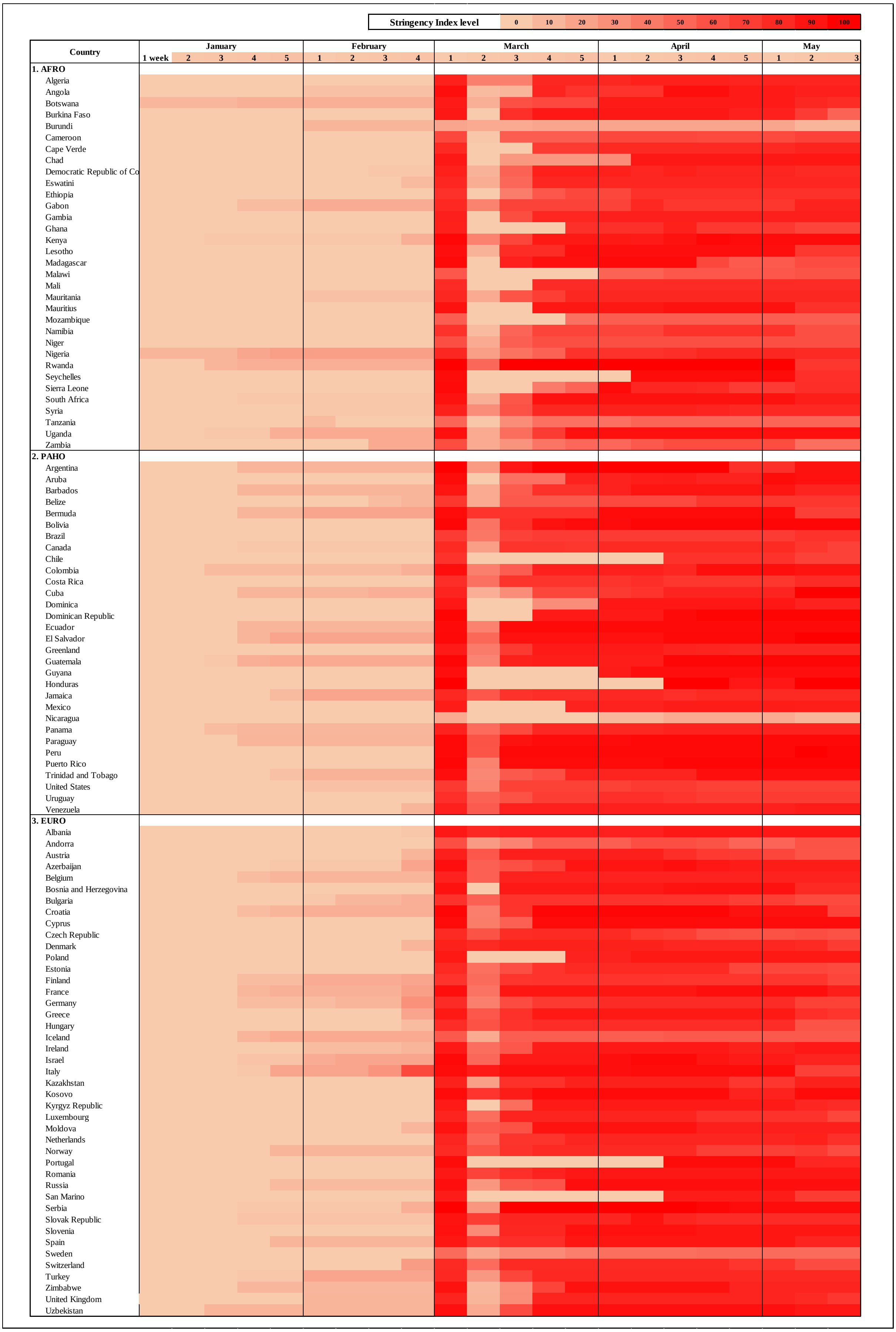

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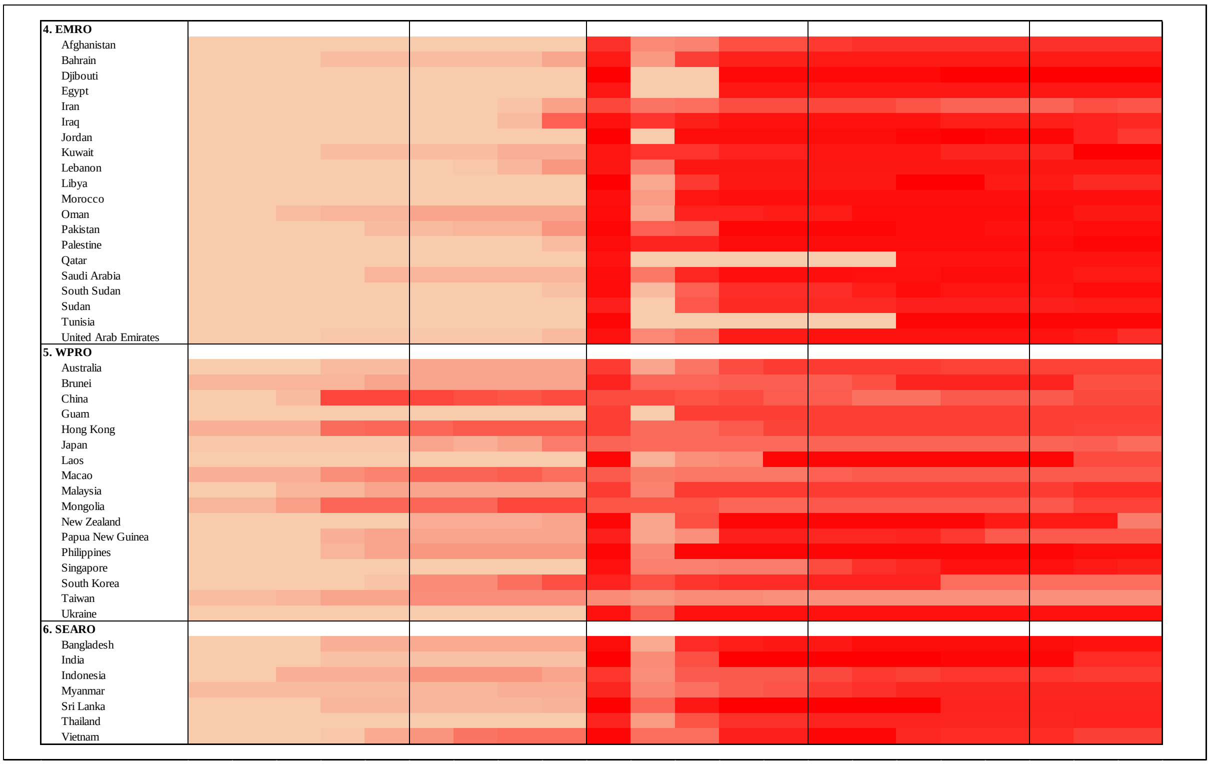
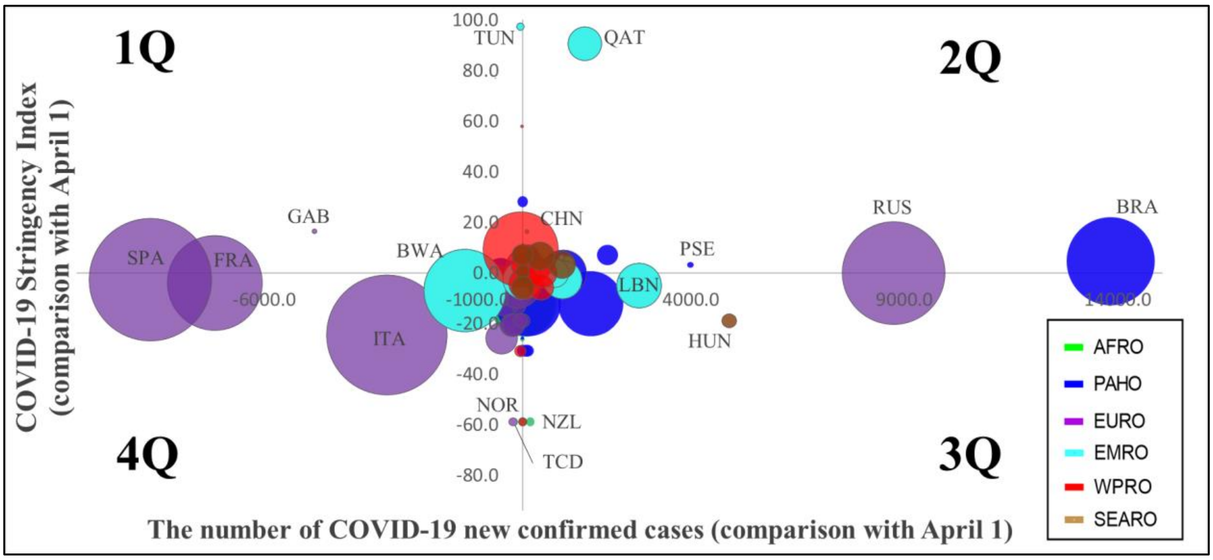


<Figure 3> The Stringency Index heat map of 151 countries



<Figure 4> The Stringency Index trend from April 1 to May 18

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<Table 2> Categories for the Stringency Index trend from April 1 to May 18

Qua-drant	Trend[a] SI[b]	NEW[c]	Level	Countries
1Q	+	+	Appropriate	(AFRO:7) Algeria, Ethiopia, Gabon, Kenya, Madagascar, Malawi, Mozambique (PAHO:9) Argentina, Bolivia, Brazil, Colombia, Cuba, Mexico, Panama, Paraguay, Peru (EURO:2) Moldova, Sweden (EMRO:7) Afghanistan, Djibouti, Iraq, Kuwait, Morocco, Oman, Qatar (WPRO:2) Mongolia, the Philippines (SEARO:3) Bangladesh, Indonesia, Thailand
2Q	-	+	Caution	(AFRO:14) Cameroon, Cape Verde, Chad, DR Congo, Eswatini, Ghana, Mali, Niger, Nigeria, Sierra Leone, South Africa, Syria, Uganda, Zambia (PAHO:8) Barbados, Canada, Chile, Ecuador, Guatemala, Honduras, Jamaica, Venezuela (EURO:8) Azerbaijan, Bulgaria, Hungary, Kazakhstan, Russia, Ukraine, the United Kingdom, Uzbekistan (EMRO:6) Bahrain, Egypt, Jordan, Pakistan, Saudi Arabia, United Arab Emirates (WPRO:4) Japan, Singapore, South Korea, Ukraine (SEARO:2) India, Sri Lanka
3Q	-	-	Stable	(AFRO:8) Burkina Faso, Burundi, Lesotho, Mauritania, Mauritius, Namibia, Rwanda, Seychelles (PAHO:7) Belize, Bermuda, El Salvador, Greenland, Guyana, Nicaragua, the United States, Uruguay (EURO:22) Austria, Belgium, Cyprus, Czech, Denmark, Estonia, Finland, France, Greece, Iceland, Israel, Italy, Kyrgyz, Luxembourg, the Netherlands, Norway, Romania, San Marino, Serbia, Slovak, Spain, (EMRO:6) Iran, Lebanon, Libya, Palestine, South Sudan, Sudan (WPRO:4) Guam, Hong Kong, Laos, New Zealand (SEARO:1) Vietnam
4Q	+	-	Excessive	(AFRO:4) Angola, Botswana, Gambia, Tanzania (PAHO:6) Aruba, Costa Rica, Dominica, Puerto Rico, Trinidad and Tobago (EURO:10) Albania, Andorra, Bosnia and Herzegovina, Croatia, Germany, Ireland, Kosovo, Portugal, Switzerland, Turkey (EMRO:1) Tunisia (WPRO:7) Australia, Brunei, China, Macao, Malaysia, Papua New Guinea, Taiwan (SEARO:1) Myanmar

[a] Trend period: April 1 to May 18

[b] SI: Stringency Index trend from April 1 to May 18

[c] NEW: COVID-19 new cases trend from April 1 to May 18

3.3 Between-within model

To analyze the determinants affecting the Stringency Index on a national level, the Between-within model and OLS model were used.

Model 1 was analyzed with the OLS model, and Models 2 through 10 with the Between-within model. Model 2 was found to be the most suitable (r^2=0·1713), followed by Model 1 (r^2=0·1465).

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In Model 2, the Stringency Index of each country was 18·53 points higher with DI a point higher (β=18·53, p<·05), and 0·00192 point lower with OOP a point higher (β=-0·00192, p<·05). Countries with 1% higher UHC Index had a higher Stringency Index, by 0·0313 point (β=18·53, p<·05), as did those with 1% higher INT, by 0·0478 point (β=0·0478, p<·05). In particular, countries with 1% higher EDU had a lower Stringency Index, by 1·125 points (β=-1·125, p<·05).

Models 3–10 analyzed national variables as time constant, and as a result, r^2 of Model 10 that included EDU was the highest with 0·0868, followed by Model 4 (r^2=0·0511), Model 8 (r^2=0·0489), Model 3 (r^2=0·0347), Model 7 (r^2=0·0331), Model 5 (r^2=0·0283), Model 6 (r^2=0·0279), and Model 9 (0·0279). Accordingly, the national variable with the highest impact on the Stringency Index was DI, followed by INT, HLE, UHC Index, OOP, and PPP.

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<Table 3> Between-within linear regression with the Stringency Index

Variables	OLS		Between-within model							
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8	Model 9	Model 10
Confirmed cases	0·000116*** (·000)	0·0000477* (0·00)	-0·0000432 (0·00)	-0·0000311 (0·00)	-0·0000635* (0·00)	-0·0000638* (0·00)	-0·0000621* (0·00)	-0·0000602* (0·00)	-0·0000631* (0·00)	-0·0000675* (0·00)
Deaths	0·000197* (·00)	0·00160* (0·00)	0·00173* (0·00)	0·00151* (0·00)	0·00196* (0·00)	0·00196* (0·00)	0·00186* (0·00)	0·00174* (0·00)	0·00198* (0·00)	0·00211* (0·00)
HLE	-0·193* (0·13)	-0·207* (0·13)	0·0433* (0·04)							
DI	20·34* (10·33)	18·53* (10·36)		5·655* (2·96)						
OOP	0·00158 (0·04)	-0·00192 (0·04)			-0·0124 (0·04)					
PPP	-0·0000997* (0·00)	-0·0000761* (0·00)				0·00000734 (0·00)				
UHC Index	0·0127 (0·04)	0·0313* (0·04)					0·0242* (0·03)			
INT	0·0498 (0·04)	0·0478* (0·04)						0·0420* (0·02)		
PD	-0·0000997* (0·00)	0·0000168 (0·00)							0·000226 (0·00)	

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EDU	-1·037**	-1·125***								-0·919**
	(0·33)	(0·33)								(0·30)
Constant	29·43***	30·68***	27·77***	26·68***	30·43***	29·99***	28·78***	27·89***	30·06***	33·08***
	(2·47)	(2·53)	(2·37)	(1·95)	(1·24)	(0·92)	(1·64)	(1·43)	(0·79)	(1·21)
r^2	0·1465	0·1713	0·0347	0·0511	0·0283	0·0279	0·0331	0·0489	0·0279	0·0868
F		2·89**	1·76	2·64	1·43	1·41	1·68	2·52	1·41	4·66**

HLE: Health Life Expectancy; DI: Demographic Index; OOP: Out-of-Pocket Expenditure; PPP: Purchasing Power Parity; UHC Index: Universal Health Coverage Index; INT: Internet using rate of population; EDU: Education Budget Ratio

* p<·05, **<·01, ***<·001

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4. Discussion

The first aim of this study was to analyze the government response of 151 countries across six regions, according to changing trends in the COVID-19 outbreak, and to identify these trends. Analysis of the data revealed that WPRO countries were the fastest to respond to COVID-19, followed by SEARO, EURO, PAHO, EMRO, and AFRO. It also showed that the date of government response of SEARO countries coincided with the date of the first confirmed case (January 17). In PAHO's case, government response took effect three days after the first confirmed case (January 20). The governments of EURO countries responded two days before the first confirmed case (January 24), those of EMRO four days before (January 29), and those of AFRO 19 days before (February 14). That is, WPRO, SEARO, and PAHO countries responded after the first confirmed case, while those of EURO, EMRO, and AFRO before. In other words, as cases rose globally, countries were better prepared to respond before confirmed cases emerged in their respective regions. Response to the H1N1/09 virus—WHO's second pandemic—was delayed due to governments' lack of knowledge on virus response and lack of a health response manual;[8] learning from that experience, government response to COVID-19 has been somewhat more active.

Nonlinear regression analysis of the Stringency Index trend by region revealed that WPRO's Stringency Index began to decline after the last week of April, and AFRO's in the first week of May. As of May 18, the level of government response (Stringency Index) is the highest in EMRO, followed by PAHO, SEARO, AFRO, EURO, and WPRO. PAHO countries are concerned about the possibility of the medical system collapsing with increase in the number of confirmed patients, and hence, their governments are controlling citizens with stringent regulations.[9] Considering their weak medical infrastructure, low education level, and poor access to information, countries in AFRO, the most vulnerable region among the six, have been making efforts to respond strongly to the outbreak; thus, they had the highest score.[10] Citizens of many of them are also protesting to express dissatisfaction with their governments' oppressive policies, leading to secondary damage. Many EURO countries, on the other hand, are easing travel restrictions—following meetings of their health ministers, kindergartens and elementary schools are reopening as well.[11] WPRO countries, especially China and South Korea, are seeing fewer confirmed cases, leading to easing of governmental regulations.[12]

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Our national level analysis from January 1 showed 147 countries' Stringency Index crossing 50 in the first week of March, a week before COVID-19 was declared a pandemic. The remaining four whose Stringency Index went from over 80 to below 50 were Burkina Faso, Madagascar, New Zealand, and South Korea. In fact, New Zealand's prime minister declared the end of COVID-19 after April saw no new confirmed cases or deaths—the government's strategy from the early days of enforcing strict social distancing and a strong travel ban was deemed successful;[13] New Zealand implemented the most stringent containment measures and conducted a large number of tests, but considering it is geographically isolated, it is unlikely that replication of this strategy will give successful results in other countries. In South Korea, the number of new confirmed cases—a maximum of 518 a day in March—reduced to a maximum of 32 a day (average of 16 a day) in May. This has led to the reopening of schools, changing of the guidelines from social distancing to in-life distancing, and introducing the K-quarantine model to the world as the standard COVID-19 government response.[14] This shows that a strict government response during the pandemic's early stages has been effective in preventing its spread.

The second aim of this study was to evaluate the change in new confirmed COVID-19 cases and in the trend of government response in stages as of April 1. The four stages identified were "Appropriate," "Caution," "Stable," and "Excessive." Among the six regions, AFRO is the most vulnerable to COVID-19 due to weak medical infrastructure and lack of medical personnel. Experts opine that, with increase in the number of confirmed cases in AFRO, lowering of government response could not only lead to further spread across the region but also cause a second wave across all six.[15] PAHO had the highest number of countries at the "Appropriate" stage—nine—besides eight at "Caution," seven at "Stable," and six at "Excessive." The US and Brazil have had the highest number of daily confirmed cases worldwide, recording 10,000 per day—after April 1, as this number in US began to decrease, on April 19, President Donald Trump ordered each government precinct to ease its COVID-19 regulations;[16] in comparison, Brazil's new confirmed cases surged, and the government's response strengthened accordingly. The Brazilian government uses a mobile phone tracking system to calculate its citizens' social distancing participation rate—this was 50% as of early May, far below the government's target of 70%; hence, it is considering lockdown of cities.[17]

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Brazilian government's initial response to COVID-19 being low, its response score has increased relatively; thus, we need to keep an eye out for whether its response is appropriate.

EURO had the most countries at the "Stable" stage—currently, a majority have decided to ease the COVID-19 restrictions by reopening schools; permitting shops, bars, and hotels to resume operations; making wearing of mask voluntary, except in shops and on public transport; relaxing the mandatory 14-day quarantine of incoming travelers; and reopening borders. WHO, however, has warned them that such actions could lead to a "Second Pandemic"—its Emergency Medical Teams stress that this would lead to its quick spread, and that governments in PAHO and EURO should strengthen their measures.[18] Countries such as Italy and the UK with their NHS (National Health Service) were initially not prepared for COVID-19, and hence, immediate response was difficult.[19] However, NHS manual and promotion, financial expansion, and improvement in screening accuracy led to proper examination of confirmed COVID-19 patients, thereby decreasing cases.[20]

EMRO had the second-highest number of countries at the "Appropriate" stage. With increase in new confirmed cases, its countries are under strict lockdown. However, the majority being Muslim countries, and Ramadan observed till May 24, including "Eid ul-Fitr" on the last day, WHO is concerned about the spread of COVID-19, and has urged the governments to initiate an active response.[21] New confirmed cases in Saudi Arabia and Pakistan, at the "Caution" stage, are increasing rapidly, and hence, strict government response is required.

WPRO had several countries at the "Caution" and "Excessive" stages—those at the former were Japan, Singapore, South Korea, and Ukraine. After South Korea's Stringency Index went from 80 to below 50, in May, social distancing measures were eased to in-life distancing, and schools were reopened.[22] Thus, South Korea has successfully shown the standard COVID-19 government response to the world, including drive-through testing and social distancing. Countries worldwide are focusing on the K-quarantine model's effect, but it is important to see whether it is effective in preventing the spread of COVID-19 over time.

The third purpose of this study was to identify the national level (variable) affecting government response, depending on the changes in COVID-19 trend among countries. HLE, DI, UHC Index, INT, and EDU were identified as significant national variables affecting government response.

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EDU was identified as a national indicator having the greatest effect on government response to COVID-19, with countries with the highest EDU having relatively lower Stringency Index. According to previous COVID-19 studies, countries with high citizen awareness and education level comply with their governments' recommended measures as well as response policy.[23] In South Korea, a representative country in this case, the number of new confirmed COVID-19 patients surged in February but dropped after citizens actively complied with the government response and voluntarily adhered to prevention measures.[24]

DI represents the state of democracy in countries by taking five factors into account: pluralism, civil liberties, government functions, political participation, and political culture. Countries with high DI showed stricter government response to COVID-19. In particular, DI was higher in PAHO and EURO countries compared with those in the other regions.[25] The fact that countries with high DI had a stronger government response means that they have the ability to flexibly cope with the pandemic's risk and urgency. However, there are many cases where, since citizens of PAHO and EURO value liberal democracy, they are more prone to violate governmental measures such as social distancing or self-quarantine.

Studies have also shown that UHC Index is higher in developed countries and in countries having the NHS.[26] This means that countries with better medical coverage are equipped with the appropriate medical infrastructure to cope with COVID-19, ensuring expedited testing and treatment. On the other hand, governments of low-income developing countries, due to overload and poor medical infrastructure, are implementing strong measures for COVID-19 that focus on social distancing rather than the use of medical institutions. For this reason, in case of a second pandemic in such countries, management of the pandemic's spread will be inadequate due to their medical system's vulnerability.

In conclusion, this study analyzed 139 days' worth of data, from January 1 to May 18, on government response to COVID-19 by region and country to identify the trend as well as national variables that affect this response. Overall, the Stringency Index of six countries has lowered, but 42 countries (14 in AFRO, eight in PAHO, eight in EURO, six in EMRO, four in WPRO, and two in SEARO) are still at the "Caution" stage with a higher risk of spread. In particular, AFRO faces the threat of a high fatality rate, and hence, active measures from its governments, and support from donor countries and organizations are necessary. On the other

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hand, 22 EURO countries are at the “Stable” stage, but governments still need to prepare for a second wave of COVID-19. In addition, to lower government response and encourage citizens to voluntarily respond to prevention measures and government guidelines, each country needs to invest in education to effectively manage such infectious diseases.

Contribution

HCL and EWN designed the study. HCL and JHK collected the data. HCL analyzed the data. HCL, JEK, SJM, JHK and EWN interpreted the data. All authors contributed to make the first draft. HCL, JHK, SJM, and EWN approved the final version.

Declaration of interest

We declare no competing interests.

Data sharing

The data in this study are available free of charge in Oxford Government Response Tracker (OxCGRT) Stringency index homepage(https://www.bsg.ox.ac.uk/research/research-projects/coronavirus-government-response-tracker) and World Bank Open data (https://data.worldbank.org/)

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This preprint research paper has not been peer reviewed. Electronic copy available at: https://ssrn.com/abstract=3631304

References

1 WHO Emergency Committee. Statement on the second meeting of the International Health Regulations (2005) Emergency Committee regarding the outbreak of novel coronavirus (COVID-19). WHO, Geneva 2020; https://www.who.int/news-room/detail/30-01-2020-statement-on-the-second-meeting-of-the-international-health-regulations-(2005)-emergency-committee-regarding-the-outbreak-of-novel-coronavirus-(COVID-19), accessed May 28, 2020.

2 Cucinotta D, Vanelli M. WHO declares COVID-19 a pandemic. *Acta BioMedica* 2020; **91(1):** 157–160.

3 WHO. Coronavirus disease (COVID-19) Situation report-119. Geneva 2020; https://www.who.int/docs/default-source/coronaviruse/situation-reports/20200518-covid-19-sitrep-119.pdf?sfvrsn=4bd9de25_4, accessed May 18, 2020.

4 GPMB. A world at risk: Annual report on global preparedness for health emergencies. 2019; https://apps.who.int/gpmb/assets/annual_report/GPMB_annualreport_2019.pdf, accessed May 18, 2020.

5 University of Oxford. The state of governance and coordination for health emergency preparedness and response. 2020; https://apps.who.int/gpmb/assets/thematic_papers/tr-1.pdf, accessed May 18, 2020.

6 Stojkoski V, Utkovski Z, Jolakoski P, Tevdovski D, Kocarev L. The socio-economic determinants of the coronavirus disease (COVID-19) pandemic. 2020; arXiv preprint https://arxiv.org/pdf/2004.07947.pdf, accessed May 16, 2020.

This preprint research paper has not been peer reviewed. Electronic copy available at: https://ssrn.com/abstract=3631304

7 Hale, Thomas, Sam Webster, Anna Petherick, Toby Phillips, and Beatriz Kira. Oxford COVID-19 Government Response Tracker, Blavatnik School of Government 2020. Data use policy: Creative Commons Attribution CC BY standard; https://www.bsg.ox.ac.uk/research/research-projects/coronavirus-government-response-tracker, accessed May 19, 2020

8 Watkins J. Preventing a covid-19 pandemic. *BMJ* 2020; **368:** m810 https://doi.org/10.1136/bmj.m810.

9 WHO/PAHO. PAHO Director calls for protection of health workers in face of the advancing COVID19 pandemic in the region of the Americas. 2020; https://www.paho.org/hq/index.php?option=com_content&view=article&id=15773:paho-director-calls-for-protection-of-health-workers-in-face-of-the-advancing-covid19-pandemic-in-the-region-of-the-americas&Itemid=1926&lang=en, accessed May 28, 2020.

10 WHO/AFRO. African countries move from COVID-19 readiness to response as many confirm cases. 2020; https://www.afro.who.int/health-topics/coronavirus-covid-19, accessed May 28, 2020.

11 The Guardian. European schools get ready to reopen despite concern about pupils spreading Covid-19. 2020; https://www.theguardian.com/world/2020/may/01/children-as-likely-to-spread-coronavirus-as-adults-says-scientist, accessed May 28, 2020.

12 WHO/WPRO. COVID-19 situation report for the Western Pacific Region. 2020; http://iris.wpro.who.int/handle/10665.1/14519, accessed May 28, 2020.

13 TIME. Why New Zealand's Coronavirus Elimination Strategy Is Unlikely to Work in Most Other Places. 2020; https://time.com/5824042/new-zealand-coronavirus-elimination/, accessed May 28, 2020.

This preprint research paper has not been peer reviewed. Electronic copy available at: https://ssrn.com/abstract=3631304

14 BBC NEWS. Coronavirus and South Korea: How lives changed to beat the virus. 2020; https://www.bbc.com/news/world-asia-52482553, accessed May 28, 2020.

15 WHO. A second COVID-19 case is confirmed in Africa. 2020; https://www.afro.who.int/news/second-covid-19-case-confirmed-africa, accessed May 28, 2020.

16 abc NEWS. Coronavirus government response updates: Top Trump officials clash over whether the CDC 'let the country down'. 2020; https://abcnews.go.com/Politics/coronavirus-government-response-updates-top-trump-officials-clash/story?id=70741532, accessed May 18, 2020.

17 BBC NEWS. Coronavirus: Hospitals in Brazil's São Paulo 'near collapse'. 2020; https://www.bbc.com/news/world-latin-america-52701524, accessed May 28, 2020.

18 FOX 4. WHO warns that 1st wave of pandemic not over, immediate 2nd peak possible. 2020; https://www.fox4news.com/news/who-warns-that-1st-wave-of-pandemic-not-over-immediate-2nd-peak-possible, accessed May 20, 2020.

19 Horton R. Offline: COVID-19 and the NHS—"a national scandal". *Lancet* 2020; **395(10229):** 1022. http://doi.org/10.1016/S0140-6736(20)30727-3.

20 NHS Nightingale. Why we Need an NHS "COVID-19 Risk Calculator". 2020; https://www.amandagoodall.com/RiskCalculatorGoodallMcCabeWiertzFINALMay2020.pdf, accessed May 28, 2020.

21 WHO. Safe Ramadan practices in the context of the COVID-19: interim guidance. Geneva 2020; https://apps.who.int/iris/bitstream/handle/10665/331767/WHO-2019-nCoV-Ramadan-2020.1-eng.pdf, accessed May 28, 2020.

22 The Washington Post. The pictures say it all: How South Korean schools are reopening. 2020; https://www.washingtonpost.com/education/2020/05/26/pictures-say-it-all-how-south-korean-schools-are-reopening/, accessed May 28, 2020.

This preprint research paper has not been peer reviewed. Electronic copy available at: https://ssrn.com/abstract=3631304

23 Zhong B, Luo W, Li H, et al. Knowledge, attitudes, and practices towards COVID-19 among Chinese residents during the rapid rise period of the COVID-19 outbreak: a quick online cross-sectional survey. *Int J Biol Sci* 2020; **16(10):** 1745–52. https://www.ijbs.com/v16p1745.htm.

24 Jeong G, Lee H, Lee K, et al. Epidemiology and Important Lessons from the Coronavirus Disease 2019 (COVID-19) Outbreak in South Korea. 2020; http://dx.doi.org/10.2139/ssrn.3559575.

25 Legido-Quigley H, Asgari N, Teo Y, et al. Are high-performing health systems resilient against the COVID-19 epidemic? *Lancet* 2020; **395(10227):** 848–850. https://doi.org/10.1016/S0140-6736(20)30551-1.

26 Armitage R, Nellums L. The COVID-19 response must be disability inclusive. *Lancet* 2020; **5(5):** e257. https://doi.org/10.1016/S2468-2667(20)30076-1.

This preprint research paper has not been peer reviewed. Electronic copy available at: https://ssrn.com/abstract=3631304