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# From descriptive epidemiology to interventional epidemiology: The central role of epidemiologists in COVID-19 crisis management

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The topic of epidemiological modeling in the context of the COVID-19 pandemic has not only been central to many scientific developments but also, and perhaps most importantly, has had very strong direct implications for crisis management. The search in the PubMed database with the keyword "epidemiological model covid" retrieved 1,669 scientific publications published between September 2020 and February 2022!

In April issue, *Anaesthesia Critical Care & Pain Medicine* is publishing a series of updates describing the extent to which clinical epidemiology has been an indispensable tool in the management of the health crisis in France, in Europe and more generally, around the world.

### **Toward an interventional epidemiology?**

The COVID-19 pandemic has certainly been exceptional, but it is not the first global health crisis in our modern history. Indeed, the H1N1 pandemic in 2009(1) and the Ebola epidemic in West Africa in 2013-2016(2) were recent opportunities to increase the interest in epidemiological modeling, as mentioned by Crépey et al. in their contribution to this issue(3).

The compelling need to develop epidemiological models was first identified in a report by scientists at Imperial College at the end of February 2020 (4), as discussed by Sofonea et al. in this issue. (5)

During the COVID-19 pandemic, epidemiological models have become the cornerstone of crisis management, as they made it possible to better understand the spread of SARS-CoV-2, to predict future risk and to assess control strategies. These models have allowed us to stay one step ahead and thus to better adapt our capabilities for the management of COVID-19 patients. From then on, epidemiological tools have been used not only to describe the pandemic but also to support crisis management decisions. [Table 1](#) summarizes the main fields of interventions for epidemiological modeling in the context of the management of the COVID-19 pandemic.

**Table 1.** Main areas of epidemiological modeling interventions in the management of the COVID-19 pandemic

<p><b>1. Forecast impact on health care</b></p> <ul style="list-style-type: none"> <li>- Adaptation of COVID health care offerings</li> <li>- Maintenance of a minimum capacity for non-COVID health care</li> </ul>
<p><b>2. Decision support for mitigation measures</b></p> <ul style="list-style-type: none"> <li>- Effects of social distancing measures (including school closures)</li> <li>- Determination of exposures associated with COVID-19 infections</li> <li>- Limiting admission to public facilities</li> <li>- Hospital admission rules to limit nosocomial infections</li> </ul>
<p><b>3. Modeling of a strategic medical evacuation plan</b></p> <ul style="list-style-type: none"> <li>- Definition of a threshold for triggering the plan</li> <li>- Definition of the number of people to be evacuated</li> </ul>
<p><b>4. Decision support for COVID vaccination policies</b></p> <ul style="list-style-type: none"> <li>- Determining priority audiences</li> <li>- Development of a booster dose administration strategy</li> </ul>
<p><b>5. To predict the effects of pharmacological interventions using within-host models of SARS-CoV-2</b></p>

Numerous epidemiological studies have focused on determining the exposures associated with COVID-19 infections (6), with the idea of obtaining decision support tools for enhanced and targeted control of these exposures to limit the spread of the virus. As pointed out by Colosi et al., school closures have been a widely used measure in the first year of the pandemic for this purpose. (7) However, the impact of these school closures has not been negligible for children’s wellbeing and mental health, and modeling work specifically studying school closures has helped determine a balance between controlling the spread of the virus and maintaining a satisfactory educational offering.

The impact on hospitals by the COVID-19 pandemic was threefold: an influx of patients with COVID-19, a significant risk of nosocomial infections, and an impact on health care professionals, causing absenteeism. Particular efforts regarding modeling nosocomial transmission have been made, allowing for a better understanding as discussed by Opatowski et al. in their contribution to this issue (8). Other epidemiological studies have rapidly alerted researchers to the risk of nosocomial infections, particularly in patients admitted for surgery, where the acquisition of a COVID-19 infection in the hospital is associated with an increase in morbidity and mortality. (9) These results led to recommendations for a preoperative screening strategy. (10)

Finally, mathematical modeling was also used to unravel some key aspects of host-pathogen interactions. (11) Within-host models of SARS-CoV-2 have been used to model viral kinetics and its impact on virus spread and the theoretical effects of new treatments.

However, it should be noted that epidemiological models have limitations. The main limitation is that they are all based on assumptions. Even if these assumptions are based on previous knowledge, data and observations, they may be partially incorrect, requiring an update of the model. Thus, the main assumptions considered were the contagiousness and severity of the virus strain, the effects of mitigation measures, the effect of natural immunity, the effect of immunity induced by vaccination and the effectiveness of medical management. It has been clearly demonstrated that all these variables have evolved over time, requiring constant adaptations of the models.

### **Open access to (good) data: the key to success!**

Building an epidemiological model requires access to robust epidemiological data. To be useful, the data that is made available must be of good quality, i.e., unbiased, understandable and frequently updated. Very quickly, many countries gave access to the data produced by their information systems. France has been particularly active in this area, making hospitalization data (SIVIC database), test data (SI-DEP database) and vaccination data (Vaccin-COVID database) available via the [www.data.gouv.fr](http://www.data.gouv.fr) website.

Thus, many teams in France and teams around the world have contributed to the epidemiological modeling of COVID-19. Far from being an unproductive competition, a worldwide collaboration has been created, even including the creation of a space for sharing different modeling approaches (for example, the European COVID-19 Forecast Hub, <https://covid19forecasthub.eu>).

Beyond epidemiological modeling, open science has also led to the sharing of technological solutions facilitating crisis management, particularly through decision-making tools for health care structures, as discussed by Garaix et al. (12)

### **The management of COVID-19 is also the management of non-COVID-19**

After the initial shock of the first waves successively affecting different continents, epidemiological modeling was used to model the maintenance of the non-COVID-19 health care offerings. Indeed, the management of the first waves of COVID-19 patients was largely to the detriment of the management of non-COVID-19-related pathologies. The impact on the prognosis of non-COVID-19 patients has been modeled; the example of the delay in diagnosis of breast cancer is particularly noteworthy. Using the theoretical frameworks of three established cancer intervention and surveillance modeling network breast cancer models, Alagoz et al. predicted that the initial pandemic-related disruptions in breast cancer care will have a small but significant long-term cumulative impact on breast cancer mortality. (13)

Here, again, epidemiological modeling has contributed to the reflection on the adaptation of care offerings with the goal of maintaining non-COVID-19 care offerings in parallel with the adaptation of the care system for the management of patients infected by SARS-CoV-2.

### **Conclusion and perspectives**

Epidemiological modeling provides reliable and objective information for decision-makers to consider the different options. However, as pointed out by Crepey et al. (3), "making the choice remains a political decision". In fact, the decision-making process not only considers the need to face the pandemic and to take the best possible care of our patients but must also consider other realities: social consequences, psychological consequences, consequences on the management of non-COVID-

19 diseases, etc. To put it another way, epidemiological modeling was one of the tools that allowed decision-makers to manage the constant uncertainty during the management of this crisis.

More than two years after the beginning of the pandemic, our health system response has improved thanks to progress in treatments, testing strategies, prevention (through social distancing and especially through vaccination) and the improvement of our capacity to model the pandemic. It is in this respect that epidemiologists, such as physicians, nurses and health system managers, have made major contributions to the fight against COVID-19.

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