Vaccination scheduling for influenza pandemic

Executive summary

Developing strategies for mitigating the severity of influenza epidemics is a top public health priority. We designed an age structured mathematical population model to construct optimal age specific scheduling of vaccination during the first wave of the 2009 A(H1N1) pandemic. Using the morbidity reports provided weekly by the Hungarian National Center of Epidemiology, the model enabled us to derive predictions about the future incidence of cases.

Challenge overview

Mathematical models are powerful tools for evaluating intervention strategies during infectious disease outbreaks, by quantifying the potential benefits of different options. The importance of age specificity is paramount in vaccination planning for multiple reasons: various age groups have very different contact profiles thus playing different roles in transmitting the disease. Furthermore, age specific susceptibility, infectiousness, vaccine efficacy and mortality patterns are also key issues. As it could be observed all around the world, vaccination campaigns and A(H1N1)v outbreaks overlapped in time, hence it was necessary to implement a dynamic modeling of the interplay of the vaccination and the disease transmission. There was a race between the outbreak and the vaccination campaign, thus adaptive scheduling became extremely important and posed new mathematical challenges as well.

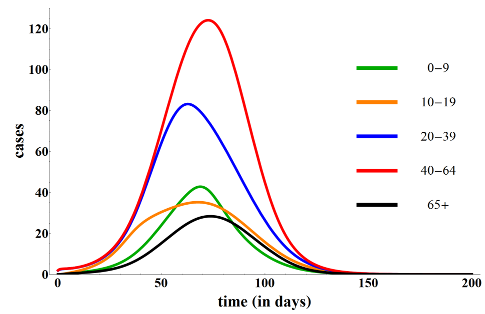
Implementation of the initiative

During the H1N1 outbreak in 2009, the Hungarian National Center for Epidemiology provided weekly influenza data to the mathematicians of the Bolyai Institute, University of Szeged. Based on such data, weekly analysis and forecasts were prepared. Also, there were regular consultations with the appointed advisor of the National Chief Medical Officer on the recent developments and predictions.

The problem

We designed an SEIR (Susceptible, Exposed, Infective, Recovered) - based model described by a system of 50 nonlinear differential equations. Three features has been incorporated to develop a more realistic model:

1. *we introduced age structure with five age groups (0–9,10–19,20–39,40–64, 65–), where the contacts between age groups were derived from the European survey of Mossong et al. 2008,*
2. *we account for the fact that it takes up to 14 days after vaccination to produce sufficient amount of antibodies to provide immunity (CDC 2009),*
3. *we assume the spread of the infection and the vaccination campaign run parallel.*



Results and achievements

The scope of our study was to compare various age specific vaccination scheduling strategies for the overall attack rates (defined as the fraction of susceptibles who do not contract the disease during the course of the outbreak). We found that, if a fixed 60% coverage is targeted within each age group, vaccinating age groups in decreasing order of their total contact numbers can reduce the overall attack rate by 5-10 % relative to other strategies where contact structure is dismissed, depending on the delay in start of vaccination.

Lessons learned and replicability

The results highlight the significance of the age specific timing in the vaccination schedule. Nevertheless, the model also demonstrates that an early start of the vaccination campaign is of particular importance: ten days delay may cause a significant, up to 6% increase in the overall attack rate.

Contacts, references

Diána H. Knipl *junior research fellow*
MTA–SZTE Analysis and Stochastics Research Group, University of Szeged, Hungary (knipl@math.u-szeged.hu)
Gergely Röst *principal investigator of the EPIDELAY ERC Starting Grant*
research associate professor, Bolyai Institute, University of Szeged, Hungary (rost@math.u-szeged.hu)

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