

Leveraging random effects to estimate the impact of non-pharmaceutical interventions on epidemic dynamics across French regions

Mélanie Prague, Annabelle Collin, Linda Wittkop, Dan Dutartre, Quentin Clairon, Philippe Moireau, Rodolphe Thiébaud, Boris Hejblum*

We developed a multi-level model of the French COVID-19 epidemic at the regional level. We rely on a global extended Susceptible-Exposed-Infectious-Recovered (SEIR) mechanistic model as a simplified representation of the average epidemic process, with the addition of region specific random effects. Combining several French public datasets on the early dynamics of the epidemic, we estimate region-specific key parameters conditionally on this mechanistic model through Stochastic Approximation Expectation Maximization (SAEM) optimization using Monolix software. We thus estimate the basic reproductive numbers by region before lockdown, attack rates (i.e. percentages of infected people) over time per region, and the impact of nationwide lockdown on the infection rate. These results confirm the low population immunity, the strong effect of the lockdown on the dynamics of the epidemics. This methodology can also be applied to assess the impact of various other non pharmaceutical interventions such as school closing or curfews.