Total containment of population and number of confirmed cases of COVID-19 in England, Belgium, France and Italy

G. Assoumou-Ella¹,²
¹) CIREGED, Omar Bongo University, Libreville, Gabon and ²) LEAD, University of Toulon, Toulon, France

Abstract

We analyse the impact of total population containment on the evolution of the growth rate of confirmed cases of coronavirus disease 2019 (COVID-19) by controlling the results by the situation observed in a country that has not applied this measure. We conducted a study of four European countries, England, Belgium, France and Italy, taking Sweden as a control country that did not confine its population. To do so, we use the interrupted time series method. Comparisons of the postintervention linear trends of COVID-19 confirmed cases from England, Belgium and France with that of Sweden show no statistically significant difference. Comparison of the postintervention linear trends of COVID-19 confirmed cases from Italy with that from Sweden shows a positive and statistically significant difference. It reflects a dynamic in the growth rate of confirmed cases in Italy higher than that observed in Sweden despite the total containment of the population. The results obtained therefore lead to the conclusion that the measure of total population containment is ineffective in the countries sampled. This suggests that the evolution of confirmed cases of COVID-19 could be the result of a combination of other factors and not specifically of total population containment.

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Introduction

Coronavirus disease 2019 (COVID-19), which was officially discovered in Wuhan, China, in December 2019, has affected not only infected but also uninfected people in most countries. Indeed, as of 27 November 2020 (https://www.worldometers.info/coronavirus/), there are 60 973 636 confirmed cases, 39 069 636 cures and 1 432 047 deaths worldwide.

In order to contain the progression of the virus, apart from medical care, social restriction measures have been taken by governments. Among these, total containment of the population has been presented as a flagship measure that can achieve this goal. In Western Europe, it has been applied in many countries, particularly in England, Belgium, France and Italy. Indeed, on 14 March 2020, England announced the total containment of its population. On 17 March France and Belgium did the same. Italy had already announced the total containment of its population on 10 March.

The application of this restrictive measure is based on the assumption that social distancing in times of epidemics slows the spread of the virus by limiting the number of contacts between infected and uninfected people. This assumption is based on the pioneering work of Kermack and McKendrick [1] and more recently of Vrugt et al. [2], who developed models showing the effectiveness of social distancing measures and isolation in slowing the spread of epidemics.

With the fear of a new rebound of the epidemic in many countries at present, total population containment is once again being evoked by some governments. However, the possibility of a return to total containment in several countries and the application of other social restriction measures are causing some concern, as is currently seen in demonstrations against the restriction of freedoms in many Western metropolises.

Corresponding author: G. Assoumou-Ella, CIREGED, Omar Bongo University, 680 Leon Mba Blvd, Libreville, Gabon.
E-mail: g.assoumouella@gmail.com
However, scientific research could shed some light on this. Indeed, if the effectiveness of total containment is scientifically proven, its implementation becomes legitimate, and vice versa. It therefore becomes important to analyse the effectiveness of the total containment measure implemented during the first act of the epidemic. To this end, existing work shows that in general, its implementation would have made it possible to flatten the contamination curve. In particular, Maier and Brockmann [3] showed that total containment was effective in mainland China using a parsimonious model that captures both the population of infected and symptomatic individuals placed in quarantine and the population placed in total containment. Similarly, Wong et al. [4] found that containment and the implementation of other restrictive measures have been effective in decelerating the increase in new daily cases of COVID-19 in 54 countries. However, this effectiveness would be less if containment is not implemented early and if health systems are not sufficiently developed [5].

The studies listed above analyse the effect of total population containment associated with a set of other restrictive measures on the evolution of the curve of confirmed cases in a country or group of countries without comparing the situation of these countries with that of countries that have not implemented total population containment. The originality of the present analysis is to evaluate the effect of a single restrictive measure, in this case total population containment, on the evolution of confirmed COVID-19 cases. To do so, a methodologic approach is required that compares the treated sample where the policy was applied and the untreated sample where the policy was not applied. It therefore leads to a comparison of the evolution of confirmed COVID-19 cases in countries that have applied the total population containment measure and the control country that has not applied the same measure. In our study, we compare the situations of England, Belgium, France and Italy with that of Sweden, which did not confine its population.

To do so, we use the interrupted time series method, which is often used to assess the effectiveness of public policies [6], the effect of new regulations [7] or the effectiveness of new health technologies [8]. In our study, we consider this method to be suitable for assessing the effectiveness of total population containment because it allows us to calculate the difference between postintervention changes in confirmed cases of COVID-19 in countries where total population containment has been applied and changes in confirmed cases of COVID-19 in the control country where total population containment has not been applied. For this purpose, we look at the statistical significance of the linear postintervention trends of COVID-19 confirmed cases. In other words, are the postintervention linear trends of COVID-19 confirmed cases that were observed during the period of total population containment in the countries where this policy was applied and in the control country where this policy was not applied statistically different?

Comparison of linear postintervention trends in COVID-19 confirmed cases conveys two main messages. Firstly, there is no statistically significant difference between the dynamics of the growth rates of the number of COVID-19 confirmed cases per day during the periods of total population containment in England, Belgium and France and the dynamics observed in Sweden during the same periods. Secondly, the dynamics of the growth rate of the number of COVID-19 confirmed cases per day during the period of total population containment in Italy is statistically superior to that observed in Sweden during the same period.

**Methods**

We model the difference in the dynamics of the growth rates of the number of confirmed COVID-19 cases in England, Belgium, France and Italy following the application of total population containment in these countries with that observed in Sweden, which did not contain its population using the interrupted time series method. Total population containment was implemented on 24 March 2020 in England, 17 March in Belgium and France and 19 March in Italy. In the model, these dates represent the start of policy intervention. The interrupted time series method has been used extensively in the literature to analyse the effectiveness of an intervention or policy implementation. In this regard, we draw on the work of Simonton [9], Huitema and McKeen [10], Linden and Adams [11] and Linden and Arbor [12,13]:

$$Y_t = \beta_0 + \beta_1 T_t + \beta_2 X_t + \beta_3 X_t T_t + \beta_4 Z + \beta_5 Z T_t + \beta_6 X Z_t + \beta_7 X Z T_t + \varepsilon_t, \quad (1)$$

where $Y_t$ is the growth rate of the number of confirmed cases of COVID-19 at time $t$, $\beta_0$ represents the level of the growth rate of the number of confirmed cases of COVID-19 before the application of total containment and $T_t$ is the time elapsed since the start of the pandemic. The coefficient $\beta_1$ that is associated to it gives an idea of the dynamics of $Y_t$ in the sample countries before the application of the policy, without comparison with the control country. $X_t$ is a dummy variable that takes the value 0 the period before the implementation of total population containment in each sample country and 1 during the period of containment. $Z$ is a dummy variable that represents the control country and gives the interaction terms $Z T_t$, $Z X_t$ and $Z X_t T_t$. The coefficients $\beta_2$, $\beta_3$ and $\beta_4$ make it possible to access the situation of confirmed cases of COVID-19 before the total containment of the population in the countries of the sample without comparison with the control country. On the other
hand, the coefficients $\beta_4$, $\beta_5$, $\beta_6$ and $\beta_7$ allow the situation to be assessed in comparison with the control country. Thus, the coefficient $\beta_4$ represents the difference in the constant, between the growth rate of confirmed cases of COVID-19 in the country where total population containment was applied and in the control country where this measure was not applied. The coefficient $\beta_5$ represents the difference in the slope (trend), between the growth rate of confirmed COVID-19 cases prior to the application of total containment, comparing the sample countries and Sweden which did not apply total population containment. The coefficient $\beta_6$ represents the difference in the level of the growth rate of confirmed COVID-19 cases, comparing the sample countries and Sweden on the first day of containment. Finally, $\beta_7$ represents the difference in the slope (trend) of the growth rates of confirmed COVID-19 cases, comparing the sample countries and Sweden, during the period of total population containment. In relation to the object of study of this work, it is the sign and statistical significance of the comparison of the linear postintervention trends, noted as Difference in Table 1, that allow us to conclude whether or not the measure of total population containment is effective. The data are taken from the European Centre for Disease Prevention and Control website (https://www.ecdc.europa.eu/en/publications-data/download-todays-data-geographic-distribution-COVID-19-cases-worldwide).

### Results and discussion

The results are presented in Table 1 and Fig. 1. As explained earlier, it is the sign and statistical significance of the coefficient of Difference in Table 1 that tells us whether or not the total containment of the population was effective. If the sign of the coefficient is negative and significant, then the situation has improved more in the country that has implemented the policy compared to the situation in Sweden and vice versa if the sign is positive and significant. On the other hand, if the coefficient is not significant, then the situation in both countries remained the same during the period of total population containment, regardless of the sign of the coefficient.

Thus, in order to have an overall appreciation of the comparative effect of total population containment on the dynamics of growth rates of confirmed COVID-19 cases, we look at the statistical significance of the estimated coefficients of Difference, which allows us to analyse the statistical significance of the comparison of postintervention linear trends. In this regard, there is no statistically significant difference between the postintervention linear trends in England, Belgium and France during the periods of total population containment in these countries and that observed in Sweden during the same periods. In addition, the difference in the postintervention linear trends for Italy and Sweden is positive and statistically significant at an error probability of less than 10%. This means that despite the implementation of total population containment in Italy, the dynamics of the growth rate of confirmed COVID-19 cases in that country was higher than that observed in Sweden, a country that had not applied the same policy. These results complement the existing literature on the effectiveness of total population containment. Indeed, while existing work shows that the curve of confirmed cases of COVID-19 flattens during the period of total containment [3,4], especially if the latter is applied very early [5], our results show that even if there may be some flattening of the curve, this is not necessarily due to total population containment because the same is observed in the control country that did not apply the same policy. Further, there is even a worsening of the situation in Italy compared to Sweden. To fully appreciate this lack of difference between the confined countries and Sweden, see Table 1.

As Fig. 1 shows, on the $x$-axis we have the time (days) and on the $y$-axis the growth rate of confirmed cases of COVID-19. The vertical and dashed column represents the date of the start of total population containment. The black dots represent the observed values of confirmed COVID-19 cases.

### Table 1. Results by country

| Characteristic | England | Belgium | France | Italy |
|----------------|---------|---------|--------|-------|
| $\text{Cst}$  | 0.881*** (0.387) | 1.112*** (0.481) | 1.112*** (0.481) | 1.255*** (0.559) |
| Time           | $\beta_4$ (0.026) | $\beta_5$ (0.046) | $\beta_6$ (0.046) | $\beta_7$ (0.046) |
| Level          | 0.032 (0.559) | -0.474 (0.672) | -0.409 (0.609) | -0.114 (0.312) |
| Trend          | 0.008 (0.039) | 0.062 (0.065) | 0.05 (0.057) | 0.138 (0.081) |
| Sweden (control) | 0.155 (0.178) | 0.224 (0.211) | 0.224 (0.211) | 0.221 (0.351) |
| Control × Time | 0.046 (0.026) | 0.087 (0.046) | 0.087 (0.046) | 0.122 (0.073) |
| Level × Control | $\beta_6$ (0.357) | $\beta_7$ (0.351) | $\beta_8$ (0.351) | $\beta_9$ (0.351) |
| Trend × Control | $\beta_5$ (0.039) | $\beta_6$ (0.065) | $\beta_7$ (0.065) | $\beta_8$ (0.065) |
| Difference     | $\beta_4$ (0.002) | $\beta_5$ (0.002) | $\beta_6$ (0.002) | $\beta_7$ (0.002) |

Values in parentheses are standard deviation. Statistically significant with **1% error, *5% error and +10% error. The value not in parentheses refers to estimated coefficients. Cst=Constant.
in the country that applied the measure and the black lines represent the values predicted by the model in that country. The circles represent the observed values of confirmed COVID-19 cases in Sweden and the dashed lines represent the values predicted by the model in that country. The graphical representation of the results shows that after the application of the total containment measure in the countries of the sample, the observed and predicted changes in the confirmed COVID-19 cases in each country plotted on the same graph with that of Sweden do not visibly show any difference, except for Italy. Indeed, the values observed in England, Belgium and France show broadly the same evolution as those observed in Sweden, without much dispersion. On the other hand, there is clearly a difference between Italy and Sweden; the values observed in Italy are globally higher than those observed in Sweden over time. Thus, in contrast to studies that do not use a control country in their analyses [3], our results lead to the conclusion that total population containment is somewhat inefficient.

**Conclusion**

Total population containment has been implemented in many countries affected by COVID-19 in order to contain the spread of the virus. An analysis of the situation in Belgium, England, France and Italy, countries that have implemented this policy, does not allow us to consider this tactic to be effective when comparing their situations with that of Sweden, which has not contained its population.

In addition to the existing literature, our results lead us to believe that the evolution of confirmed cases of COVID-19 could result from a set of other factors and not specifically from the total containment of the population. It could be
related to the awareness and behaviour of the population, the quality of care, the availability of screening tests, the climate, the ventilation of living and working places, the age of the population, the natural evolution of epidemics and so on. All these possibilities open up important research prospects.

Conflict of interest

None declared.

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