NEW INSIGHTS ON THE SPREAD OF INFLUENZA THROUGH AGENT BASED MODELING

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INTRODUCTION

The aim of this work is to create an agent based model to simulate the progression of influenza seasons under different circumstances.

Goals

- Explaining effects of past influenza seasons
- Simluating interventions for past influenza seasons ("what would have happened if...")
- Simulating interventions for future influenza seasons

Current research

- Adopting the model on the situation in Austria in detail
- Finding out about further crucial impacts on the spread influenza

MODEL

The model

- Agent based model
- Simulating single persons
- A person can be susceptible, infected, resistant or vaccinated
- Simulating contacts between persons
- Transmissions are possible upon contacts
- Individual progress of disease (depending on age and other factors)

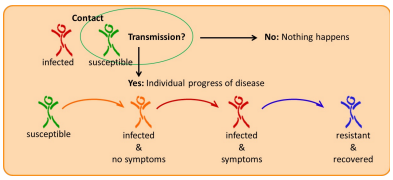

Figure 1: The agent based influenza model

Testing the model

- Contacts for airborne infections are known (special thanks to POLYMOD EU-Project SP22-CT-2004-502084 [1])
- Careful calibration of transmission probabilities
- Duration of infection is known from clinical studies
- External validation with past influenza seasons

COMPARING WITH PAST SEASONS

Data from season 2007

- Duration of season: ~3 months
- Vaccination rate: 16.7%
- Cases: ~5% of the whole population
- Shape of the curve: Provided by a sample from the Austrian Influenza Network (DINÖ)

Comparison with model

The parameterized and calibrated model is able to reproduce the season satisfyingly well (number of cases, shape of epidemic curve).

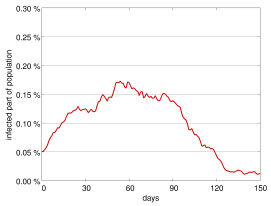

Figure 2: Results of the model

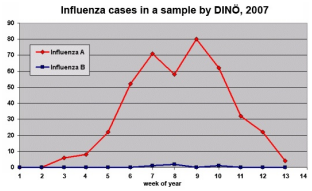

Figure 3: Data from DINÖ

LITERATURE

[1] Mossong J, Hens N, Jit M, Beutels P, Auranen K, et al. 2008 Social Contacts and Mixing Patterns Relevant to the Spread of Infectious Diseases. PLoS Med 5(3): e74. doi:10.1371/journal.pmed.0050074

[2] Fuhrmann, C. (2010), The Effects of Weather and Climate on the Seasonality of Influenza: What We Know and What We Need to Know. Geography Compass, 4: 718–730. doi: 10.1111/j.1749-8198.2010.00343.x

[3] Soebiyanto RP, Adimi F, Kiang RK (2010) Modeling and Predicting Seasonal Influenza Transmission in Warm Regions Using Climatological Parameters. PLoS ONE 5(3): e9450. doi:10.1371/journal.pone.0009450

A CONSIDERABLE THOUGHT EXPERIMENT

First considerations

Remember the data from the 2007 Influenza epidemic.

- *Why does the epidemic start?* - Because more people get infected than people recover.
- *Why does the epidemic stop?* - Because less people recover than people get infected.
- *What is the difference between day 1 and day 120?* - The number of susceptible people is about 5% lower. Infected people meet less susceptible and more resistant, vaccinated or infected people at day 120.

Implications

- The system behaves extremely sensitive because a small difference in the number of immune people is responsible for outbreak or termination of an epidemic.
- A vaccination rate of 21.7% instead of 16.7% would prevent from an influenza epidemic.

Both implications are obviously not true for the influenza (compare past seasons and other countries with different vaccination rates). We can develop these implications further:

- The influenza epidemic does not only depend on certain virus characteristics, contacts and transmissions.
- There must be impacts on influenza epidemics that are not considered yet.

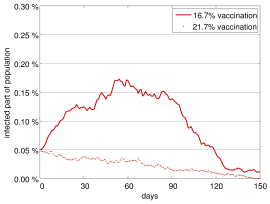

Figure 4: Comparing 16.7% and 21.6% vaccination in the model

Role of the model

- The thought experiment is completely model independent. The model just confirms the implications.
- The model helps to test possible solutions of this issue.

POSSIBLE IMPACTS ON THE INFLUENZA

Climate

- Influenza epidemics always start when it gets cold and terminate when it gets warm.
- Laboratory studies with guinea pigs show that a cool, dry environment promotes transmission dramatically [2].
- Strong statistical and stochastical dependencies between weather data and Influenza epidemics can be found [3].

Thesis: Transmission probability depends on the climate ⇨ an epidemic starts because it gets cold and terminates because it gets warm.

Predestinated persons

Assumption that only a few people are susceptible. The rest of the population is

- resistant because of current or past vaccination or
- resistant because of a "strong immune system" or
- does not have symptons in case of infection but can spread the virus further ("occult infection").

Thesis: Less susceptible people ⇨ a higher part of the susceptibles fall sick ⇨ less sensitive system, moderate additional general vaccinations do not terminate the epidemic.

CONCLUSIONS & DISCUSSION

- There are important impacts on influenza that must be identified to calculate the spread of influenza epidemics in a valid way.
- The effect of an influenza vaccination on the population cannot be estimated by modeling contacts & transmissions only.
- Considering the results of the thoughts experiment it seems unlikely to assess the outcome of a vaccination strategy without knowledge of these impacts.

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