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Brief Overview on the COVID-19 Pandemic in Spain

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Abstract

We analyze the evolution of the COVID-19 pandemic in Spain. Several numerical methods and models are studied to understand how the evolution of this pandemic is referenced. We also justify the adjustments that we have made in order to interpret the public data supplied by the Spanish Government. Finally, we present some of the lessons learned so that we way carry out early actions when we are immersed in similar pandemics.

Keywords: Pandemic; Numerical simulation; SIRD model; Mathematical modeling

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Description

Since the emergence of the coronavirus (SARS-CoV-2) in December 2019 in China and its spread worldwide, humanity has suffered one of the worst known pandemics to date. The disease caused by this virus was called COVID-19 by the World Health Organization (WHO), and as of May 2021, it has caused the infection of 150 million people and the death of approximately 5 million of these people. In Spain, there have been 3,678,390 confirmed cases and 79,953 deaths [1].

In this work, we analyze the development of the COVID-19 pandemic in Spain by adjusting several existing mathematical models to describe the evolution of infections. For the most part, we use the analysis carried out in the paper "A Modified SIRD Model to Study the Evolution of the COVID-19 Pandemic in Spain" [2], which describes the evolution of this pandemic during the first wave suffered in Spain during the months of March and April 2020. We consider that a wave of the pandemicoccurs when the number of infections reaches a maximum in a finite period of time, followed by and decrease.

Models of Infectious Disease Dynamics

The SIRD model

The SIRD model was proposed in 1927 [3] by Kermack and McKendrick; since then, it has been widely used [4-9]. This modelconsiders four types of people:

(S) Susceptible: the people who could become infected.

(I) Infected: the people who are infected at that moment.

(*R*) Recovered: the people who have had the disease and are now healthy.

(*D*) Deceased: the people who have died of the disease.

It is governed by the following system of differential equations given by

$S'(t) = -\beta S(t)I(t)$

$I'(t) = \beta S(t)I(t) - \alpha I(t) - \gamma I(t)$

$R'(t) = \alpha I(t)$

$D'(t) = \gamma I(t)$

Where α is the recovery rate, β is the infected rate and γ is the death rate, all of them per unit of time. It shows typical behavior, as indicated in **Figure 1**.

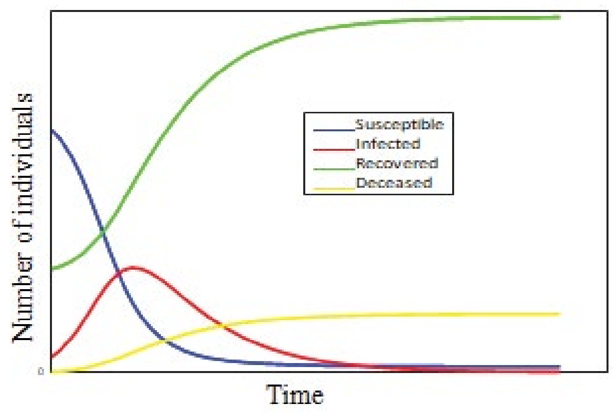

Figure 1: Typical behaviour of an epidemic's evolution over time.

The paper "A Modified SIRD Model to Study the Evolution of the COVID-19 Pandemic in Spain [2], described the adjustment of this model to the first wave of the COVID-19 pandemic in Spain. This work led to the following conclusions:

- The SIRD model, like others, is strongly dependent on the initial data used to adjust the parameters. It also depends on thepeople exposed to the virus, i.e. the variable *S,* susceptible people. Depending on the strictness of the isolation measures, this variable may be significantly higher or lower at each stage of the pandemic.
- The precision of the estimated parameters is determined by theoretical reasoning. The paper shows the evolution of the reproduction number during the latency period, which is very helpful for understanding the evolution of the epidemic.
- The model allows us to make short-term predictions, which are useful for making decisions that reduce harmful effects, for example, to reduce the number of deaths using quarantine [10]. Since the data is change, if we adjust the parameters according to the restrictions imposed in each case, a more appropriate global behavior can be observed.
- The paper shows the fit of a piecewise estimate at each stage, considering changes in conditions during the evolution of theepidemic. The model allows us to adjust the parameters in real time when the disease is latent. Given the simplicity withwhich its parameters can be calculated, the model can be easily adapted for similar infections.

Interested readers can find a great deal of detail on these findings in the paper "A Modified SIRD Model to Study the Evolution of the COVID-19 Pandemic in Spain" [2].

Other models

There is a wide variety of models to study of the COVID-19 pandemic in the scientific literature: using Bayesian and stochastic techniques [11-13], including mobility, confinement and quarantine, fractional models, and logistic models, among others [14-18]. In particular, show similar behaviors in the estimates [11-12].

Update of the Pandemic Data since May 2020

After the first wave, which was the most unexpected, four more waves arrived. The data are shown in **Figures 2 and 3**, in which it can be seen that the maximum number of deaths occurred several days after the maximum number of infections. The surprising thing is that during the first wave, more deaths occurred with fewer infections. This could be explained by the low number of tests carried out during the first wave, which indicates that the number of infections reported was much lower than the actual number that existed during those dates.

Due to the worsening of the situation during the second wave, on October 25, 2020 the Spanish Government decreed another state of alarm [19] on October 25, 2020, imposing restrictive mobility measures. On Sunday, May 9, 2021, this state of alarm ended, primarily due to the successful implementation of vaccination program. The success of vaccines in combating the COVID-19 pandemic worldwide deserves a particular mention. Since December 2020 and after a year of global research, there are already four vaccines that have been authorized by the European Medicines Agency (EMA) for inoculation in Europe: Pfizer-BioNTech, Moderna, AstraZeneca and Janssen.

On Sunday, December 27, 2020, the first dose of the Pfizer vaccine was administered in Spain. From then until May 12, 2021, the number of doses of vaccines administered was reached 18,032,517, and 9,221,285 people had received the full dose. These amounts are increasing at a good pace and it is expected to reach 70% of the population of Spain will have been vaccinated by the end of the summer of 2021. It is worth mentioning that in June 2021 a new vaccination record was broken in Spain: 624,261 doses in 24 hours.

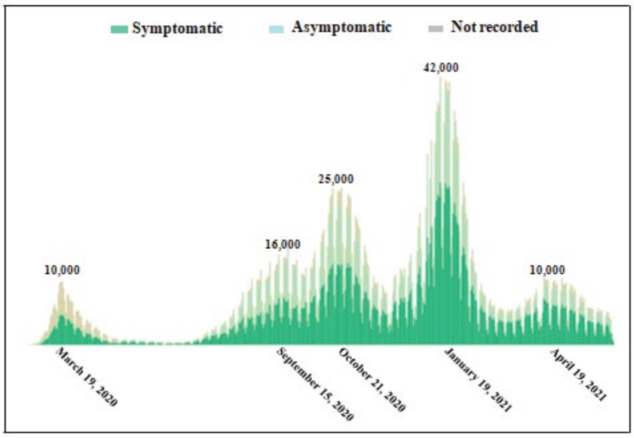

Figure 2: Confirmed daily cases of COVID-19 in Spain (May 30, 2021). Source: Spanish Government on 31 May 2021.

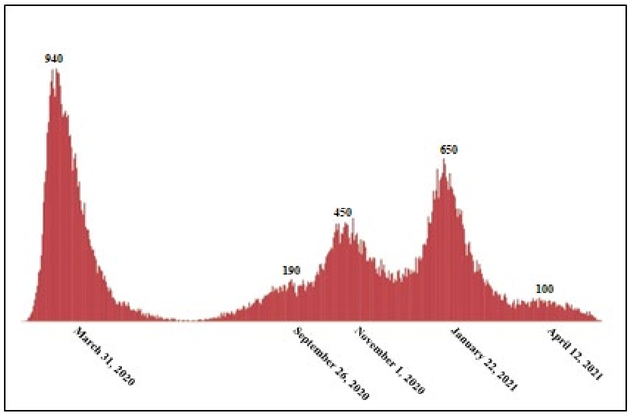

Figure 3: Number of daily deaths from COVID-19 in Spain (May 30, 2021). Source: Spanish Government on 31 May 2021.

As a final reflection, we will compare the COVID-19 pandemic with the Spanish flu pandemic that took place between 1918 and 1920 [20-22]. This terrible pandemic left more than 40 million victims worldwide, and Spain was one of the most severely affected countries, with 8 million people infected and 300,000 dead. In today's society, with the interconnections that exist in aglobalized world, the pandemic could have caused more damage, but health and technological resources are far superior those of the early twentieth century. However, the only existing measures that have been effective then and now are isolation measures (quarantine). This is the only measure that can reduce the number of people susceptible to infection with the disease(variable *S* of the SIRD model) [15,23-25] and therefore stop its expansion and the consequent deaths [10]. Perhaps the only thing that differentiates us now from then is that the greater research capacity and worldwide collaboration have made it possible to obtain vaccines in just one year, a milestone that would have been impossible to achieve in 1918 [26-36].

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