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The hearth of mathematical and statistical modelling during the Coronavirus pandemic

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In December 2019, news emerged about a new flu-like virus affecting people in the city of Wuhan (China). Unfortunately, the virus quickly spread with an exponential increase in the number of confirmed cases in just a few weeks. Despite the strong efforts to contain the virus in Wuhan, it quickly spread to other regions of China, and soon, to other countries in Asia. In January 2020, the World Health Organization (WHO) officially renamed the virus as severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) and the disease as Coronavirus disease 2019 (COVID-19) [1].

Since clusters of COVID-19 positive patients were identified in mid-February 2020 in northern Italy, the number of confirmed cases in Italy has been increasing very rapidly. Five weeks after the first registered patient, on 27 March 2020, over 86,498 positive cases have been identified, with a death toll of 9,134. At this point, most deaths have occurred in the elderly, a generation which is of invaluable importance to the younger generations, not only as objects of affection, but also as part and parcel of daily life. The Lombardy region has had the highest number of patients with COVID-19 in Italy, and appears to be the epicentre of the Italian outbreak [2]. Every evening at 6 pm, the Italians gather in front of their television to follow the updates from health and civil officials, a new ritual officiated by the priests of science, who as modern-day haruspices, try to decipher the data and stick to the percentages in an attempt to rid the people of their fears. Every day, these data become the subject of statistical and epidemiological analyses. However, how reliable are these numbers, and what do they reveal? Even if, first, it would abolish the daily evening ritual of numbers, a few glimmers of hope can be seen since the Italian lockdown appears to be producing a few results. Some researchers are analysing the data with the Poisson regression model, others with the exponential or logarithmic scales. Regardless of the method of choice, in short, the results of all statistical analyses and mathematical models are always the same: stay at home!

We know very well that mathematical and statistical modelling offers a valuable tool to comprehensively analyse the dynamics of infectious diseases, which reflect population behaviour, the availability of public healthcare resources and effectiveness of public health interventions (such as social distancing) [3]. In the early stages of a new infectious disease outbreak, the transmission dynamics of the infection should be fundamentally understood. Transmission dynamics could offer an insight into the developments in other countries and could determine whether or not the outbreak control measures are exerting a significant effect. However, there are several challenges to such analyses: a delay in symptomatic presentation resulting from the incubation period, the high proportion of unreported cases resulting from limited detection and testing capacity. Furthermore, data sources might be biased, incomplete or only capture certain aspects of the outbreak dynamics [4]. Epidemic curves are time-series data of the number of infected patients per unit time. They are an essential indication for the seriousness of an epidemic as a function of time. During the preliminary growth phase, the cumulative cases follow on a logarithmic-linear scale an approximately linear relationship with time. Consequently, in the linear range, the number of deaths grows exponentially with time. The number of deaths per unit time is described in the mortality curve and reveal a similar pattern with an approximately exponential growth during the initial phase of the outbreak [5]. The meaning, on the other hand, is different from the logistic function parameters. The logistical model has been widely used to describe the growth of a population. Similarly, an infectious outbreak can be seen as the growth of a pathogenic agent. Thus, a logistic model seems reasonable since the spread of an infection will stop in the near future [6]. However, several days after the beginning of the disease outbreak, the logistic curve better fitted the description of an infection. The number of persons infected before the end increases, the maximum numbers of new infections often occur on the current or the next day. Although the logistic model appears to be the most sensible one, the shape of the curve would probably shift due to external influences, such as government lockdown actions. Therefore, the prediction models will start to become useful only within a few weeks, presumably after the infection peak [6]. The ability to understand the effectiveness of lockdown measures in different settings will be crucial in comprehending

the dynamics of the epidemic, and increase the likelihood of containing or effectively mitigating the transmission of SARS-Cov-2 [4]. On the other hand, the statistical and mathematical models could also analyse the effectiveness of a protection strategy of respiratory protective devices (e.g. face masks) in reducing the spread of infection via inhalable droplets [7].

Nonetheless, as rightly pointed out by the scientist 'Alberto Bardelli', a genome of 30,000 base pairs of ribonucleic acid (RNA) virus has effectively divided the continents and produced a significant shock to our financial systems. It is no wonder that it is so challenging to decode cancer which has 100,000 times as many base pairs [8].

Since World War II, there has been no greater challenge towards our countries, and nothing has depended so much on our solidarity than what we are facing today. In his books, the novelist 'Giovannino Guareschi' (1908–1968) described 'Don Camillo', a hot-headed priest in a small rural city in the Po valley (northern Italy), after World War II, who was continuously at odds with the communist mayor. In the story, a flood completely devastated the region [9]. In a church which was standing on the completely flooded country, Don Camillo sent a message of comfort and hope to the displaced population: 'it is not the first time that the river invades our houses, but one day the waters will retreat, and the sun will return to shine. Then, we will remember the brotherhood that united us in these terrible hours and with the tenacity that God has given us, we will start fighting again for the sun to be more shining, for the flowers to be more beautiful and, for the misery to disappear from our cities and villages. We will forget the discord, and when we want death, we will try to smile; so that everything will be easier, and our country will become a small Heaven on Earth' [https://youtu.be/AWH3v6b5LQI (in Italian)].

Let us hope that the flood of COVID-19 would soon retreat, and the sun will return to shine upon our beautiful countries without us forgetting these terrible days.

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