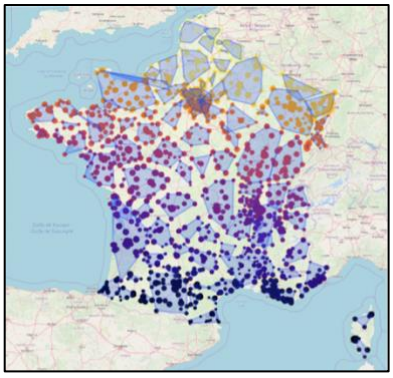
Title: Decision-making and hospital preparedness for respiratory virus X: Modeling the flexibility of healthcare capacity

Background and Objectives

During the COVID-19 pandemic, hospitals in most European countries[1], the US[2], or Australia[3], have been able to absorb a surge of hospitalizations beyond their theoretical capacity. In France, while only 5 000 ICU beds were registered in the country in 2019, it has been shown that this number could increase over 20 000 mostly by converting acute and post anesthetic care units into ICU[4]. To match hospital capacity to the demand for care, hospitals may reallocate resources by reducing their quality of care (reduce patients' length of stay, staff per patient), and reducing (postpone non-priority care) or diverting part of their activity to other healthcare institutions. The extent and nature of these adjustments will also strongly depend on the intensity and profile of the demand for hospitalization, which itself varies with several factors: the characteristics of the pandemic pathogen, mitigation measures that may decrease other hospitalization needs (curfew, lockdowns), but also on the demographic characteristics of the hospital catchment area, and the local density of healthcare offer. This PhD project aims at evaluating and modeling the flexibility of hospital capacity and its multidimensional determinants.

Research Questions



This PhD project seeks to address the question: How can hospital systems adapt to a sudden surge in demand caused by a pandemic, and how can decision-makers be reliably informed, before and during the crisis, of the risk of hospital overload? As observed during the COVID-19 pandemic, hospital resources may become scarce and turn into a trigger for local or national mitigation measures (social distancing, curfews, lockdown, …). Yet, hospitals also demonstrated a certain degree of flexibility, notably through resources reallocation.[4] This project will aim to quantify that flexibility, identify key adjustment levers, and develop a healthcare capacity model capable of simulating the system's potential for adaptation and informing strategies to strengthen it efficiently.

Methodology

We will retrospectively analyze the French hospital discharge database (PMSI) from 2019 to 2021 to document effective surge capacity by hospital and ward type, as well as the decrease in non-COVID-19 activities, and how these activities were postponed or diverted. This approach will make it possible to assess to what extent hospitals adapted their medical technology to perform supplementary COVID-19 treatments conditionally on the type of medical equipment at their disposal. In the detail, hospital activity is measured through the number of stays, and medical technology is a weighted sum of indicators for various services. Length of stay may also be an interesting indicator as it has been shown to be related to hospital capacity and driven down in time of lack of bed supply [5]. This analysis will also provide information on how and where hospital activities have been diverted during hospital surge events of COVID-19 pandemic. We have demonstrated in previous works our ability to harness hospital discharge database to build healthcare networks of patient transfers and analyze such objects[6,7]. For this project, we will build on tools already developed within the team[8] to identify structural changes of the healthcare network under various epidemic context. These elements will serve as foundation to model healthcare capacity.

Expected Outcomes

The resolution of the healthcare capacity model will then output numbers of patients treated and non-treated, either due to Pathogen X or to the capacity adaptation process. These outputs will be translated in terms of public health outcomes like number of hospitalizations, deaths, and life-year lost. Similar dynamic approach regarding hospital bed requirements have been used already to simulate the impact of public health policies at a national level[9] or to optimize waiting time[10]. Others have modelled the public health consequences of excess hospitalizations during COVID-19 epidemic waves[11]. However, none of these studies aimed at considering the flexibility of hospital capacity and its potential consequences during a surge hospital demand.

PhD thesis project - ANRS|MIE PhD grant – PReViX project

Supervision

The proposed PhD research will be supervised by Pr. Pascal Crépey and Pr. Nicolas Sirven at EHESP School of Public Health. Pascal Crépey is a biostatistician and epidemiologist specialized in infectious diseases modeling, and Nicolas Sirven is an economist/ econometrician specialized in healthcare organization. The student will work in close collaboration with other researchers within the Health Services Research team (RSMS) and within the PReViX project (https://tinyurl.com/phdprevix**)**.

Setting

The position will be set at *Ecole des Hautes Etudes en Santé Publique* (EHESP) in Rennes, France, with possibilities of short terms stays with other project partners. EHESP is a prestigious French graduate school of public health, recognized for its excellence in teaching and research in various fields of public health, including epidemiology, biostatistics, health policy, and environmental health. It offers a dynamic and stimulating academic environment that fosters interdisciplinary collaboration and innovation. EHESP has a strong research focus with several research units and centers dedicated to various aspects of public health. Doctoral students will have the opportunity to work alongside leading experts in their field, participate in cutting-edge research projects, and benefit from access to state-of-the-art facilities and resources. In addition, the school also offers a variety of training programs and workshops to help doctoral students develop their research skills, communication abilities, and career prospects. Rennes is a vibrant and dynamic city located in the heart of Brittany, just 1h30 from Paris. Known for its rich cultural heritage, stunning natural beauty, and high quality of life, doctoral students will enjoy a safe and welcoming environment with easy access to affordable housing, excellent public transportation, and various recreational activities. Overall, EHESP offers a unique opportunity for doctoral students to pursue their research interests in a world-class institution with strong support and resources, while also enjoying the benefits of living in a charming and lively city in France.

Candidate profile

This project offers a unique opportunity for students with a background in physics, applied mathematics, computer science, and econometrics to apply their skills to a real-world problem with significant societal impact. Candidates with a public health, health economics, or medical background able to demonstrate advanced competencies in biostatistics and programming may also apply. The project's interdisciplinary nature, international collaboration, and cutting-edge research make it an exciting and rewarding experience for anyone interested in using mathematical modelling and computational simulations to improve public health.

Application and information

Interested candidates must submit as soon as possible and no later than Monday **July 21st, 2025**:

- CV (including names of two referees),
- cover letter,
- master's transcript
- master's internship report (if available)

Applications and request for additional information must be sent to:
Pascal Crépey, Professor EHESP,
pascal.crepey@ehesp.fr

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