PHD CANDIDATE ON BAYESIAN NETWORKS APPLIED TO GLOBAL EPIDEMIC SPREAD

We seek for a PhD candidate for the PhD program of the Sorbonne Center for Artificial Intelligence (SCAI) at Sorbonne Université (SU). The selected candidate will be enrolled in the PhD school Pierre Louis of Public Health to work within a collaboration between the Team 'Communicable Diseases Surveillance and Modelling' of the *Pierre Louis Institute of Epidemiology and Public Health* (INSERM, SU) and the Team 'Statistics, data and Algorithm' of the *Laboratory of Probability, Statistics and Modelling* (LPSM, SU).

In a national and international context of competition in artificial intelligence, SCAI brings together, a strategic range of disciplines of modern artificial intelligence in the heart of Paris. The SCAI PhD doctoral program will support research projects in the field of artificial intelligence in the broadest sense. The doctoral school Pierre Luis of Public Health promotes research in epidemiology and biomedical information science, with focus on fields such as epidemiology of infectious diseases, epidemic modelling and biostatistics, among the others.

We are looking for a strongly motivated person with a passion for computational modeling and machine learning, and a keen interest in multidisciplinary research. The candidate should have a M2 degree (or expect to have it by this fall) in quantitative science, such as statistics, physics, applied mathematics, computer science, epidemiology or any close related discipline. Proven ability to work independently and to quickly adapt to new scientific environments are essential for this position. Good communicative skills to successfully collaborate with the other members of the group, and a good knowledge of both oral and written English are required.

The PhD thesis will focus on open questions in the global spread of epidemics, with influenza and COVID-19 as case studies. Large scale mobility, sociodemographic and epidemiological data will be integrated through Bayesian network techniques. A summary of the project is reported below. The student will work under the supervision of Chiara Poletto, Maud Thomas and Pierre-Yves Boëlle.

Applications should be submitted via mail to Dr. Chiara Poletto (chiara.poletto@inserm.fr) and Dr. Maud Thomas (maud.thomas@sorbonne-universite.fr) by Wednesday May 27, and must include a detailed CV. Applicants will undergo an internal selection. The pre-selected candidate will be then interviewed by the SCAI PhD commission. **The interview will take place on Tuesday June 2, 2020**. It will be online via Zoom and will last 15 minutes (5 minute presentation and 10 minute questions).

Summary of the PhD Subject:
Bayesian networks to uncover the drivers of global epidemic spread

Modern human mobility infrastructures increase the risk of exposure of individuals to infectious diseases and let old and new viruses circulate faster. Many studies elucidated the role of human mobility on the global spread of infections. However, the complexity of the interactions between

infection natural history, environmental factors, human mobility and countries' response to the epidemic presents fundamental issues that still require elucidation.

In this project, we plan on using Bayesian networks, to address two case studies of high epidemiological relevance: (i) the global co-circulation of seasonal influenza strains and the drivers of strain (co-)dominance in a given country; (ii) the dynamics of worldwide spread of COVID-19 and its interplay with the progressive disruption of the airline network, due to progressive restrictions posed by governments. The project will rely on a large-scale dataset of airline fluxes connecting all commercial airports of the world for different years. These data will be combined with incidence data of influenza and COVID-19 at national and sub-national level and other relevant socio-demographic information.

We will study global seasonal influenza to identify patterns in strain (co-)dominance. Dynamic Bayesian Networks (DBN) will establish causal relationships (including e.g. mobility, weather and demography) and enable predictions of the global strain co-circulation.

The study of COVID-19 will focus on the effect of travel restrictions. The flight reductions to/from regions may have changed with local and global incidence, and vice versa. We will combine mechanistic modeling with automated learning using suitable DBN approaches. Counterfactual analyses of the change in transportation network will help quantify the impact of decisions on the actual spread of diseases.