Effect of timing of implementation of the lockdown on the number of deaths for COVID-19 in four European countries

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https://github.com/CSSEGISandData/COVID-19/tree/master/csse_covid_19_data/csse_covid_19_time_series
Dear Editor,

the COVID-19 epidemic has rapidly evolved into a global health emergency. However, there has been a substantial heterogeneity in timing and magnitude of the public health response to the pandemic among different countries. A key factor in explaining why China was successful in curbing the epidemic is that the government implemented containment measures in the Hubei province in the very early phase of the epidemic. On the contrary, Europe has been slower in responding to the emergency. Lockdown in France, Italy, Spain and United Kingdom, the four European countries which have been impacted the most by the COVID-19 emergency, was enforced 13 to 16 days after the one in Hubei, when normalizing for the time when the outbreak hit 50 cases in all countries. This prompts the question on how many deaths for COVID-19 could have been avoided during the early phase of the pandemic, had containment measures in European countries aligned in timing with those adopted in China.

We modeled the daily number of COVID-19 deaths in France, Italy, Spain, and United Kingdom from January 23rd to August 15th. Data were downloaded from 2019 Novel Coronavirus COVID-19 (2019-nCoV) Data Repository. The time-series included a small amount of days in which the number of deaths was negative. We considered these figures as missing values and replaced them interpolating the number of deaths recorded in the previous and in the following day. We estimated the effect of the national lockdown implementing an Interrupted Time Series analysis. Specifically, for each country we modeled the time-series of daily deaths ($Y_t$) using the following quasi-Poisson regression model:

$$\log(Y_t) = \alpha + \beta_1 T + \beta_2 T_2 + e_t$$

where $T$ is the time elapsed since the start of the observation period (January 23rd); $T_2$ is the time elapsed since the implementation of lockdown (set to 0 before the lockdown); $Y_t$ is the number of new deaths at time $T$; $\alpha$ is the intercept of the model; $\beta_1$ represents the trend of new cases before the lockdown; $\beta_2$ is the slope change following the lockdown; and $e_t$ is the error term of the model.

To take into account COVID-19 incubation period and the mean time between the symptoms onset and death, we assumed a 18 days lag between the national implementation of the lockdown and the start of its effects. Then, we created four separate counterfactual scenario by predicting the daily number of deaths that would have been observed in the four countries if the lockdown had been implemented at the same time as in Hubei (3 days after the outbreak hit 50 cases). This time would correspond to the following dates: February 25th for Italy, March 2nd for France, March 3rd for Spain.
and March 6th for United Kingdom. Finally, we estimated the relative change in the number of total deaths in the counterfactual scenario, compared to the observed one. All the analyses were performed using the R software.

Figures 1-2 display the daily and total number of deaths in the four countries. As of August 15th, there were 31,174, 35,449, 30,731 and 41,361 deaths in France, Italy, Spain and United Kingdom, respectively. If an early lockdown had been implemented, the death toll would have been 2461 (95%CI: 1440 to 4272), 6769 (95%CI: 5652 to 8135), 6792 (95%CI: 4154 to 11525) and 4071 (95%CI: 3281 to 5067), corresponding to a 92% (95%CI: 86% to 95%), 81% (95%CI: 77% to 84%), 78% (95%CI: 62% to 86%) and 90% (95%CI: 88% to 92%) relative reduction, as compared with observed data.

We found that a more rapid and homogeneous response would have avoided a substantial number of deaths. Our results underline the need of strengthening public health emergency preparedness at national and global level. Currently, no health care system can sustain an uncontrolled epidemic of COVID-19 or similar disease. Community containment measures are still the most important interventions to minimize the health impact of a possible second wave of infections, avoiding unnecessary loss of lives.
References

1. Center for Systems Science and Engineering (CSSE) at Johns Hopkins University. 2019 Novel Coronavirus COVID-19 (2019-nCoV) Data Repository. 2020 [cited 20/08/2020]; Available from: https://github.com/CSSEGISandData/COVID-19/tree/master/csse_covid_19_data/csse_covid_19_time_series
2. Li C, Romagnani P, von Brunn A, Anders HJ. SARS-CoV-2 and Europe: timing of containment measures for outbreak control. Infection 2020.
3. Blavatnik School of Government, University of Oxford. CORONAVIRUS GOVERNMENT RESPONSE TRACKER. 2020 [cited; Available from: https://www.bsg.ox.ac.uk/research/research-projects/coronavirus-government-response-tracker
4. Palladino R, Bollon J, Ragazzoni L, Barone-Adesi F. Excess Deaths and Hospital Admissions for COVID-19 Due to a Late Implementation of the Lockdown in Italy. Int J Environ Res Public Health 2020; 17.
5. Bernal JL, Cummins S, Gasparrini A. Interrupted time series regression for the evaluation of public health interventions: a tutorial. Int J Epidemiol 2017; 46: 348-55.
6. Zhou F, Yu T, Du R, et al. Clinical course and risk factors for mortality of adult inpatients with COVID-19 in Wuhan, China: a retrospective cohort study. Lancet 2020; 395: 1054-62.
Figure 1 - Observed (gray points), fitted (black line) and predicted (dashed line) number of new deaths in France, Italy, Spain and United Kingdom, assuming an early implementation of the national lockdown (3 days after the outbreak hit 50 cases in each country). Observed points were averaged over 3 days.
Figure 2 – Observed (gray points), fitted (black line) and predicted (dashed line) total number of deaths in France, Italy, Spain and United Kingdom, assuming an early implementation of the national lockdown.