Modelling in the times of COVID-19

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Abstract. One of the greatest strengths of nonlinear dynamics is its ability to reproduce qualitative aspects of a phenomenon using extremely simplified equations that capture the basic dynamics behind the data. On the other hand, its most important weakness is precisely its ability to reproduce qualitative aspects of a phenomenon using extremely simplified equations that capture the basic dynamics behind the data.

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During the 2020 pandemic of COVID-19, thousands of data scientists, engineers, applied mathematicians and physicists turned to the literature and discovered simple epidemiological models, like the celebrated SIR model by Kermack and McKendrick [1]. In this model, a population is partitioned in compartments (susceptible, infected, and recovered), and the rate of change of the variables describing the relative size of each population was prescribed by a system of ordinary differential equations. The highest nonlinearity in the model is a quadratic one, used to account for the encounters between susceptible and infected subjects. Only two parameters are needed, accounting for the recovery time of the infected population and how infectious the pathogen is. The model, with its breathtaking simplicity, was capable of reproducing the temporal evolution of the weekly deaths from plague in the island of Bombay from December 17, 1905, to July 21, 1906. That event, with minimal pharmaceutical or non-pharmaceutical interventions, in an ambient which could be considered homogeneous, could be captured with extreme elegance and minimal fitting effort by the 3D SIR model.

Since that seminal work by Kermack and McKendrick, a sound branch of epidemiology devoted to the elaboration of richer models: more compartments, the use of stochastic models to reproduce the dynamics when the number of infected people is small, multi-agent strategies to properly describe the complex network of social interactions, just to mention a few directions in which the field grew. A vast and complex literature which was hard or almost impossible to absorb by thousands of scientists that jumped to model the COVID-19 pandemics this year, and who had weeks to catch up as the disease spread across continents. Hundreds of manuscripts where simple SIR, SEIR, or other homogeneous models were fitted with an early number of cases flawed editorials, archives, or even social media. Competent reviewers were overloaded, and the whole peer review system was saturated with simple exercises which addressed little of the real challenges that this particular disease was offering. Again, that even the simplest models could offer ‘epidemic peak looking’ solutions were misleading for non-experts, who were not warned on the limitations of the models, the underlying hypotheses behind them, or the uncertainties of their predictions. That had (and will have) serious consequences, as diverse and contradictory predictions emerged from the scientific community to politicians and communicators.

In some cases, well intended scientists felt this was one opportunity to give back to the society for the privilege of working on basic science. In other cases, this pandemic was seen as an opportunity to show the power of disciplines usually under-funded, as applied mathematics and modelling. Others followed grant money, and may be many more jumped to the field by a mixture of all these motivations. But whatever the reason, some of the work seen in modelling this event reminds us of the Dunning–Kruger effect: the cognitive bias in which people learning to perform a task overestimate their ability [2]. In figure 1 I show a schematic that caricatures this effect by displaying a variable quantifying ‘confidence’ as a function of another one measuring ‘competence’. The sharp peak at small ‘competence’ is followed by a deep valley. Consistent with this ‘effect’, epidemiologists were challenged by the extremely
complex circumstances surrounding this epidemic event: global connectivity, instantaneous information across the globe, permanent application of non-pharmaceutical measures, as well as extremely non-homogeneous focuses. Their perplexity is proportional to the productivity of less informed colleagues who, in many cases, communicated their results through non-refereed sites, or social media. In this way, journalists and policymakers ended up quoting the work of scientists, yes, but unaware that the work they were quoting had not been passed through any of the filters of the scientific system.

This pandemic event will leave uncountable lessons. On epidemic dynamics, on the modelling of complex systems, on this particular epidemic, on the role of non-pharmaceutical measures... among so many other ones that we had to learn in this unique, unprecedented global experience. To the list of homework, we will need to review how the scientific community, as well as the system of scientific communication, responded to the challenge. Let us hope we have a long time to prepare for the next global challenge, and that by then, we have learned our lessons.

References