English summary

2.2 SEIR model (continued)

eigenvalues (jacobian fixed point): \( \lambda_1 = -\mu, \lambda_2 = -\beta + \gamma \)
\[
\lambda_3 = -\frac{\mu R}{2} \pm \sqrt{\left(\frac{\mu R}{2}\right)^2 - \frac{\gamma^2}{4A^2}}
\]
\( A = \frac{1}{\mu(R-1)}, \quad \delta = \frac{1}{\mu + \gamma} + \frac{1}{\mu + \gamma}, \quad \rho = \frac{\gamma R}{(\mu + \gamma)(\mu + \gamma)} \)

\( \sqrt{\text{fixed point}} \)

homework: Barabasi-Albert model (scale-free networks)

dynamics of degree \( k_i \) of node \( i \) introduced at \( t=t_i \) with \( m \) links (\( k_i(t_i) = m \))
\[
k_i(t) = \frac{k_i(t_i)}{2t} \implies \text{solution: } k_i(t) = m \sqrt{\frac{t}{t_i}}
\]

3 Agent-based models

3.1 Mobility and spreading of individuals
plan: use movement-patterns for human trajectories (major routes / infection)

probability of a bill to travel a distance $r$: $p(r) \sim \frac{1}{r^\alpha}$ (powerlaw! empirics: $\alpha \approx 2.6$

typical distance: $1 \leq d(t) \sim t^\beta \Rightarrow$ Levy flights (random walk with long-distance jumps possible)

SIRS dynamics:
\[
\frac{dS}{dt} = -\beta \frac{SI}{N} + \mu I + \sum \left[ w_{in} I_{in} - w_{out} I_{out} \right]
\]
\[
\frac{dI}{dt} = \beta \frac{SI}{N} - \mu I + \sum \left[ w_{in} I_{in} - w_{out} I_{out} \right]
\]

average waiting time at node $i$: $\langle \tau \rangle = \frac{1}{\sum w_{in} \tau_{in}}$

Case study: SARS in 2002/2003

3.2 "very sparse" and $I \leq ph$ strategies

Sind diese Fehmals besser eingesetzt als du?

Frage: Welchen Grad hat ein zufällig ausgewählter Knoten?

$\Rightarrow$ Grad verteilung $P_\Delta$

Welchen Grad hat ein Nachbar eines Knoten $z$?
Lassen sich auch gemäß $P_k$?

Indem $\sum_i k_i$ ist

Wahrscheinlichkeit, dass zwei zufällig ausgewählte Knoten bei Knoten mit Grad $k$ landet: $\frac{k}{2m}$

$\#$Knoten mit Grad $k$: $N_P k$

Gesamt-Mittelwert bildet: $\frac{k}{2m} N_P k = k_P k \frac{k}{2m} <k> \neq P_k$

$\#$ Knoten und Grad $k$: $N_P k$

$\#$ Knoten

= größere Wahrscheinlichkeit, einen Knoten mit höherem Grad zu finden

= Knoten mit Grad $k$ haben $k$ Chancen eingesetzt zu werden

Frage: Durchschnittlicher Grad eines Nachbarn?

$\sum_k \frac{k P_k}{<k>} = \sum_k \frac{k^2 P_k}{<k>^2} = \frac{<k^2>}{<k>} \neq P_k$

Startet bei Knoten mit Grad $k$:

$\frac{<k^2>}{<k>} - \frac{<k>}{<k>^2} = \frac{1}{<k>} (\frac{<k^2>}{<k>} - \frac{<k>^2}{<k>^2}) = \frac{<k^2>}{<k>} > 0$
Deine Nachbarn haben mehr Nachbarn als du!

<table>
<thead>
<tr>
<th>Network</th>
<th>( n )</th>
<th>Average degree</th>
<th>Average neighbor degree</th>
<th>( \langle k^2 \rangle ) / ( \langle k \rangle )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biologists</td>
<td>1,520,252</td>
<td>15.5</td>
<td>68.4</td>
<td>130.2</td>
</tr>
<tr>
<td>Mathematicians</td>
<td>253,339</td>
<td>3.9</td>
<td>9.5</td>
<td>13.2</td>
</tr>
<tr>
<td>Internet</td>
<td>22,963</td>
<td>4.2</td>
<td>224.3</td>
<td>261.5</td>
</tr>
</tbody>
</table>

\[ q_k = \frac{(k+1)}{\langle k \rangle} \]

\[ \sum_{k} q_k = 1 \] (automatisch gegeben)

⇒ Konsequenzen für Impfstrategien:
- Zufällig?
- Zielstellung: Ziehe solche Knoten mit hohem Grad zu identifizieren/implizieren
Seasonal transmission potential and activity peaks of the new influenza A(H1N1): a Monte Carlo likelihood analysis based on human mobility

Duygu Balcan\textsuperscript{1,2}, Hao Hu\textsuperscript{1,2,3}, Bruno Goncalves\textsuperscript{1,2}, Paolo Bajardi\textsuperscript{1,4,5}, Chiara Poletto\textsuperscript{4}, Jose J Ramasco\textsuperscript{4}, Daniela Paolotti\textsuperscript{4}, Nicola Perra\textsuperscript{1,6,7}, Michele Tizzoni\textsuperscript{4,8}, Wouter Van den Broeck\textsuperscript{4}, Vittoria Colizza\textsuperscript{4} and Alessandro Vespignani\textsuperscript{*1,2,4}
**Background:** On 11 June the World Health Organization officially raised the phase of pandemic alert (with regard to the new H1N1 influenza strain) to level 6. As of 19 July, 137,232 cases of the H1N1 influenza strain have been officially confirmed in 142 different countries, and the pandemic unfolding in the Southern hemisphere is now under scrutiny to gain insights about the next winter wave in the Northern hemisphere. A major challenge is pre-empted by the need to estimate the transmission potential of the virus and to assess its dependence on seasonality aspects in order to be able to use numerical models capable of projecting the spatiotemporal pattern of the pandemic.

**Metapopulations model und Mobilität zwischen den 3362 Subpopulationen auf globaler und lokaler Skala (6 \cdot 10^5 Individuen, \Delta t = 1 Ty, R_0 = 1,75 > 1 und Andere Daten)**
Schematic illustration of the GLobal Epidemic and Mobility (GLEaM) model. Top: census and mobility layers that define the subpopulations and the various types of mobility among those (commuting patterns and air travel flows). The same resolution is used worldwide. Bottom: compartmental structure in each subpopulation. A susceptible individual in contact with a symptomatic or asymptomatic infectious person contracts the infection at rate $\beta$ or $r_0\beta$ [30,32], respectively, and enters the latent compartment where he is infected but not yet infectious. At the end of the latency period, each latent individual becomes infectious, entering the symptomatic compartments with probability $1 - p_\lambda$ or becoming asymptomatic with probability $p_\lambda$ [30,32]. The symptomatic cases are further divided between those who are allowed to travel (with probability $p_t$) and those who would stop traveling when ill (with probability $1 - p_t$) [30]. Infectious individuals recover permanently with rate $\mu$. All transition processes are modeled through multinomial processes.

Conclusion: The analysis shows the potential for an early epidemic peak occurring in October/November in the Northern hemisphere, likely before large-scale vaccination campaigns could be carried out. The baseline results refer to a worst-case scenario in which additional mitigation policies are not considered. We suggest that the planning of additional mitigation policies such as systematic antiviral treatments might be the key to delay the activity peak in order to restore the effectiveness of the vaccination programs.
Table 2: Seasonality time-dependent reproduction number in the Northern hemisphere

<table>
<thead>
<tr>
<th>Month</th>
<th>$R(t)$ in Northern hemisphere</th>
</tr>
</thead>
<tbody>
<tr>
<td>May</td>
<td>1.19 to 1.49</td>
</tr>
<tr>
<td>June</td>
<td>1.07 to 1.33</td>
</tr>
<tr>
<td>July</td>
<td>1.05 to 1.24</td>
</tr>
<tr>
<td>August</td>
<td>1.07 to 1.33</td>
</tr>
<tr>
<td>September</td>
<td>1.19 to 1.49</td>
</tr>
</tbody>
</table>

The values of $R(t)$ for the Northern hemisphere correspond to the rescaling of the maximum likelihood value of $R_0$ in Mexico and in the Tropical regions ($R_0 = 1.75$) and the best values for the seasonality rescaling factor, $0.6 < \alpha_{\text{min}} < 0.7$. The parameter $\alpha_{\text{min}}$ indicates the minimum value of the seasonal rescaling of $R_0$ induced by the sinusoidal forcing in the Northern hemisphere [17].
<table>
<thead>
<tr>
<th>Region</th>
<th>Estimated activity peak time</th>
</tr>
</thead>
<tbody>
<tr>
<td>North America</td>
<td>25 September to 9 November</td>
</tr>
<tr>
<td>Western Europe</td>
<td>14 October to 21 November</td>
</tr>
<tr>
<td>Lower South America</td>
<td>30 July to 6 September</td>
</tr>
<tr>
<td>South Pacific</td>
<td>28 July to 17 September</td>
</tr>
</tbody>
</table>

The table reports the 95% confidence interval (CI) for the pandemic activity peak time for geographical areas in the Northern and Southern hemispheres estimated for the best-fit seasonality scaling interval, \( 0.6 < \alpha_{\text{min}} < 0.7 \), and for the maximum likelihood value of \( R_0 \) found for the baseline parameters, \( R_0 = 1.75 \). The confidence interval is obtained from the set of numerical observations of the peak time in a given region obtained from the 2,000 stochastic runs of the model. In Additional file 1 we report the results for the full sensitivity analysis. In all cases we obtain activity peak time intervals close to those reported for the baseline scenario. Peak time estimates in this table are obtained from the epidemic profile of the entire geographical region. Single country belonging to each region could have different peak time estimates (see text).

<table>
<thead>
<tr>
<th>Country</th>
<th>Peak time</th>
<th>New daily cases at the peak time (thousands)</th>
<th>New daily cases at the peak time (% of population)</th>
<th>Epidemic size at 15 October (% of population)</th>
</tr>
</thead>
<tbody>
<tr>
<td>United States</td>
<td>24 September to 9 November</td>
<td>2,983 to 3,302</td>
<td>1.06 to 1.17</td>
<td>4.99 to 7.38</td>
</tr>
<tr>
<td>Country</td>
<td>Time Period</td>
<td>Peak Incidence</td>
<td>95% Confidence Interval</td>
<td>Total Size</td>
</tr>
<tr>
<td>--------------</td>
<td>----------------------</td>
<td>----------------</td>
<td>-------------------------</td>
<td>------------</td>
</tr>
<tr>
<td>Canada</td>
<td>4 October to 14 November</td>
<td>1.04 to 1.17</td>
<td>2.28 to 4.56</td>
<td>16.90 to 27.41</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>9 October to 18 November</td>
<td>1.21 to 1.36</td>
<td>1.77 to 4.45</td>
<td>11.11 to 27.29</td>
</tr>
<tr>
<td>France</td>
<td>12 October to 21 November</td>
<td>1.26 to 1.38</td>
<td>1.83 to 3.87</td>
<td>10.86 to 26.40</td>
</tr>
<tr>
<td>Germany</td>
<td>11 October to 20 November</td>
<td>1.43 to 1.59</td>
<td>1.02 to 2.41</td>
<td>8.57 to 26.25</td>
</tr>
<tr>
<td>Italy</td>
<td>17 October to 23 November</td>
<td>1.39 to 1.52</td>
<td>0.93 to 2.20</td>
<td>6.71 to 22.13</td>
</tr>
<tr>
<td>Spain</td>
<td>8 October to 19 November</td>
<td>1.23 to 1.34</td>
<td>2.39 to 3.70</td>
<td>13.26 to 27.95</td>
</tr>
<tr>
<td>China</td>
<td>8 November to 11 December</td>
<td>1.16 to 1.34</td>
<td>0.65 to 5.34</td>
<td>1.51 to 9.49</td>
</tr>
<tr>
<td>Japan</td>
<td>13 October to 16 November</td>
<td>1.21 to 1.43</td>
<td>1.47 to 4.86</td>
<td>5.84 to 24.65</td>
</tr>
</tbody>
</table>

Peak times of the epidemic activity, daily new number of cases predicted at peak time and % of the population, and epidemic size on 15 October are shown. Intervals refer to the 95% confidence interval (CI). After 1 year from the start of the epidemic the percentage of total population infected is close to 45% with small differences of the order of 5% across different countries.
Real data as of May 19, 11 AM EDT

Worst case scenario
[calibration up to May 16]

Canada 10,654 (13,404)
France 1,255 (3,989)
UK 3,000 (4,778)

- Canada 503
- USA 4,908
- Mexico 3,648
- Guatemala 3
- El Salvador 4
- Ecuador 1
- Peru 2
- Cile 5
- Argentina 1
- Brazil 8
- Colombia 11
- Costa Rica 8
- Panama 59
- Spain 103
- Italy 9
- Greece 1
- Turkey 2
- Iran 1
- Japan 191
- South Korea 3
- China and Hong Kong 5
- New Zealand 8
- Canada 10,654 (13,404)
- France 1,255 (3,989)
- UK 3,000 (4,778)

Virus-Erkrankung, erstmals Ausbruch 1976, Sterberate bis zu 70%
Übertragungswege: von Wildtieren auf Menschen
2013: 26. kezdetek
Vezetőjel: 27.000
Testjel: 11.000
(14.5.2015)
Westafrika (kongo, Libéria, Sierra Leone...)
ISO-ban félre jött az US, Spania, Drezdensch...
Name: Ebola-Fluss im Kongo (Kuem. Zaïre)
Eich: Yambuku (60 km von Fluss entfernt)
Hämorrhagische Fieber (Masnaka Blodungen)
"Outbreak": Buch 1997, Film 1995
Assessing the impact of travel restrictions on international spread of the 2014 West African Ebola epidemic

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6. Department of Biostatistics, University of Florida, Gainesville, Florida, United States

Fortsetzung folgt...