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Keywords: OxCGRT, movement restrictions, Covid-19
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UNIVERSITEIT STELLENBOSCH UNIVERSITY

Department of ECONOMICS

Physical Address
Research on Socio-Economic Policy (RESEP)
Department of Economics
Matieland
7602

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ABSTRACT

A group at the University of Oxford has recently launched a dataset, updated on a daily basis, on the stringency of the measures countries are taking in response to the Covid-19 crisis. The dataset is known as the Oxford COVID-19 Government Response Tracker, or OxCGRT. It provides countries with an opportunity to examine how typical or atypical their responses are. Interpreting these types of cross-country comparisons must of course be done carefully. Yet they can be invaluable in guiding the debates around next steps.

Decisions by countries point roughly to a hierarchy of actions used when 'the screws are tightened' in response to the pandemic. International travel restrictions are the first to be imposed, then schools are closed and public events cancelled, then internal movement is restricted, then workplaces are closed, and lastly public transport is shut down. South Africa has more or less followed this pattern, but with an above average degree of stringency. If one examines each country's most recent level of overall stringency, just 30 (of 139) countries had reached the maximum stringency level. One of these countries is South Africa.

If one brings in additional World Bank indicators into the analysis, a multivariate analysis is possible of what characteristics of countries are associated with greater or less stringency in their Covid-19 responses. It is clear that developing countries have responded more stringently, when one takes into account where each country lies in the evolution of the pandemic. Having fewer hospital beds relative to the population is associated with a more stringent response, for instance. Thus, it appears that stricter restrictions on movement are imposed where the risk of overwhelming the health system seems greater.

South Africa's response has been stringent, even in comparison to economically similar countries. For instance, restrictions with respect to accessing the workplace have been over twice as stringent as one might expect, at South Africa's current point in the pandemic's trajectory. Yet South Africa is not unique. The level of workplace restrictions in the Latin America and Caribbean region, the highest in the world, is at South Africa's level. If one examines the lag between a country's first Covid-19 case and workplace restrictions of maximum stringency, South Africa was about average.

Absolute numbers of deaths, or Covid-19 deaths relative to how many deaths a country could have expected anyway in 2020, provide what is probably the best basis for comparing, across multiple countries, the speed with which Covid-19 multiplies. There is clearly a large variety of trajectories for Covid-19 deaths across countries. South Africa's trajectory is not that

unusual. Predicting how sensitive these pathways are to restrictions imposed by governments is hugely important, and will preoccupy analysts in the coming months and years. Datasets such as OxCGRT will be important for this work. Some very preliminary analysis done for the current paper points to the difficulty of detecting meaningful correlations, let alone cause and effect.

Martin Gustafsson
Department of Economics
University of Stellenbosch
Private bag X1, 7602
Matieland, South Africa
E-mail: mgustafsson@sun.ac.za

The author is Associate Professor at the University of Stellenbosch.

1 Introduction

The Covid-19 crisis has triggered important data work, much of it occurring at faster than normal speeds, given how urgently the evidence is needed. This obviously creates unavoidable risks in relation to the accuracy of the evidence. Decision-makers should take this risk into account. Apart from the vital epidemiological modelling occurring, new datasets have emerged, and are being increasingly used, on how countries have responded to the crisis.

One noteworthy new dataset is the Oxford COVID-19 Government Response Tracker, or OxCGRT. This dataset provides country-specific and daily data, based on analysis of publicly available government and media reports. OxCGRT draws from the work of almost 100 analysts[1].

The aim of the current paper is to provide an initial analysis of where South Africa, and Sub-Saharan Africa more broadly, stand with respect to the Covid-19 response, with a specific focus on restrictions on educational and economic life. Tracking across-country differences and similarities can stimulate ideas, and inform public debates. Across-country differences are of course not a firm indication of whether any country is responding optimally or not, in part because local contexts differ considerably.

2 The data

The OxCGRT data were downloaded on 14 April[2]. Dates range from 1 January 2020 (138 countries) to 14 April (135 countries). If one focusses only on the seven sub-indicators used to calculate the aggregate OxCGRT indicator, and which relate mainly to movement restrictions, one finds that there are delays in updating each of the seven for specific countries. The aggregate indicator is referred to as the 'COVID-19 Government Response Stringency Index'. In some cases, a country could have more recent updates for one of the sub-indicators than for another one. 132 countries had non-missing values for all seven sub-indicators for 1 April, but just 101 for 8 April, and 46 countries for 13 April.

One of the sub-indicators deals with school closures. The OxCGRT data in this regard consider seven days a week, regardless of school holidays, after the initial school closure day, as a day of closure. Notes in the dataset indicate that for around six countries, the source of the school closures information is the separate dataset on school closures maintained by UNESCO[3]. In other cases, it appears that OxCGRT collected the information independently. As in the case of the UNESCO dataset, there is no systematic differentiation between education levels, and counting weekends and holidays as school closures is a feature the OxCGRT data shares with the UNESCO data.

The OxCGRT data are quite well documented in Hale *et al* (2020). Further details on the data are discussed in the analysis below, where relevant. Six indicators in the OxCGRT dataset which do not feed into the aggregate indicator were not analysed for this paper. Those six indicators deal with matters such as fiscal measures and testing policies, matters which have a less direct or immediate impact on the population as a whole. The focus of the paper is in other words largely on policies relating to the restriction of movement.

[1] Hale *et al*, 2020.
[2] https://www.bsg.ox.ac.uk/research/research-projects/oxford-covid-19-government-response-tracker. The .csv file was downloaded.
[3] 'COVID-19 Educational Disruption and Response' at https://en.unesco.org/covid19/educationresponse (accessed 12 April).

3 Analysis

Graphing and mapping of the OxCGRT data on the OxCGRT website, and in Hale *et al*, as well as in a BBC feature[4], provide an idea of what can be done with the OxCGRT data. Much of the focus below is on adapting in some way that work, in a manner that is informative for, above all, South Africa. For instance, the country-specific graphs produced by OxCGRT to date are of a small selection of countries, excluding South Africa.

The analysis is organised in terms of three questions: (1) Is there a systemic prioritisation of restriction types? (2) What is the typical response in a given country context? (3) How does the stringency of responses relate to Covid-19 pathways? In particular question (3) is dealt in a short and exploratory manner. Doing justice to that question would require far more time and data than were available when this paper was produced.

3.1 Is there a systemic prioritisation of restriction types?

The seven sub-indicators are: (1) school closures; (2) workplace closures; (3) public event cancellations; (4) public transport closures; (5) presence of public information campaigns; (6) restrictions on internal movement; and (7) international travel restrictions. Clearly, sub-indicator 5, dealing with information, is not about a restriction, but the other six sub-indicators do deal with actual movement restrictions.

Figure 1 provides a sense of the data, using the example of South Africa. Six of the sub-indicators carry four values (0 to 3), while the information sub-indicator carries just three (0 to 2). Each sub-indicator value is rescaled to a scale where the minimum is zero and the maximum 100. The aggregate indicator is a simple average across all seven rescaled sub-indicator values. Each of the sub-indicators draws from two variables, one dealing with intensity, and the other with geographical extent. To obtain the seven overall sub-indicator values, which are not provided in the dataset, the technical report was followed and a check was run that the average across the seven did indeed equal the overall aggregate indicator value in the dataset.

Turning to South Africa, day zero in Figure 1 is 6 March, when the first case was confirmed. By then, limited international travel restrictions were already in place. Then information campaigns were intensified to a level of 100. On 15 March, workplace, public event and internal movement restrictions were intensified. On 18 March, schools were closed. Then international travel was further restricted. Finally, on 27 March the most stringent possible set of restrictions were imposed when all sub-indicator values became 100, including public transport. South Africa was one of 30 countries, in a total set of 139 countries, to have reached the maximum for all seven sub-indicators in its most recent data.

[4] Article titled 'Coronavirus: The world in lockdown in maps and charts' and dated 7 April 2020 at https://www.bbc.com/news/world-52103747 (accessed 12 April)

Figure 1: Sub-indicator evolution in South Africa

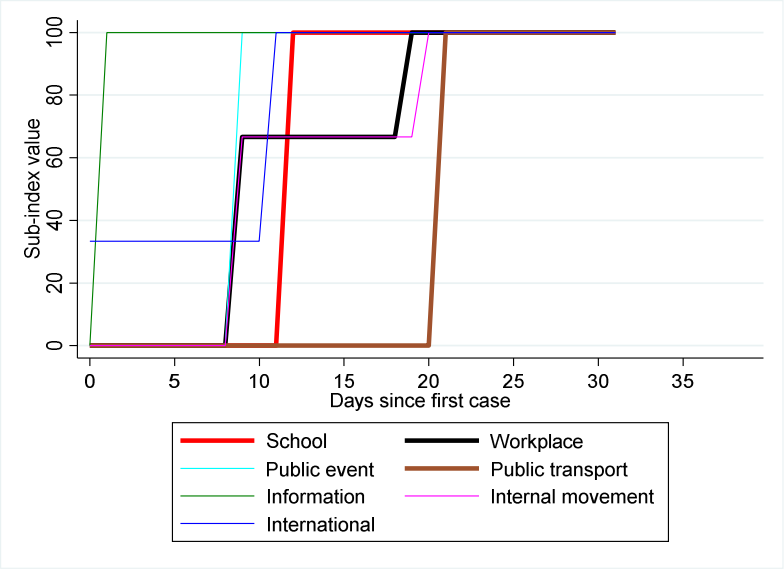
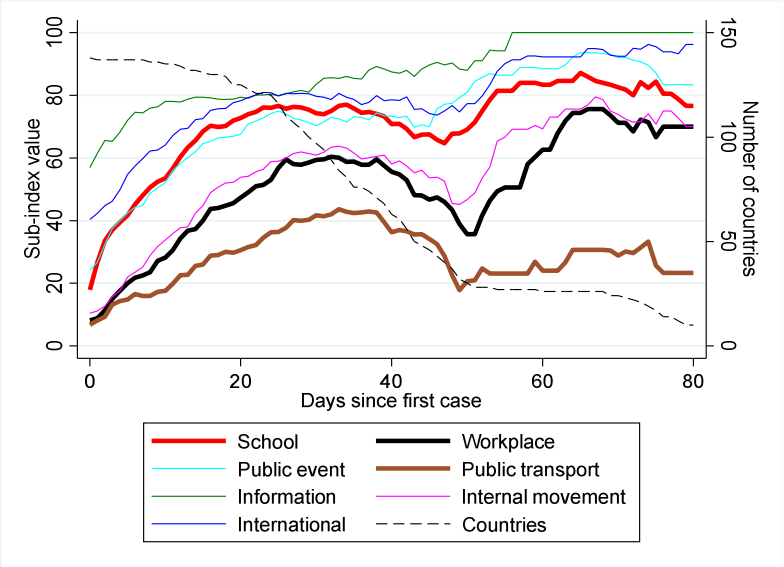


Figure 2 draws from the data of 138 countries, with the number of countries with available data declining from left to right. The dip in the curves at around day 50 reflects a group of countries with a relatively long experience of the pandemic which increased the stringency of their measures late in the process. This global picture illustrates patterns also found in the South Africa graph, for instance the fact that countries try to keep public transport open as long as possible.

Figure 2: Sub-indicator evolution in the world



Note: The dashed line (Countries) should be read against the right-hand vertical axis.

Table 1 draws from 107 countries for which at least 30 days had lapsed since the first case, and then no data from beyond day 39 was considered. Values are means across all country-day observations in the data, with the number of days being roughly the same for all countries (and never greater than 39). Values for the world point to information campaigns being

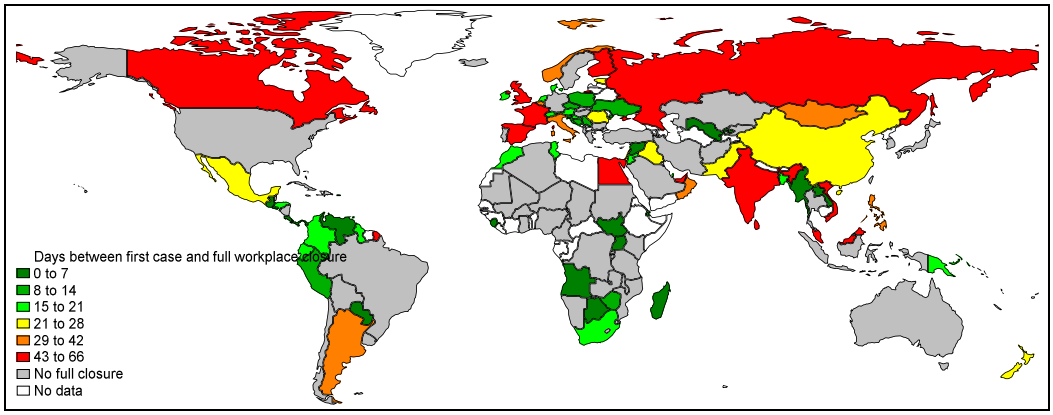
prioritised first, then international travel restrictions, then schools and public events, then internal movement, then the workplace, and lastly public transport. Green means a value exceeds the world average by more than 10, and red that it falls more than 10 below the world average. South Africa's values equal or exceed world values. South Africa exceeds furthest when it comes to workplace restrictions. Yet South Africa is in a region, Sub-Saharan Africa, which places a relatively low emphasis on workplace restrictions. South Africa's workplace restrictions have been on a par with those of Latin American and the Caribbean, the region that has imposed the most stringent restrictions on the workplace[5].

Table 1: Prioritisation within the first 39 days

	South Africa	World	Sub-Saharan Africa	Northern Africa and Western Asia	Latin America and the Caribbean	Central and Southern Asia	Eastern and South-eastern Asia	Europe and Northern America	Oceania
School	63	62	**77**	68	**74**	68	59	55	**27**
Workplace	**61**	41	**29**	42	**62**	40	**31**	43	**27**
Public event	**72**	62	**76**	58	**74**	60	59	59	**41**
Public transport	34	25	34	**45**	29	**39**	**9**	19	**13**
Information	**97**	81	74	**71**	85	**93**	90	77	**96**
Internal movement	**60**	45	45	47	**58**	**59**	**34**	44	**27**
International	77	71	**82**	80	79	64	71	61	**94**
Countries	1	107	13	16	20	7	14	35	2

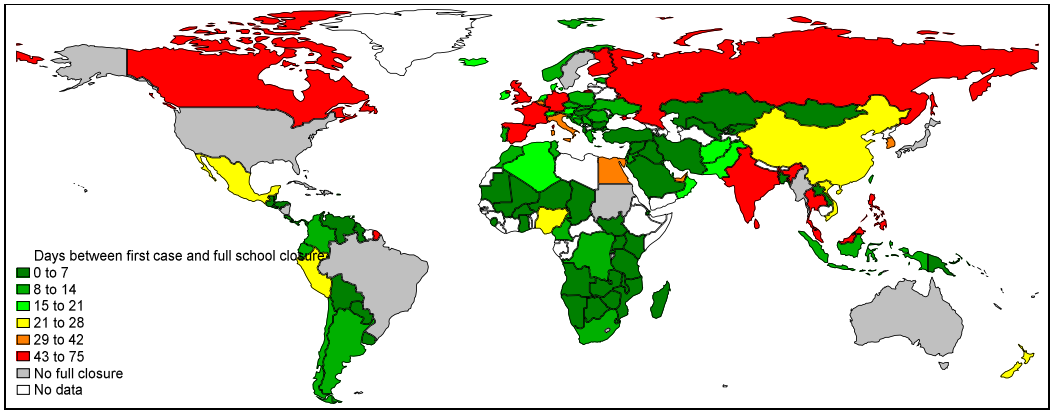
What about the timing of the restrictions? Figure 3 illustrates 81 countries which reached maximum stringency with respect to the workplace. South Africa is in position 43 from the bottom when it comes to the lag between the first case and full workplace restrictions. South Africa's lag was 19 days. Figure 4 produces a similar map for education. Of 126 reaching the maximum in terms of school closure, South Africa was in position 76 – here South Africa's lag was 12 days. There were 22 countries which closed their schools totally *before* the first Covid-19 case.

Figure 3: Days to full workplace closure



[5] Regions used in this paper are those commonly used by UNESCO, specifically those appearing in the *2019 Global Education Monitoring Report*.

Figure 4: Days to full school closure



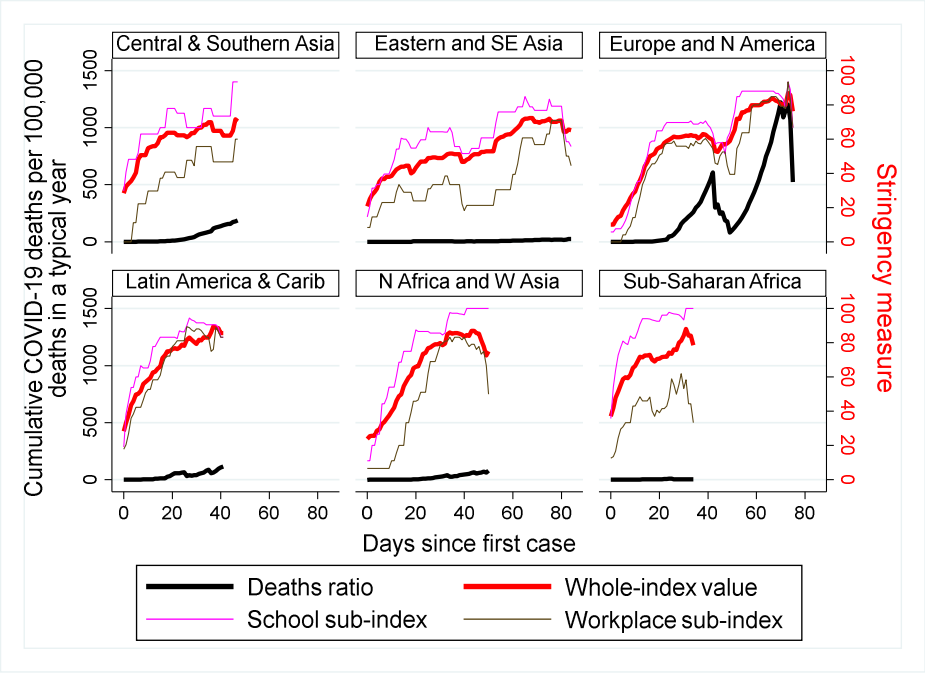
The vertical axis in Figure 5 below represents cumulative Covid-19 deaths per 100,000 deaths one might expect anyway in 2020. Cumulative deaths (as well as cumulative cases) is found in the OxCGRT data, which in turn obtains this from the World Health Organization (WHO). The expected 2020 deaths was found by multiplying each country's 2018 death rate by an estimate of the 2020 total population based on the assumption that each country's 2018 to 2020 population growth was equal to its 2016 to 2018 growth in percentage terms. Data for this were obtained off the World Bank's DataBank, in which the most recent values were for 2018[6]. Taiwan's figure, not available in the World Bank data, was sourced separately. Focussing on deaths, as opposed to Covid-19 cases, provides a more reliable basis for understanding how far the pandemic has progressed in a country, given the sensitivity of the quantity of testing, and hence confirmed cases, to country-specific logistical and cost factors. Moreover, Covid-19 deaths per 100,000 deaths which would have occurred anyway produces a statistic that is not only sensitive to a country's total population, but also its age structure.

The horizontal axis refers to days since the first case. While the number of cases over time per country is likely to suffer from serious comparability problem, this would be much less so for the date of the first Covid-19 case. This date appears to be the best available marker of when Covid-19 infections began in a country.

Figure 5 serves as a reminder of how important it is to look at trends below the aggregate indictor (the 'whole-index value'). If one considers just two of the sub-indicators, dealing with school and workplace stringency, it is clear that in some regions, for instance Sub-Saharan Africa, these two diverge, while in others, such as Europe and Northern America, they do not. Three regions – Sub-Saharan Africa, Eastern and South-eastern Asia, and Central and Southern Asia – prioritise school closures over workplace closures to a large degree.

[6] https://databank.worldbank.org/home.

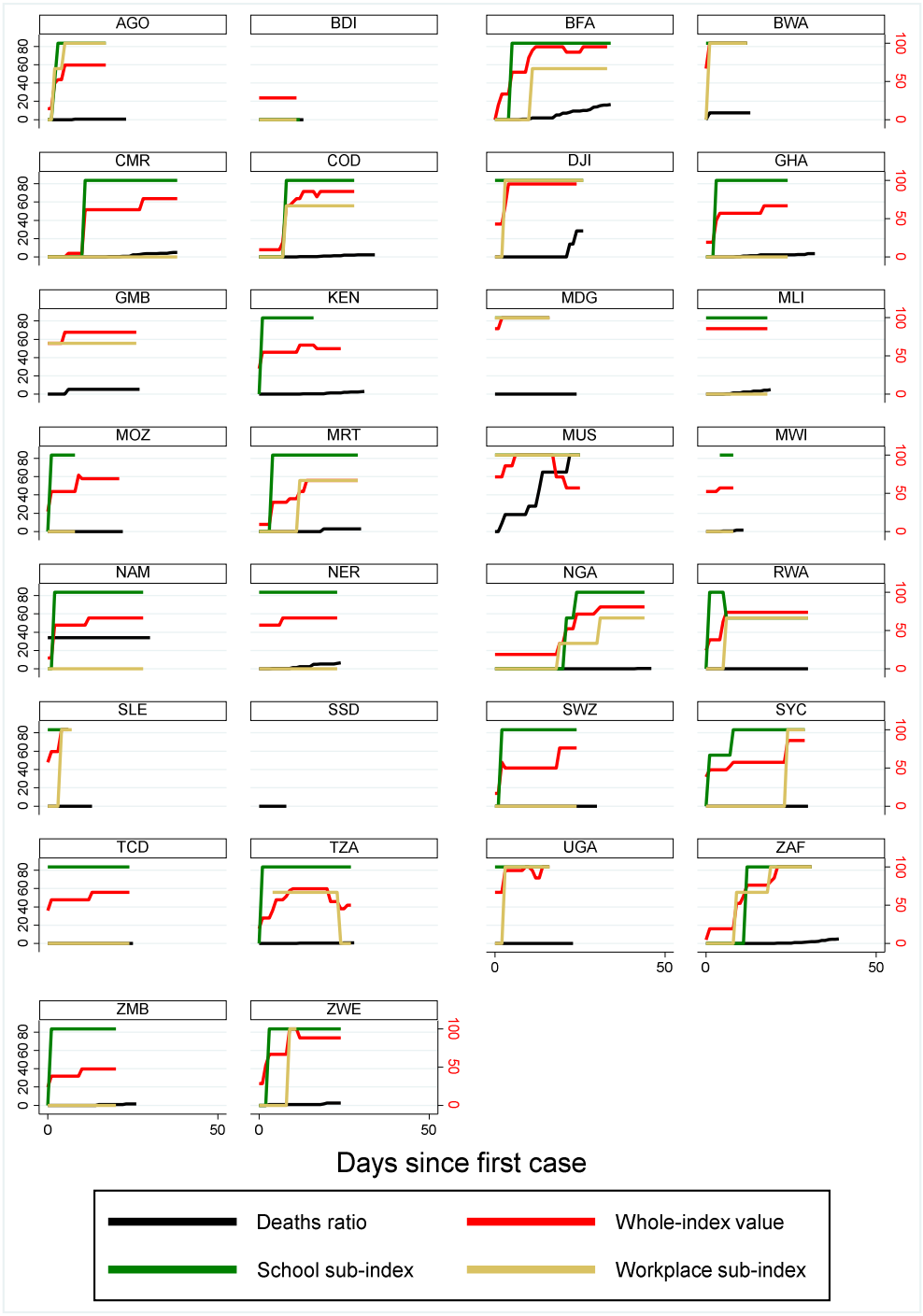
Figure 5: Historical movement of stringency values by region



Note: The Oceania region is excluded due to the low number of data points.

Figure 6 below provides details per country in the Sub-Saharan Africa region. There were 18 countries for which days since the first case was 25 or more. Of these 18, 13 had a value for workplace stringency on day 25. Four of the thirteen had reached the maximum level of 100 for this sub-indicator on this day: South Africa (ZAF), Mauritius (MUS), Seychelles (SYC) and Djibouti. Twelve of the 18 had a value for school stringency, and all of these were at level 100 by day 25, with just one exception being Rwanda, with a value of 66. The notes in the dataset do not explain what made Rwanda's restrictions lower. As seen in Figure 4, many African countries introduced school closures before South Africa.

Figure 6: Historical movement of stringency values by SSA country



Note: The left-hand and right-hand vertical axis labels would be as in Figure 5.

3.2 What is the typical response in a given country context?

Table 2 below focusses on conditional correlations between various country-specific background factors and the degree and type of Covid-19 restrictions. The aim is in part to establish what the typical levels of stringency are in different types of countries, which in turn

can provide a 'norm' against which a single country's behaviour can be gauged. Obviously, the 'norm' is not what is optimal, but what is typical.

The first column of coefficients is aimed at determining behaviours at different levels of country development. Days since 1 January predicts the aggregate level of stringency to a greater extent than the length of time a country has been dealing with infections ('Days since first case'). This suggests that countries entering the pandemic later take decisions based in large part on what they have seen in the rest of the world. Specifically, such countries may take action earlier. The greater the number of deaths, the more stringent the actions. Having experienced the first death is moreover a strong positive predictor. A key variable is income per capita. The negative coefficient suggests that developing countries take stronger action, when controlling for the point each country is in the pandemic. This would be line with what was seen in Figure 5: higher elevations of the whole-index value in the last three sub-graphs relative to the Europe and Northern America sub-graph. Rich countries are more able to absorb the health shocks, and perhaps to lower the rate of infections through voluntary action, and hence they employ less stringent restrictions.

The remaining three columns of Table 2 bring in more explanatory variables, and the school and workplace sub-indicators as dependent variables. While a measure of hospital bed availability is positively correlated with stringency, the interaction of this measure and the income measure produces a negative coefficient. The net effect of the two coefficients is for more beds in a country such as South Africa to *reduce* the predicted stringency. For example, if South Africa's availability of beds increases from the 2.8 measure we currently have to 3.8 beds per 1,000 inhabitants, this is associated with an 25-point *drop* in the workplace stringency sub-indicator (see the note beneath the table on South Africa's 2.8 value). A greater ability to deal with expected hospitalisations thus appears to come with less stringency.

Turning to world regions, coefficients tend to be significant and positive as the reference region is Europe and Northern America where, conditional on other variables, stringency levels tend to be relatively low. The noteworthy exception is workplace restrictions in Sub-Saharan Africa, which tend to be low (this was also seen in Figure 5).

Table 2: Results of regression on index value

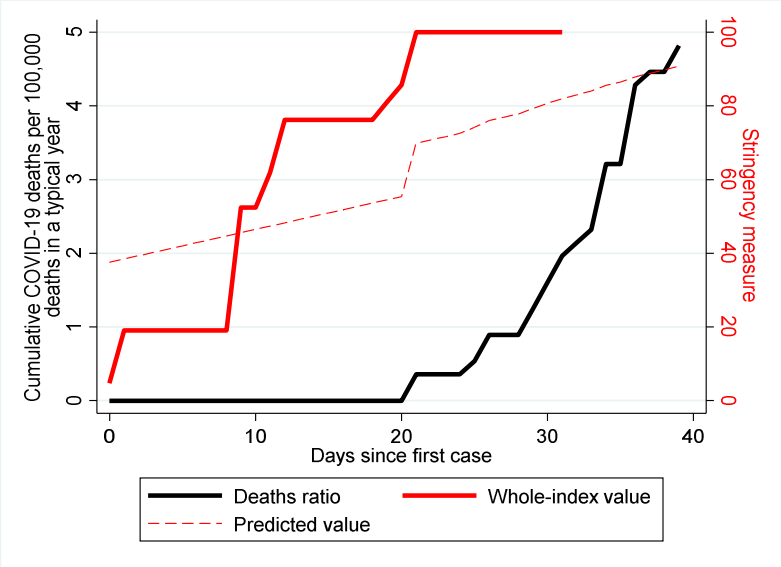
Dependent variable →	S Overall	S Overall	S1 School	S2 Workplace
Natural log of deaths ratio (with zero replaced by 0.1)	1.1***	1.9***	2.6***	3.0***
Whether the first death has occurred	18.1***	20.0***	26.6***	28.4***
Natural log of GDP per capita in PPP terms	-0.7**	0.3	-0.7	1.6***
Hospital beds per 1000 population		13.4***	18.3***	16.7***
Interaction of beds and income (above 2)		-1.2***	-1.6***	-1.6***
Days since first case	0.04**	-0.1***	-0.3***	-0.1***
Days since 1 January	0.9***	1.0***	1.3***	1.0***
Central and Southern Asia		8.8***	13.2***	0.3
Eastern and South-eastern Asia		11.1***	18.7***	4.2***
Latin America and the Caribbean		-1.5	-1.4	3.3***
Northern Africa and Western Asia		8.8***	16.3***	1.0
Oceania		3.8**	-14.1***	-6.3**
Sub-Saharan Africa		-0.2	9.1***	-18.2***
Adj. R-squared	0.581	0.647	0.550	0.483
N	5250	4779	4804	4754
Countries	127	113	112	112

*Note: *** indicates that the estimate is significant at the 1% level of significance, ** at the 5% level, and * at the 10% level. Variables not drawing from the OxCGRT source are income and hospital beds, which both use recent World Bank values. 169 country-specific hospital bed indicator values from no later than 2010 were available. South Africa only displayed an older 2005 value, of 2.8 beds per 1000 population. This 2.8 value is widely quoted in the literature but no more recent value could be found. This value was inserted into the dataset used for the analysis.*

The next three graphs depict actual stringency levels in South Africa, and what the three last regressions of Table 2 predict for South Africa, with predicted stringency levels capped at 100. Figure 8 suggests South Africa has been fairly typical when it comes to school closures, while

Figure 9 indicates that South Africa has been atypically stringent when it comes to restricting the workplace. Figure 7 moreover suggests that at the aggregate level, when taking into account all seven stringency sub-indicators, South Africa has been highly stringent.

Figure 7: Actual and predicted overall stringency in South Africa



Note: Red curves should be read against the right-hand vertical axis.

Figure 8: Actual and predicted SCHOOL stringency in South Africa

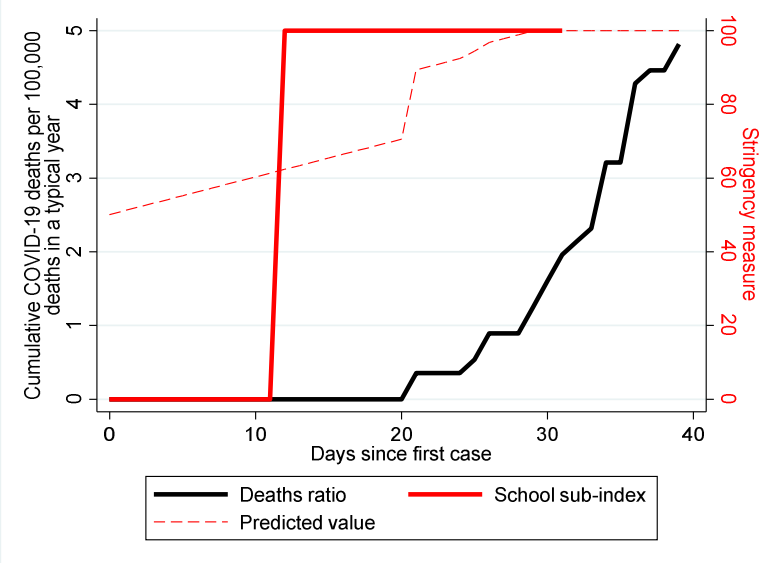
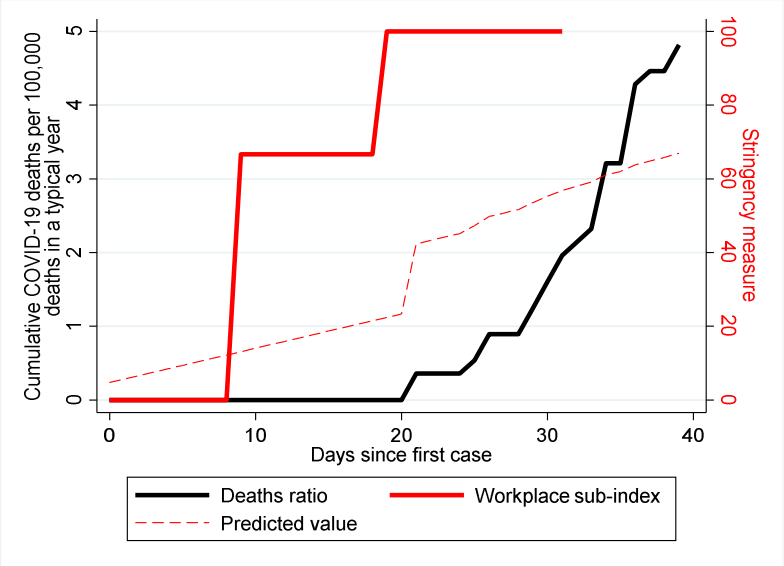


Figure 9: Actual and predicted WORKPLACE stringency in South Africa



3.3 How does the stringency of responses relate to Covid-19 pathways?

The first four graphs below illustrate the multitude of Covid-19 mortality pathways that different countries have experienced. The source is the OxCGRT dataset, which in turn uses WHO figures. South Africa's pathway, shown as a thick red curve in Figure 11 and Figure 13, is not unusually high or low. By day 18 after the first death, South Africa had registered 27 deaths. In Figure 11, of 93 countries where at least 18 days had lapsed since the first death, 42 had experienced more deaths than South Africa by day 18, while 50 had experienced fewer deaths. If one gauges South Africa's placement relative to deaths per 100,000 deaths expected anyway in 2020 (Figure 13), of the 91 countries[7] with data on day 18, 69 countries had a higher value than South Africa's 4.8, while 21 countries displayed a lower value. Thus, if one takes South Africa's population and typical deaths into account, South Africa is much closer to the bottom of the distribution than the top.

[7] For two countries, there was no data on expected non-pandemic deaths in 2020.

Figure 10: Cumulative deaths by country day – all values

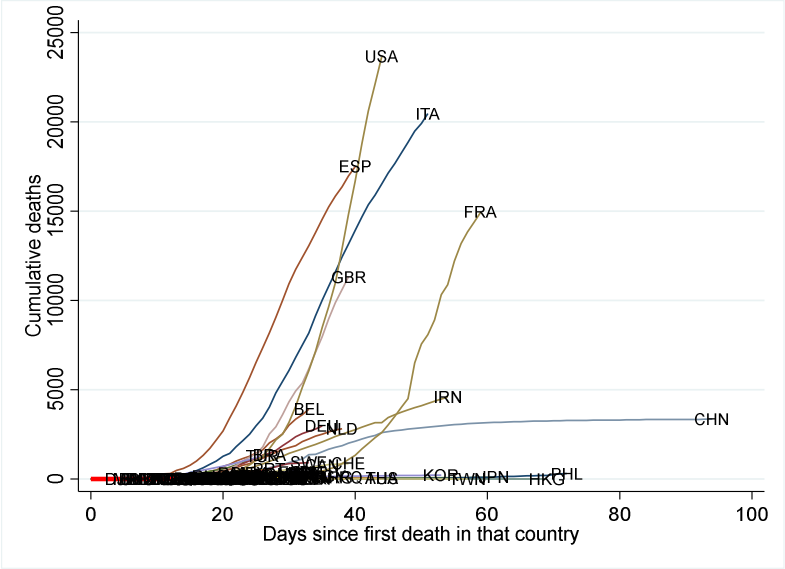


Figure 11: Cumulative deaths by country day – low values

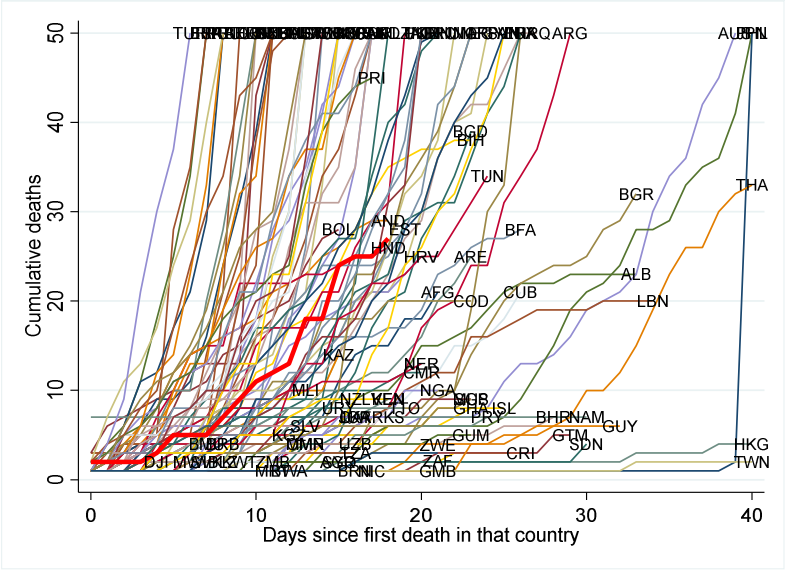


Figure 12: Deaths ratio by country day – all values

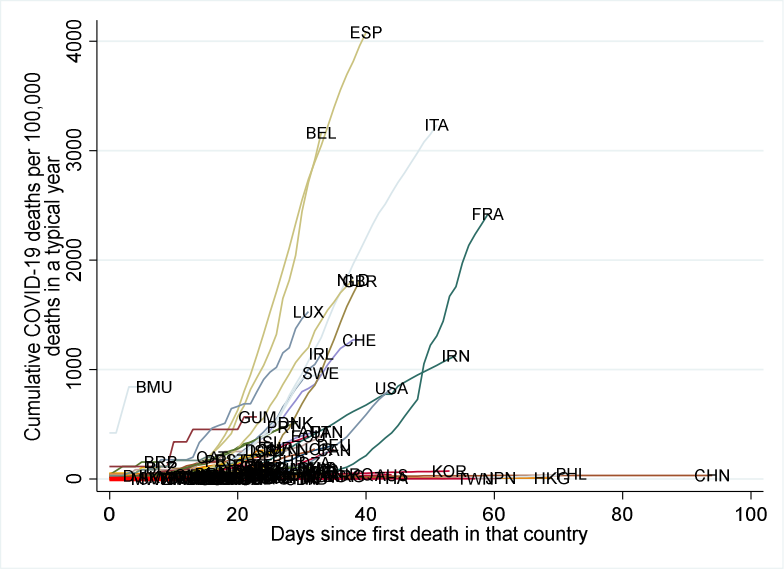
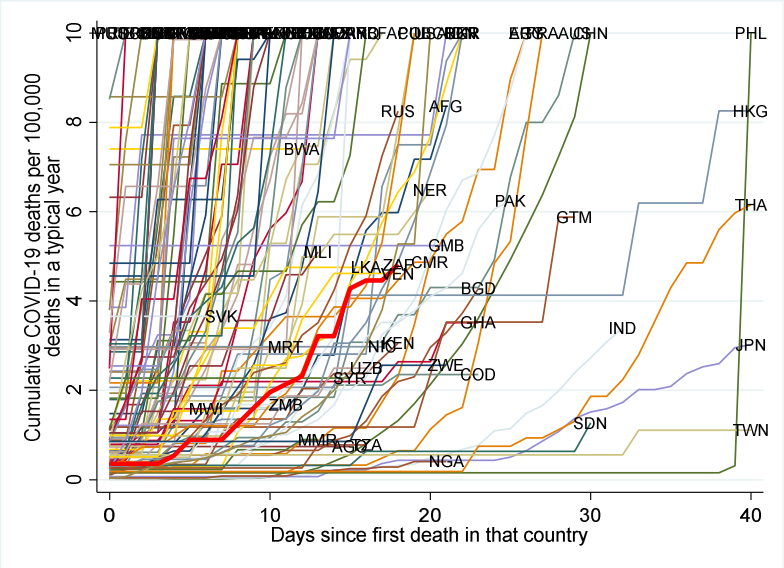
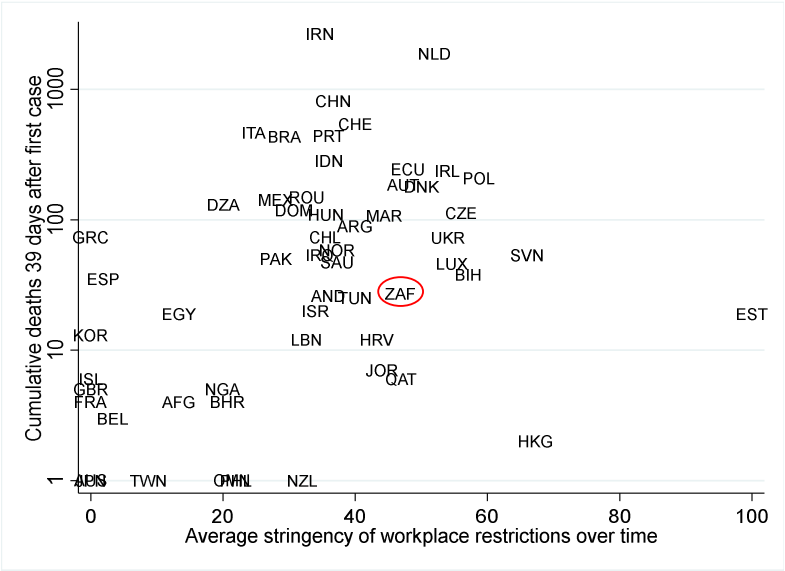


Figure 13: Deaths ratio by country day – low values



Clearly, a critical task in the coming months and years will be to use the OxCGRT data, and date like it, within analyses that attempt to identify how different movement restrictions, in different contexts, restrict infections. There are certainly no easily detectable trends in this regard in the current version of the OxCGRT data. A few analyses were attempted. Frequently, the result was the counter-intuitive finding that more stringency was weakly correlated with *more* deaths. This could be because causality is bi-directional. While restrictions are aimed at 'flattening the curve', countries may also ramp up restrictions in response to unexpectedly high rates of mortality. Figure 14 below illustrates the general problem. The horizontal axis in this case reflects the mean workplace stringency measure across 50 days in each country, the period being the 11 days before the first recorded Covid-19 case, and the 39 days thereafter. Only countries with a Covid-19 presence of at least 39 days were included.

Figure 14: Cumulative deaths and workplace restrictions



Note: The vertical scale is logarithmic.

4 Conclusion

The above analysis is preliminary both because the analytical approaches need to be further scrutinised, and because the OxCGRT data will reveal further patterns as the pandemic proceeds.

What seems confirmed at this stage is that certain types of restrictions are prioritised over others, in a manner one would expect. South Africa has pursued a particularly stringent approach, though according to the OxCGRT there are even more stringent implementers – for instance many Sub-Saharan African countries closed schools even earlier in the pandemic's country-specific trajectory.

An interesting finding is that when one controls for each country's point in both the world trajectory of the pandemic, and days after the country's first Covid-19 case, one finds that poorer countries have imposed the most stringent restrictions in general. Fewer hospital beds, relative to the population, emerges as a predictor of greater stringency, which presumably points to a willingness to sacrifice movements and the economy to an even greater extent when the risk of an overwhelmed health system seems greater.

There is a multitude of pathways that Covid-19 is currently taking within countries, with respect to the number of Covid-19 deaths. South Africa's placement among the pathways of the countries of the world is not unusual. Predicting how sensitive these pathways are to restrictions imposed by governments is hugely important, and will preoccupy analysts in the coming months and years. Datasets such as OxCGRT will be important for this work. Some very preliminary analysis done for the current paper points to the complexity of detecting meaningful correlations, let alone cause and effect.

References

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