

# THE LANCET

## Supplementary appendix

This appendix formed part of the original submission. We post it as supplied by the authors.

Supplement to: Mitjà O, Arenas A, Rodó X, et al. Experts' request to the Spanish Government: move Spain towards complete lockdown. *Lancet* 2020; published online March 26. [http://dx.doi.org/10.1016/S0140-6736\(20\)30753-4](http://dx.doi.org/10.1016/S0140-6736(20)30753-4).

# Supplementary Appendix

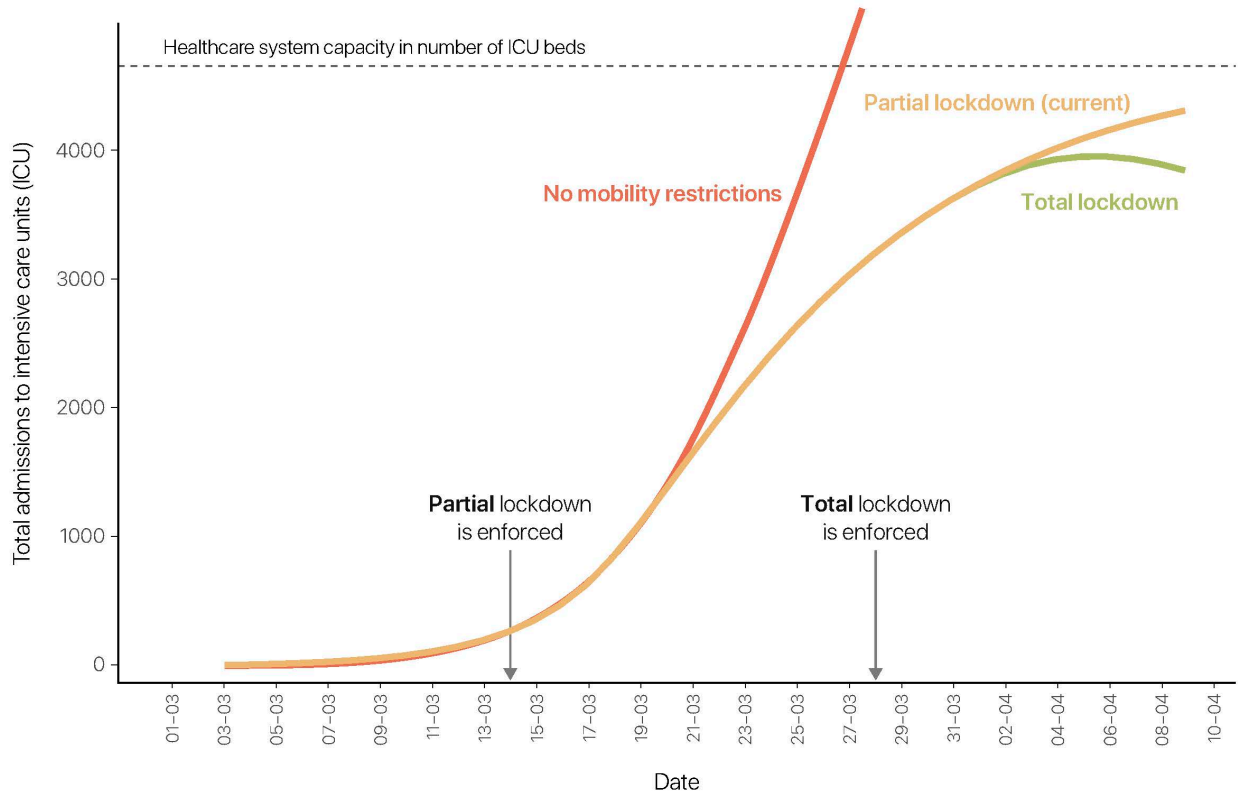
This appendix has been provided to give readers additional information about their correspondence.  
Supplement to: Mitjà O, Arenas A, Rodó X, Tobias A, Brew J, Benlloch JM. Spain needs to move towards complete lockdown. Experts' request to the Spanish Government. Lancet.

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## Supplementary material – Figures

Figure 1 – Progression of the number of patients who will require hospitalization in intensive care units (3 scenarios)



Credit – Clara Granell

Figure 2. A) Accumulative number of cases by Autonomous Community since start of the epidemic.

Number of confirmed cases  
Data as of 2020-03-25

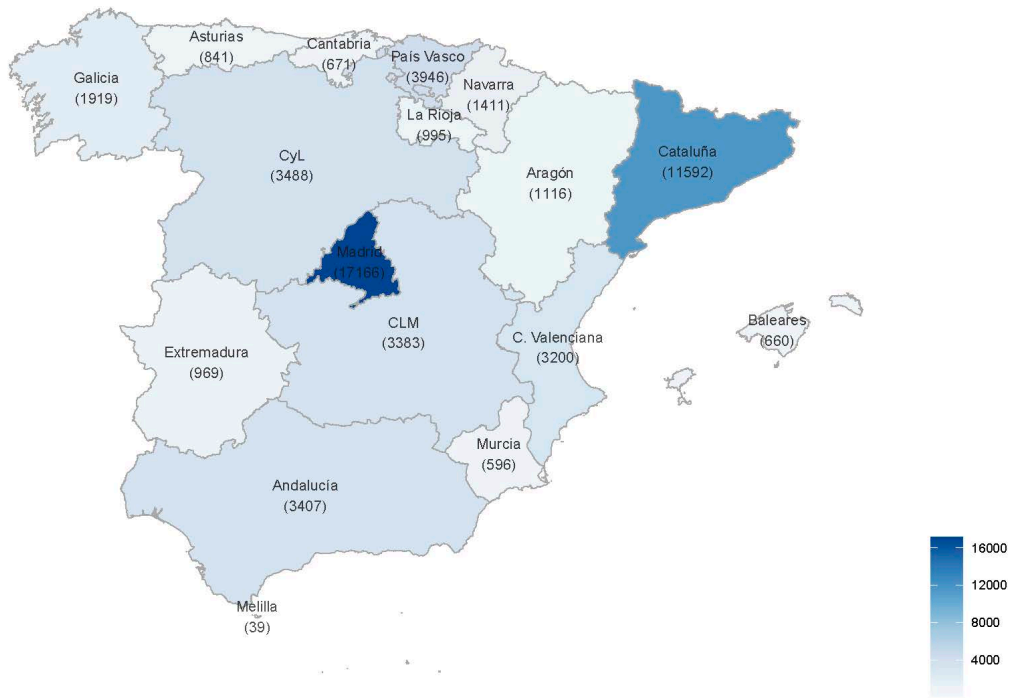
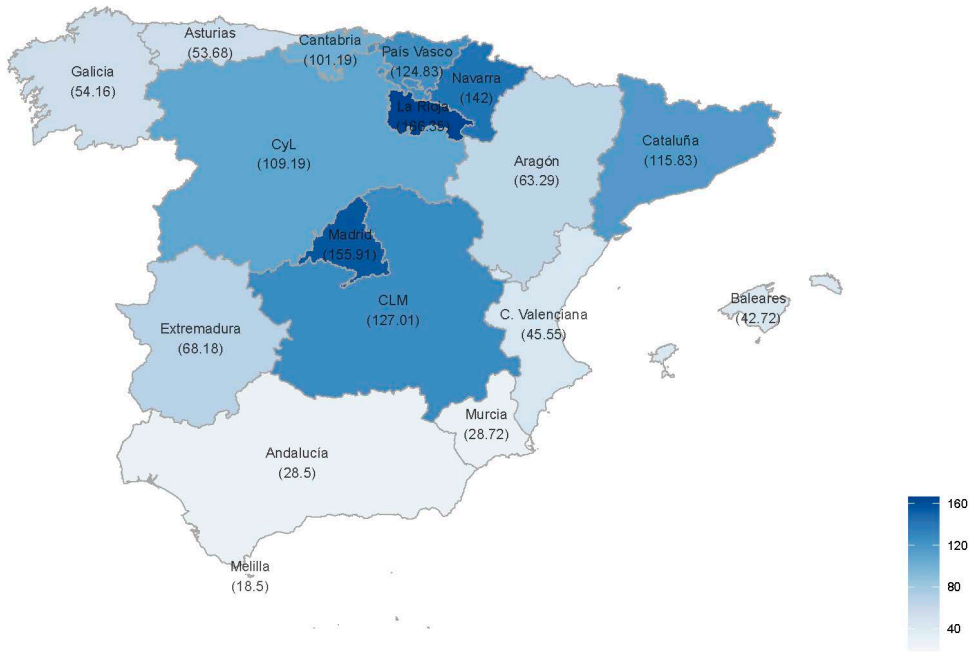


Figure 2. B) Number of cases (7 most recent days) adjusted by population: polygons

Number of confirmed cases per 100,000  
Data as of 2020-03-25



Cumulative incidence over the week from 2020-03-19 through 2020-03-25

Credit – Joe Brew

## Supplementary material – Mathematical model

The simulation was conducted using the last version of a family of discrete-time epidemiological models,<sup>1</sup> specifically tailored to describe the transmission dynamics of SARS-COV-2, the etiological agent of COVID-19. The model aims to estimate the risk rate for each Spanish municipality, considering the following parameters: (1) the transmission dynamics of SARS-COV-2, (2) the usual movement patterns of the Spanish population, and (3) the demographics of the Spanish population.

### Transmission dynamics

Virus transmission was described using a compartmental model that groups the population according to the infection status into the following categories:

- **Susceptible:** individuals without COVID-19, but still at risk.
- **Exposed:** infected individuals within the incubation phase and no transmission capacity.
- **Asymptomatic:** infected individuals without clinically relevant symptoms but transmission capacity.
- **Infected:** individuals with symptoms that are likely to be attributed to COVID-19.
- **Hospitalized:** infected individuals who have been identified and admitted to a hospital, thus blocking the transmission capacity.
- **Recovered:** individuals who have been infected but cannot transmit the disease because they have either died or recovered and developed immunity.

### Movement patterns of the Spanish population

Transitions between the infection states drive the probabilities of transmission, recovery, etc., obtained from COVID-19 studies published to date. Regarding movements, we have included data from the National Institute of Statistics (NIS) on travel to the workplace between and within towns.<sup>2</sup> The NIS record includes all movements between Spanish municipalities greater than 100 inhabitants and reporting more than 10 trips. The inclusion of individual movements into the model is essential to understand how the virus spreads across the country and allows simulating the outcome of movement restrictions both globally and locally.

### Spanish demographics

The Spanish population has been divided into three age groups:

- Young (from 0 to 25 years old).
- Adult (from 26 to 65 years old).
- Older (more than 65 years old).

The rationale for age grouping has been based on the recent evidence on COVID-19 that shows a different effect of the infection in each age group.<sup>4</sup> In our model, the following differences between age groups have been considered:

- Young and older are less likely to move across the territory than adults.
- Young are more likely to experience an asymptomatic disease (or with mild symptoms) and are, therefore, more challenging to identify.
- Older people are more likely to require hospitalization than young and adults.

### Limitations

- The model does not predict or consider international inputs of infected individuals.
- The model has been based on epidemiologic parameters reported to date; however, these parameters may change in the near future.
- The model assumes the movement data reported by the NIE, which may vary in case of mobility restrictions.

### Strengths

- The model allows modifying the epidemiologic parameters as new reports come up.

- The model allows for investigating the influence of the asymptomatic period and associated infectivity.
- Based on the current parameters, we can build risk maps of new cases and foresee infection spread by asymptomatic subjects.
- General mobility restrictions can be quickly introduced into the model to yield new predictions with these assumptions. This feature is of particular interest for policymakers and health authorities, which will be able to explore the foreseen impact of the previewed restrictions on infection spread.

### **References**

1. Soriano-Panos D, Lotero D, Arenas A, Gomez-Gardenes J. Spreading processes in multiplex metapopulations containing different mobility networks, *Physical Review* 2018, X8, 031039.
2. Soriano-Panos D, Ghoshal G, Arenas A and Gomez-Gardenes J. Impact of temporal scales and recurrent mobility patterns on the unfolding of epidemics, *Journal of Statistical Mechanics: Theory and Experiment* 2020; 2, 024006.
3. Gomez-Gardeñes J, Soriano-Paños D, Arenas A. Critical regimes driven by recurrent mobility patterns of reaction-diffusion processes in networks, *J Nature Physics* 2018 14, 391–395.
4. Wang D, Hu B, Hu C, et al. Clinical Characteristics of 138 Hospitalized Patients With 2019 Novel Coronavirus–Infected Pneumonia in Wuhan, China. *JAMA* 2020;323(11):1061-1069.

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