Evaluating the impact of the weather conditions on the influenza propagation

**CURRENT STATUS:** ACCEPTED

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**DOI:**  
10.21203/rs.2.10422/v1

**SUBJECT AREAS**  
Infectious Diseases

**KEYWORDS**  
influenza epidemic, simulation, meteorological model
Abstract

Background: Predicting the details of how an epidemic evolves is highly valuable as health institutions need to better plan towards limiting the infection propagation effects and optimizing their prediction and response capabilities. Simulation is a cost- and time-effective way of predicting the evolution of the infection as the joint influence of many different factors: interaction patterns, personal characteristics, travel patterns, meteorological conditions, previous vaccination, etc. The work presented in this paper extends EpiGraph, our influenza epidemic simulator, by introducing a meteorological model as a modular component that interacts with the rest of EpiGraph's modules to refine our previous simulation results. Our goal is to estimate the effects of changes in temperature and relative humidity on the patterns of epidemic influenza based on data provided by the Spanish Influenza Sentinel Surveillance System (SISSS) and the Spanish Meteorological Agency (AEMET).

Methods: Our meteorological model is based on the regression model developed by Barreca and Shimshack, and it is tuned with influenza surveillance data obtained from SISSS. After pre-processing this data to clean it and reconstruct missing samples, we obtain new values for the reproduction number of each urban region in Spain, every 10 minutes during 2011. We simulate the propagation of the influenza by setting the date of the epidemic onset and the initial influenza-illness rates for each urban region.

Results: We show that the simulation results have the same propagation shape as the weekly influenza rates as recorded by SISSS. We perform experiments for a realistic scenario based on actual meteorological data from 2010-2011, and for synthetic values assumed under simplified predicted climate change conditions. Results show that a diminishing relative humidity of 10\% produces an increment of about 1.6\% in the final infection rate. The effect of temperature changes on the infection spread is also noticeable, with a decrease of 1.1\% per extra degree.

Conclusions: Using a tool like ours could help predict the shape of developing epidemics and its peaks, and would permit to quickly run scenarios to determine the evolution of the epidemic under different conditions. We make EpiGraph source code and epidemic data publicly available.

Full-text
Due to technical limitations, full-text HTML conversion of this manuscript could not be completed. However, the manuscript can be downloaded and accessed as a PDF.

Figures

Figure 1

Overview of the data sources, processed data, and EpiGraph components.
Figure 2

Data reconstruction example of temperature values for Alcobendas urban region (the reconstructed values are in red color). X-axis units corresponds to tens of thousand samples and the total number of samples displayed is 52,560 (one sample every 10 minutes for one-year span).
Figure 3

Comparison of normalized values between EpiGraph (in red) and real values (in blue) for Navarra, Madrid, Pais Vasco and Valencia communities. Real values correspond to the total number of infected $N_{tot}$, obtained by means Equation 4 from influenza surveillance data.
Figure 4

Meteorological parameters (T, RH, P) and the obtained R0s values for a one-year simulation (2011) for Tarrasa urban area.
Figure 5

Effect of long-term changes of relative humidity on the influenza propagation for the different communities considered in the simulation. Meteorological parameters (T, RH, P) and the obtained R0s values for a one-year simulation (2011) for Tarrasa urban area.
Figure 6

Effect of long-term changes in the temperature on the influenza propagation for the different communities considered in the simulation.
Effect of long-term changes in the relative humidity (percentile reduction) and temperature (value increment in Celsius) on the influenza propagation for the average nation-wide infection rates.
Figure 8

Effect of long-term parameter variation on the infection distribution shape for Andaluca. In (a) different RH scales are evaluated (100% in red, 90% in green, 80% in blue and 70% in black); in (b) different temperature offsets are evaluated (0 degrees in red, +1 degrees in green, +2 degrees in blue and +3 degrees in black).
Figure 9

Effect of short-term changes in the relative humidity on the influenza propagation for the different communities considered in the simulation.
Figure 10

Effect of short-term changes in the temperature on the influenza propagation for the different communities considered in the simulation.