Modeling numbers of infected and deceased - Adjustment by test volume

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Results

- We observed a strong connection between infections and deaths numbers in 1st wave
- We found a simple sufficient model for 1st and 2nd wave and the interim time
- Only test adjusted infection numbers serve for riskiness and deaths prediction

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During 1st wave, numbers of deaths followed number of infected (confirmed cases).

- Germany: 4.8 % of the total number of infected persons have died 13 days after confirmation during 1st wave
- Dependence is valid for many countries, but with different delays and percentages
- Published in Medrxiv in August, 11 ("On the numbers of infected and deceased in the second Corona wave")
- After June, deviations began and led us to model the data

Data from John-Hopkins-University (JHU)
Only one wave in district Paderborn, Germany, until shortly. A good base for modeling.

- First wave did not end in June, in contrast to prediction by a SIR model applied to contact restriction.
- The continuous exponential growth since June is small, as masks and distance keeping were principally observed.
- Combination of SIR model with an SI model shows a good compliance with real data above.

Accumulated infected for district Paderborn (300,000 inhabitants)

Daily infected for district Paderborn

Data from local health department (PB)
Data for Germany show apparently a big 2nd wave since July

- Since July, infection course deviates heavily from SIR+SI model.
Germany since July: infection data rising, but deaths data remaining low

- Only since October, a much lower 2nd wave in deaths appears so far in Germany.
- This is also true in many European countries like Italy, France, Great Britain, Netherlands etc.
Test volume has tripled in Germany since June, coinciding with rising confirmed infections

- **Daily test volume** has increased from about 50,000 tests per day during 1st wave until 170,000 in October
- **Test volume** coincides with rising infection data since June
Dividing infection numbers by numbers of tests gives more realistic Covid-19 state

- We divided the **daily infection number** by the **daily test number** (equivalent to the positive rates), and scaled them to the 1st wave.
- This **test adjusted infection number** follows the **SIR+SI model** from start in February until October.
- A 2nd wave has started only since October.
During 1\textsuperscript{st} and 2\textsuperscript{nd} waves, numbers of deaths follow the number of test adjusted infected in Germany

- Only with test adjusted infection numbers we obtain realistic agreement with deaths numbers
- Between the two waves, daily deaths numbers are even smaller than expected after test adjustment
- **Test adjusted mortal calculations** show how many deaths may be expected 13 days ahead in Germany
- This prediction makes it possible to plan ahead 13 days the capacities of the medical system
During 1\textsuperscript{st} and 2\textsuperscript{nd} waves, numbers of deaths follow the number of test adjusted infected in USA

- Only with test adjusted infection numbers we obtain realistic agreement with deaths numbers
- In USA, at the start of the pandemic only few tests were made
- \textbf{Test adjusted mortal calculations} show how many deaths may be expected 14 days ahead in \textbf{USA}
- This prediction makes it possible to plan ahead 14 days the capacities of the medical system
Modeling the test adjusted infection data allows for a more realistic outlook into the second wave

- For the 2nd wave, we added a second SIR model to the SIR+SI function
- According to this SIR+SI+SIR model, the 2nd wave of test adjusted infections may be smaller than the present infection data suggest
- Nevertheless, only a clear turning point of the models in the 2nd wave can give certainty
Conclusions

- A strong **relationship** between infections and deaths numbers is observed in the 1st wave in many countries.
- The first wave and the following period can be replicated in many countries using a simple **SIR+SI model**.
- High infection numbers after June can be explained in Germany and USA mainly by the **increased test volume**.
- To estimate the pandemic realistically, it is necessary to **include the test volume**.
- Only test adjusted infection numbers serve for **riskiness** and **deaths prediction** of the pandemic.

The Excel file as the base of this lecture includes all JHU data and is easy updatable. It will be available soon, as well as the presentation: 
[https://physik.uni-paderborn.de/en/alumni/mimkes](https://physik.uni-paderborn.de/en/alumni/mimkes) (Publikationen)
Thank you for your attention!
Used models

SIR model for the 1st and further waves

Time dependent variables:

- **S**  Susceptible individuals. At start, S = N
- **I**  Infectious individuals
- **R**  Resistant, recovered and removed individuals = “infected” individuals

\[ \text{d}S = -bS*I \]
\[ \text{d}I = bS*I - g*I \]
\[ \text{d}R = g*I \]

Constants:

- **N**  Susceptible population S + I + R.
- **b**  Infection rate of SIR model
- **g**  Recovery rate

Combined SIR+SI model after a wave

Constants:

- **N_p**  Inhabitants of a country or district
- **b_0**  Basic infection rate of inhabitants

\[ \text{Infected} = \frac{(R \text{ of the SIR model}) + \text{exponential growth from start until whole population is infected (SI-Model)}}{(N/N_p + (1 - N/N_p) * \text{EXP}(b_0 * t))} \]