Data analysis and forecast of the epidemiological situation in Ukraine to support decision-making

Working group on mathematical modeling of the SARS-CoV-2 coronavirus epidemic in Ukraine

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Classical SEIR model

Population is divided into several compartments. Fluxes between compartments are described using the system of ordinary differential equations.

Susceptible → Exposed → Infectious → Recovered

S – The number of **s**usceptible individuals

E – Exposed, infected but not yet infectious themselves during incubation period

I – The number of **i**nfectious individuals

R – The number of Recovered (Removed) individuals

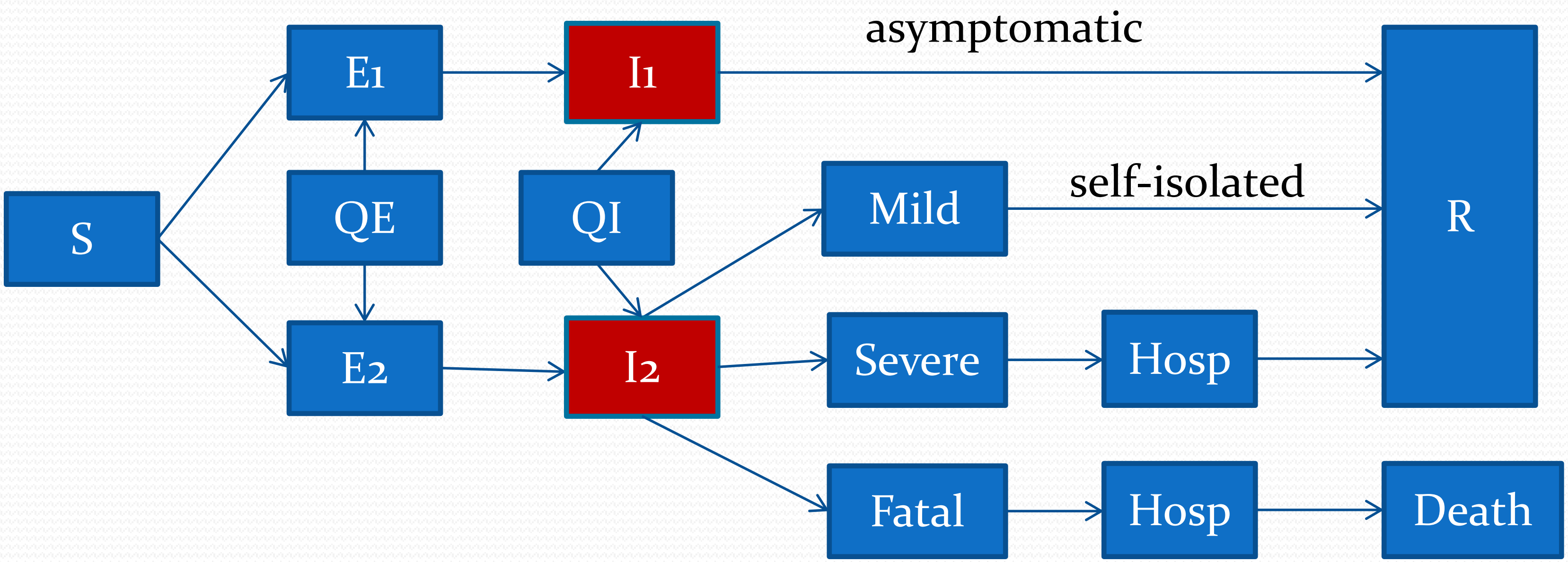
$$\frac{dS}{dt} = -\frac{\beta IS}{N},$$

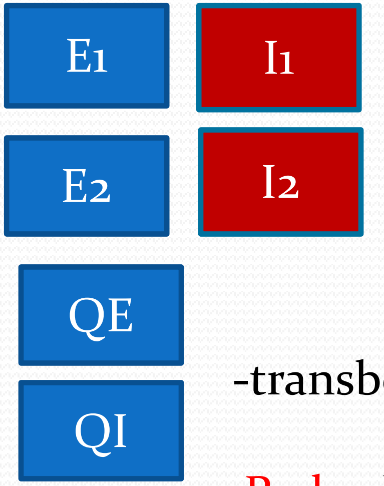
$$\frac{dI}{dt} = \frac{\beta IS}{N} - \gamma I - \mu I,$$

$$\frac{dR}{dt} = \gamma I,$$

$$\frac{dD}{dt} = \mu I,$$

Developed by NASU mathematical model for Covid-19 analysis and forecasts in Ukraine





- infected asymptomatic

- infected symptomatic

-transboundary fluxes

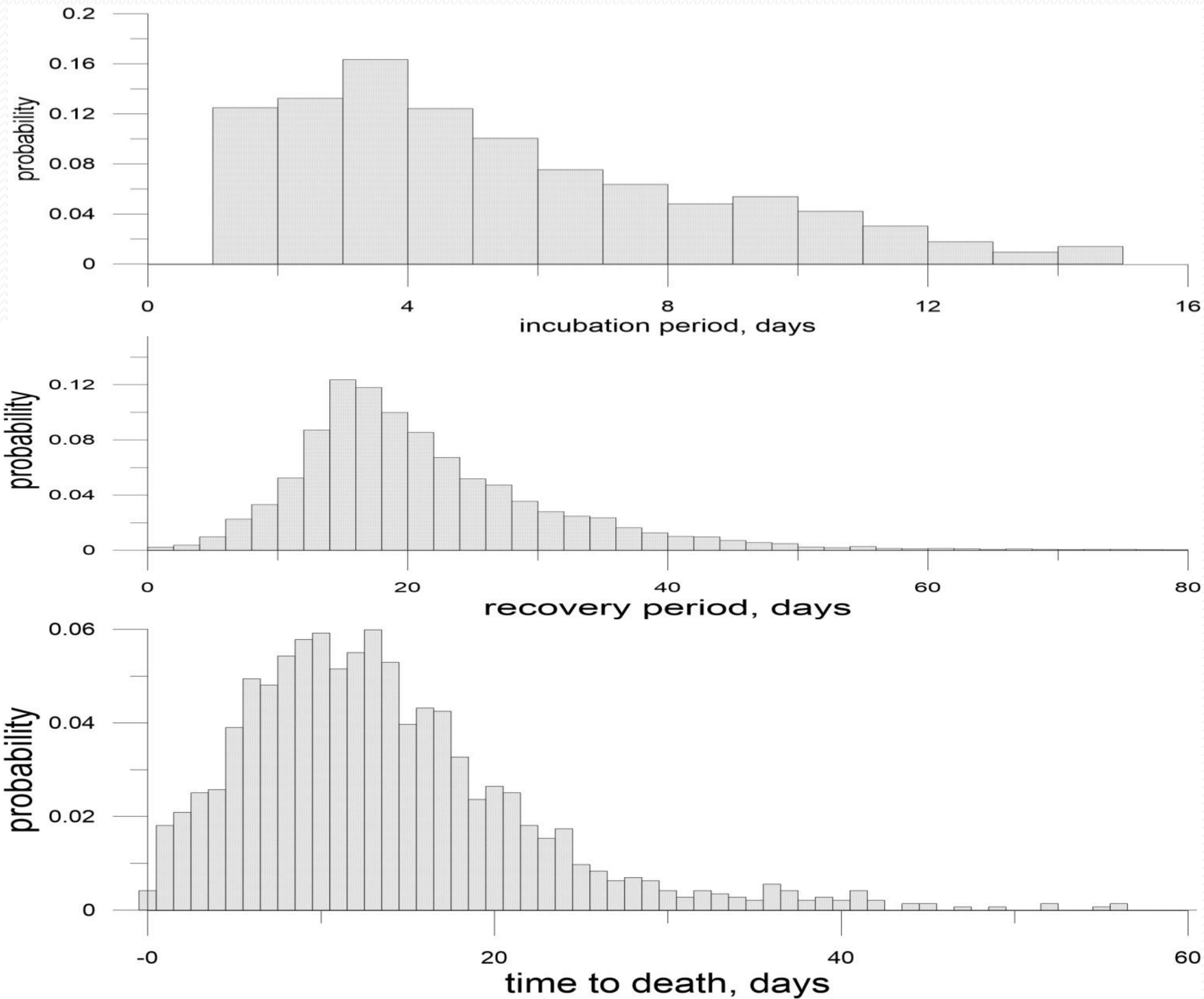
Red color denotes infectious compartments

Features:

- Consist of 12 compartments
- Can take into account asymptomatic cases
- Inflow of infected foreign travelers
- Several scenarios of decease (mild, severe and fatal)
- Hospitalizations
- Automatic parameter calibration
- Flexible structure, can be updated according to the new information

Estimation of parameters from statistics

Data available from the Public Health Center of Ukraine is used to determine main model parameters



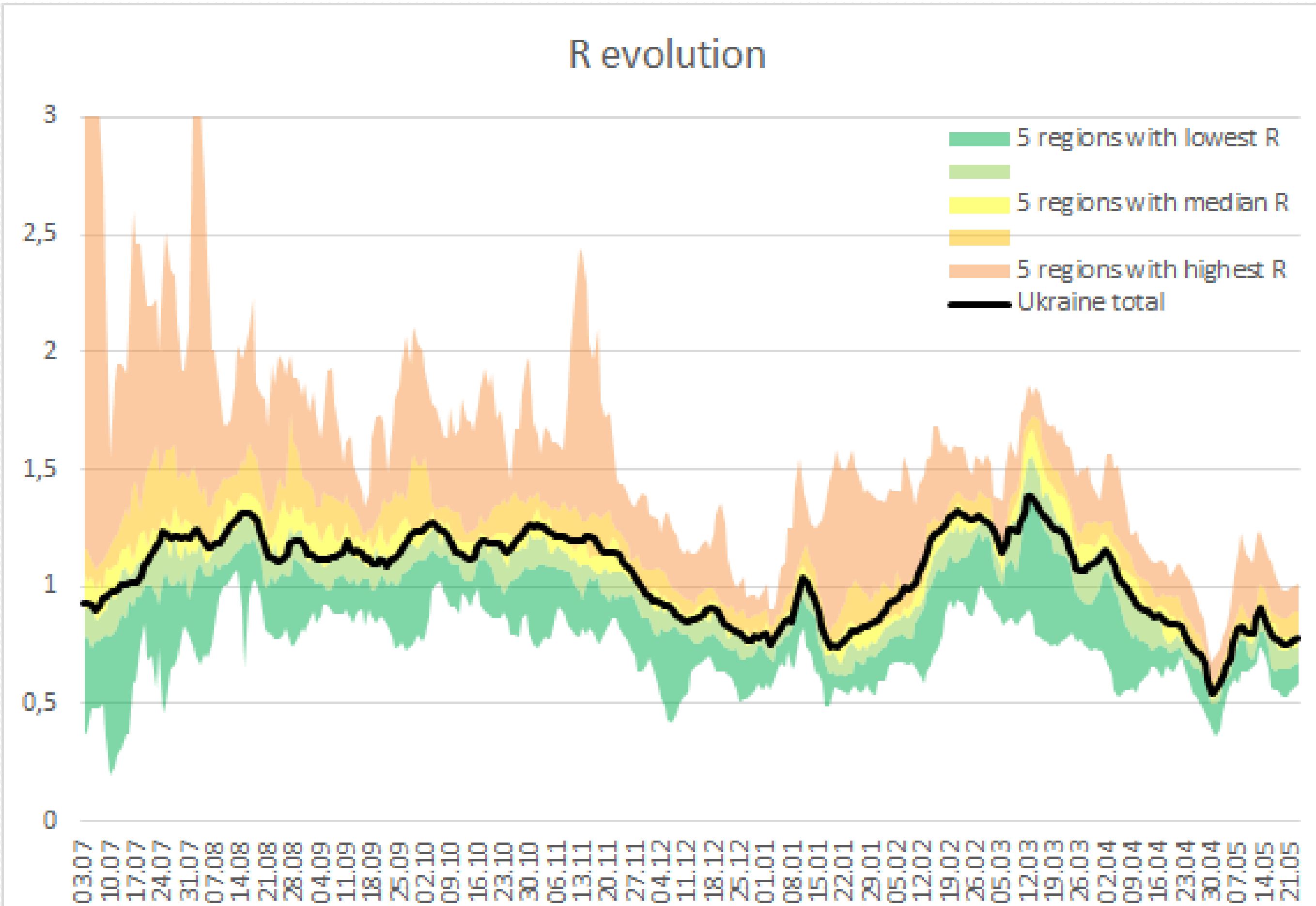
Incubation period

Recovery period

Time to death

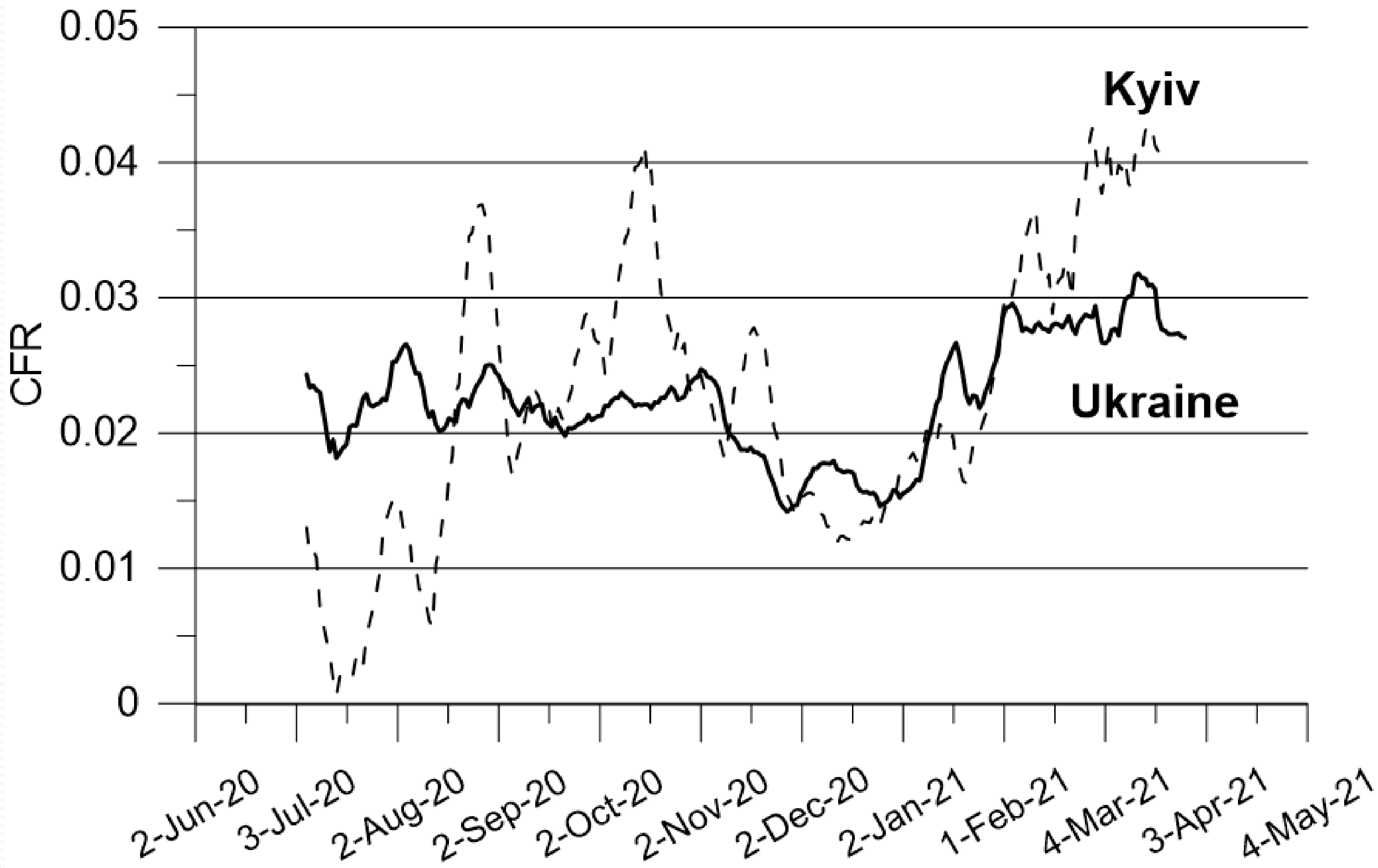
Calibration of unknown parameters

Calibration algorithm is used to determine the mathematical model parameters

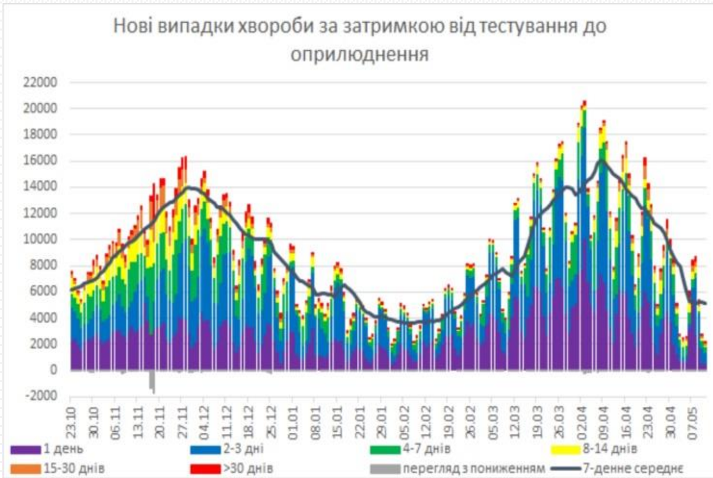


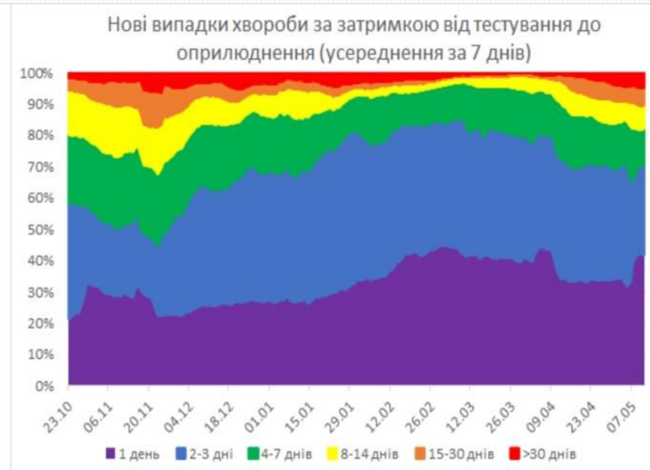
Effective reproduction number for Ukraine and each region

Calibration of Case Fatality Ratio

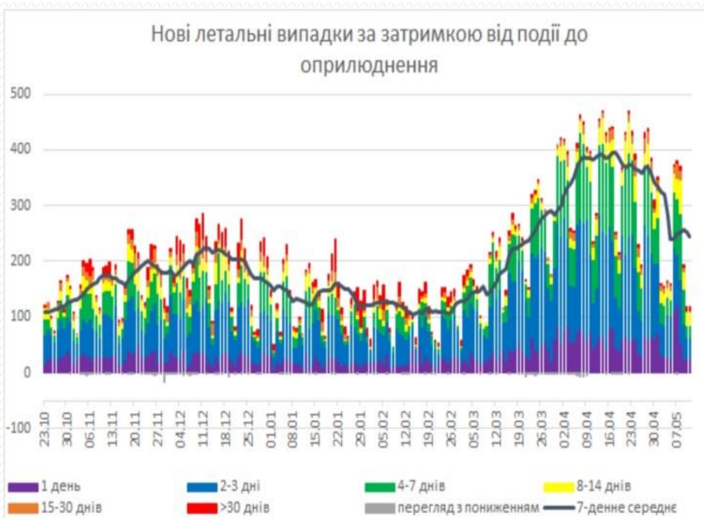


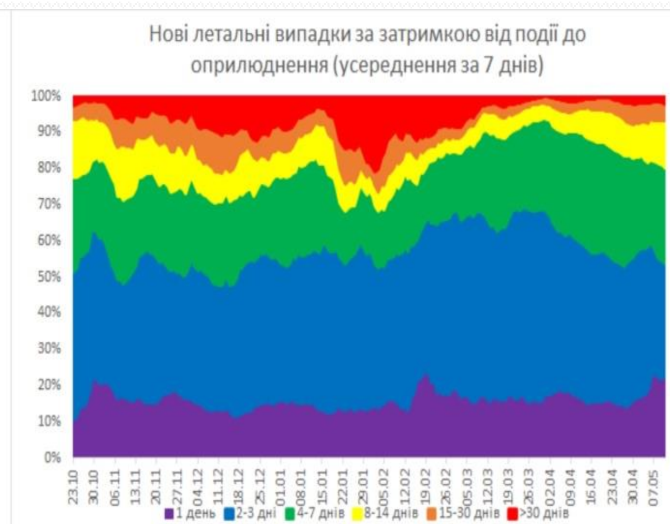
Delays of data publication





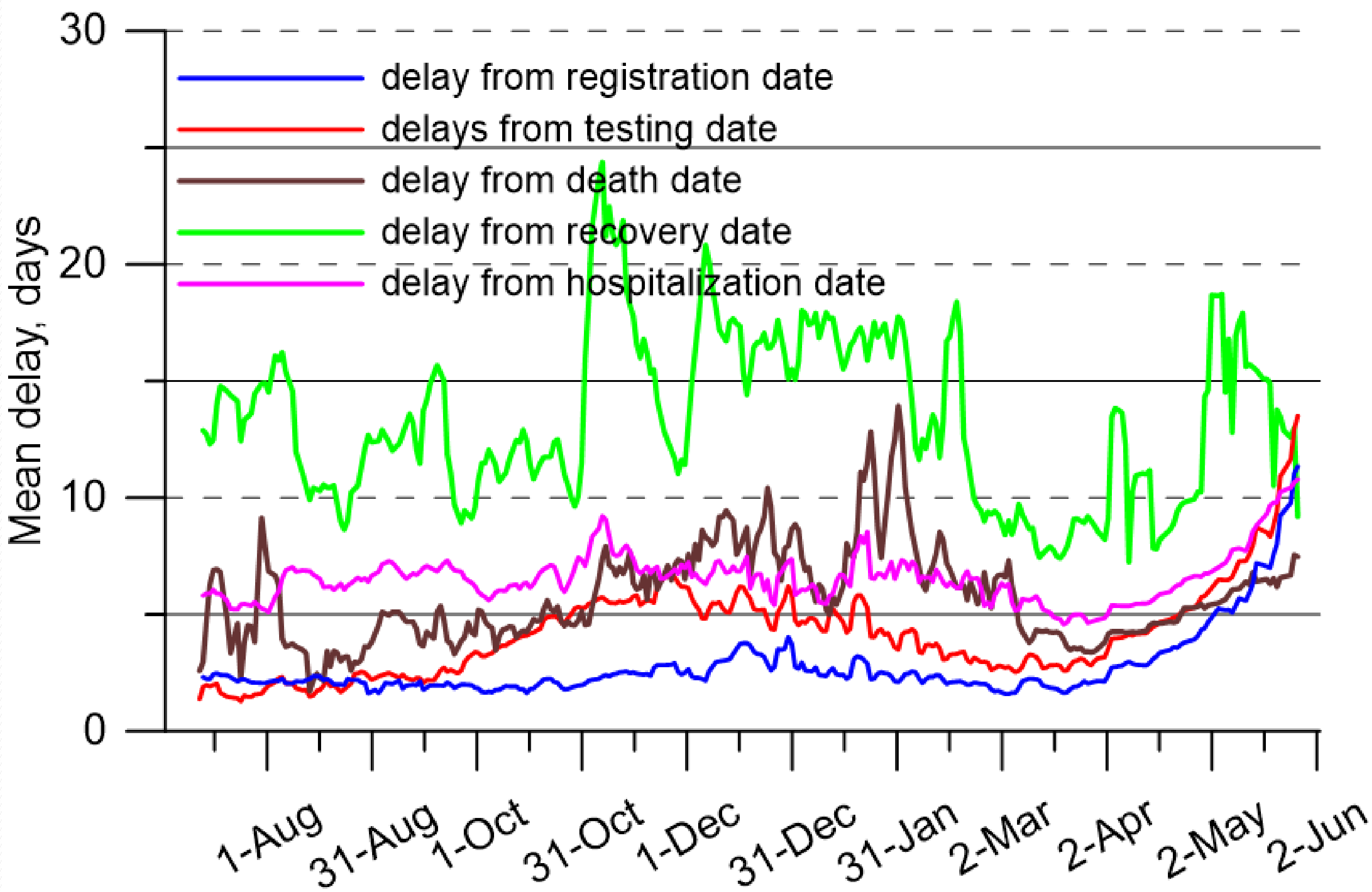
New cases



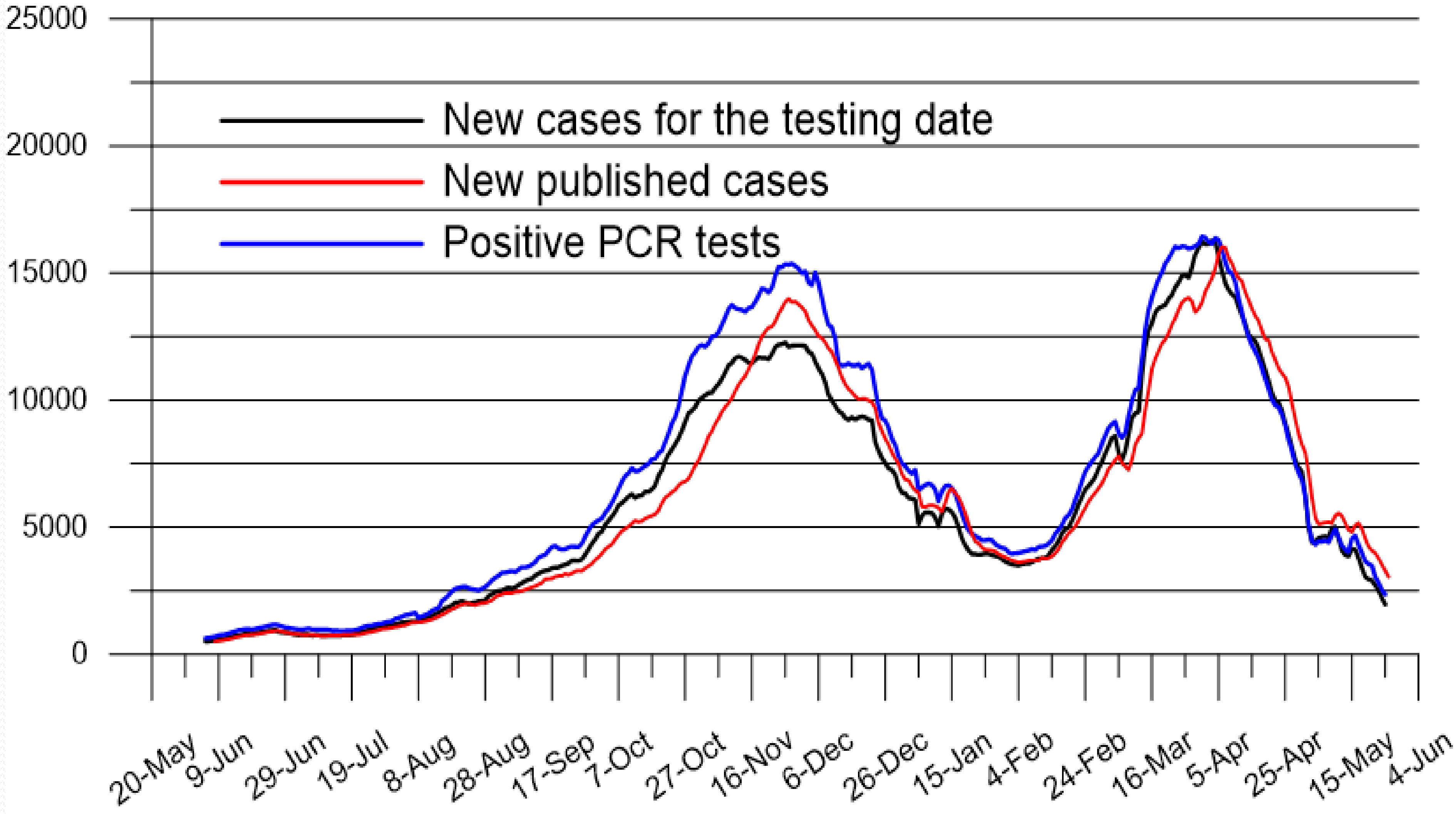


New deaths

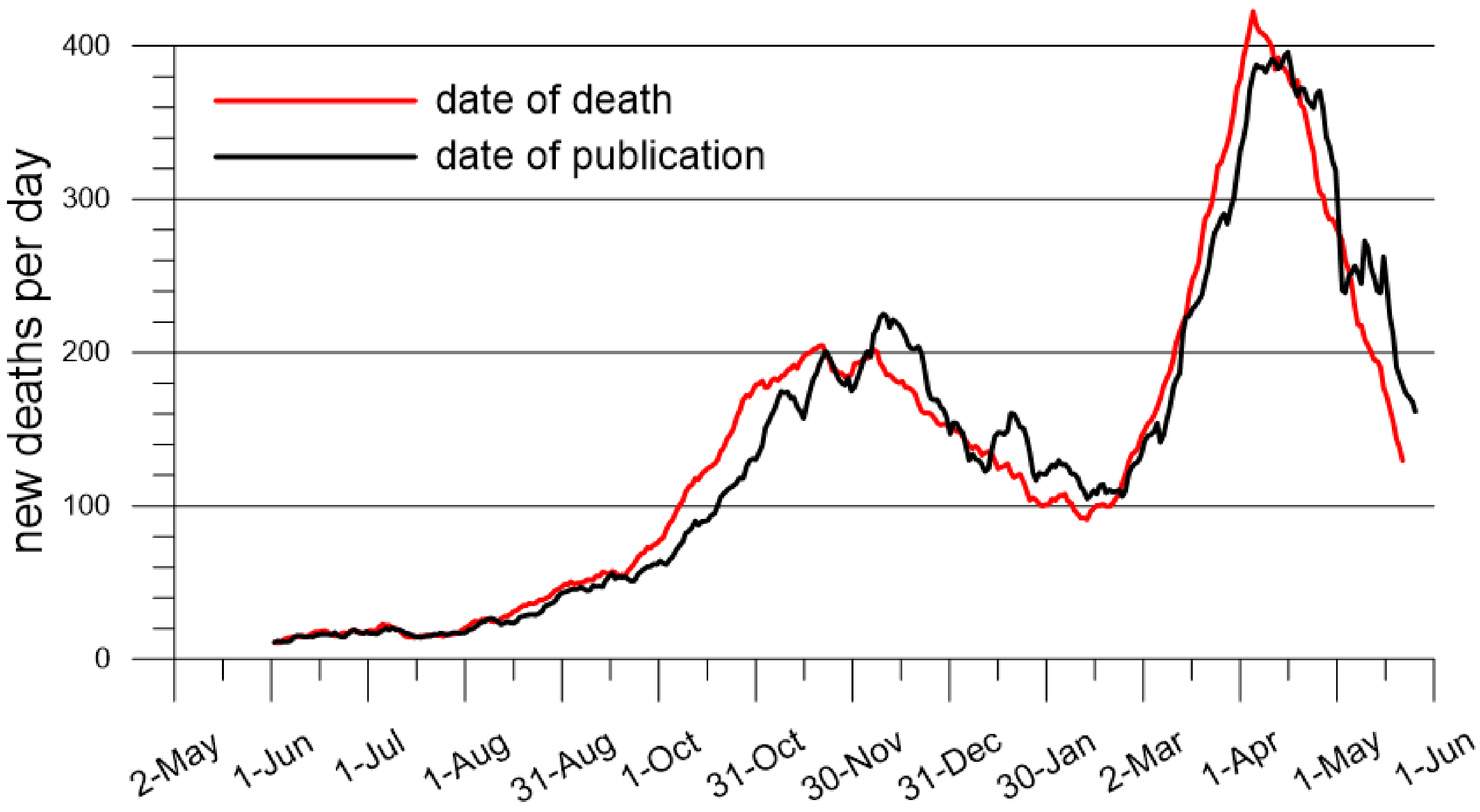
Average publication delays



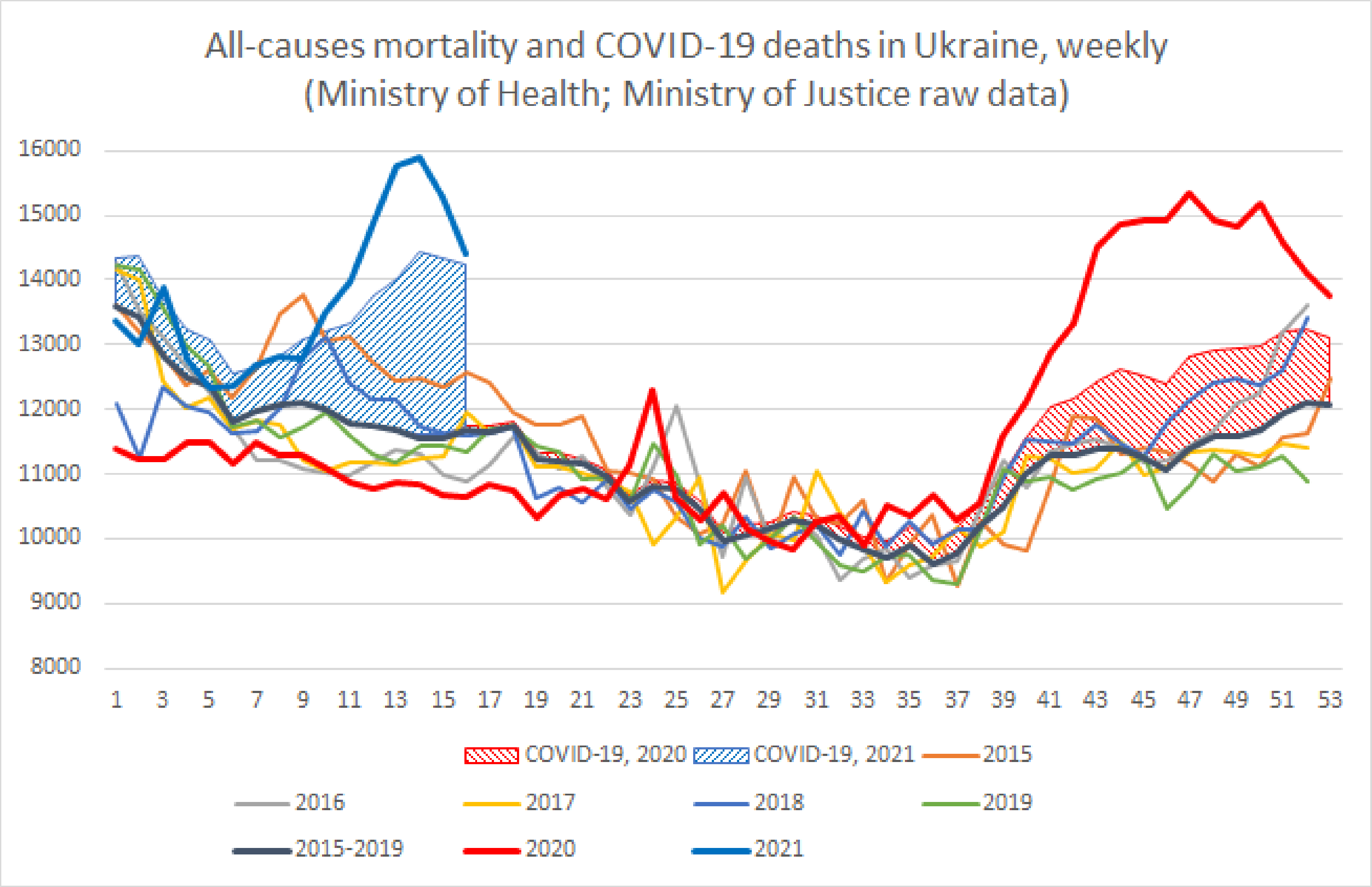
Comparison of published and real dates for new cases



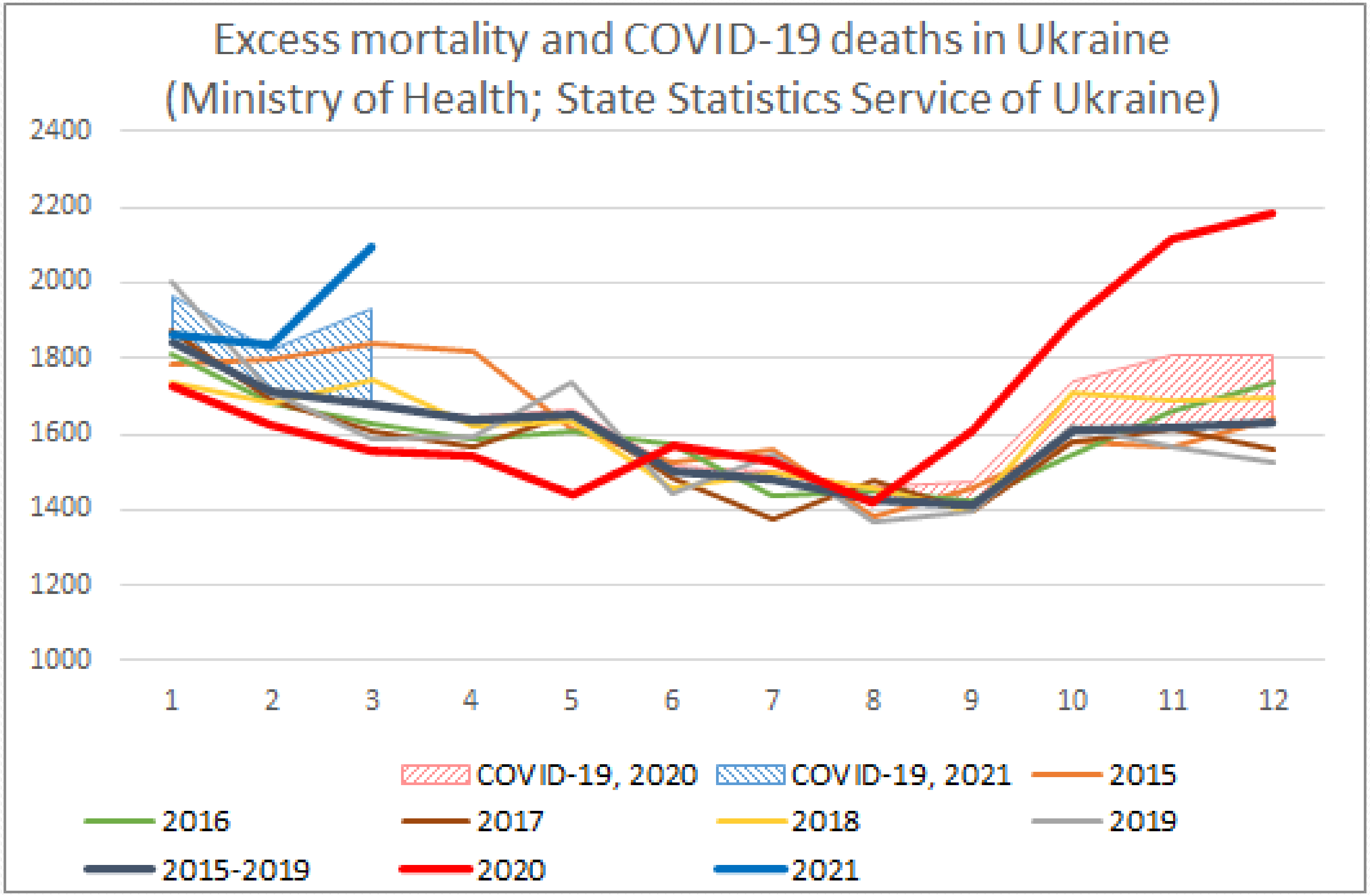
Comparison of published and real dates for new deaths



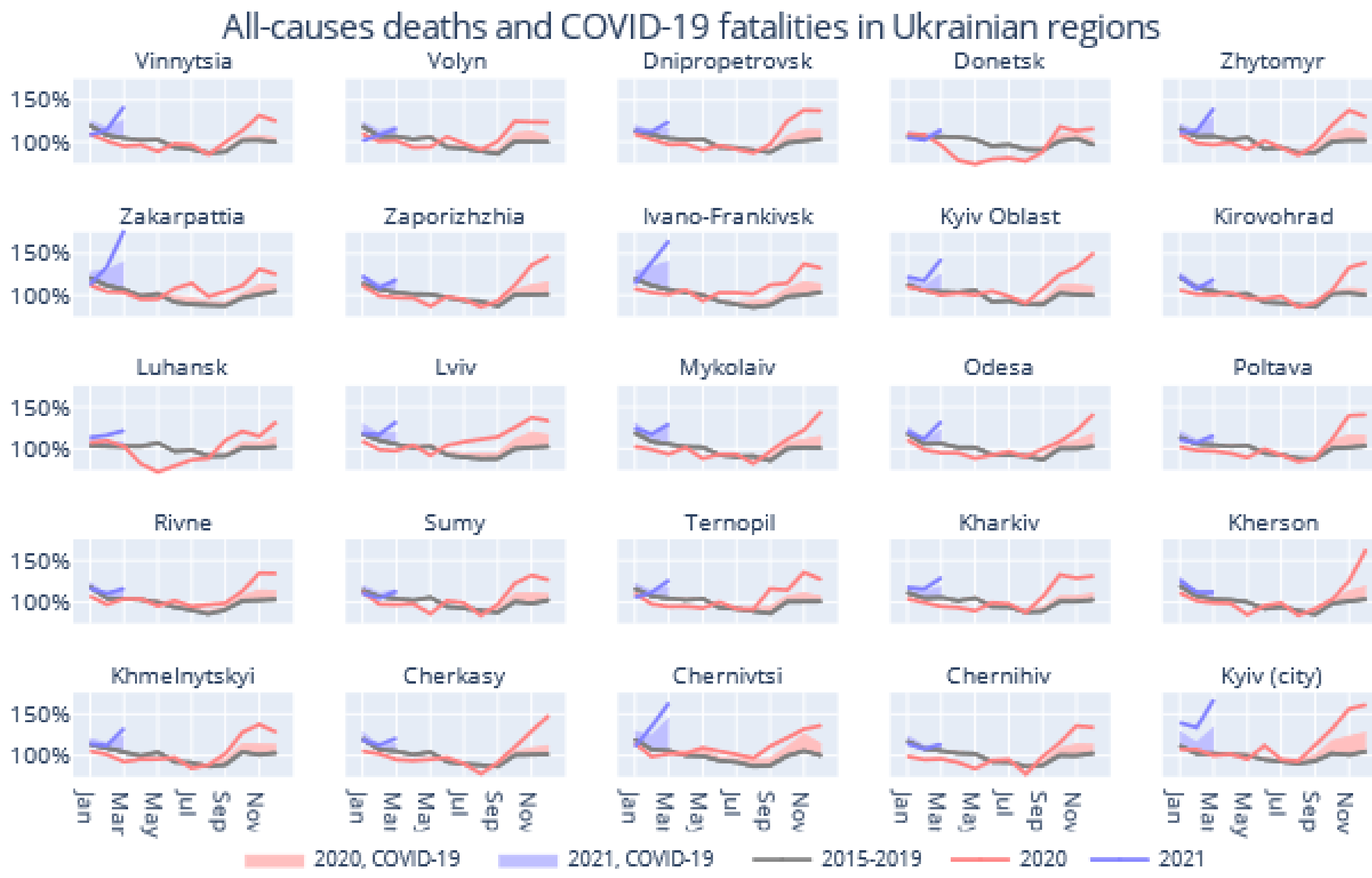
Excess mortality



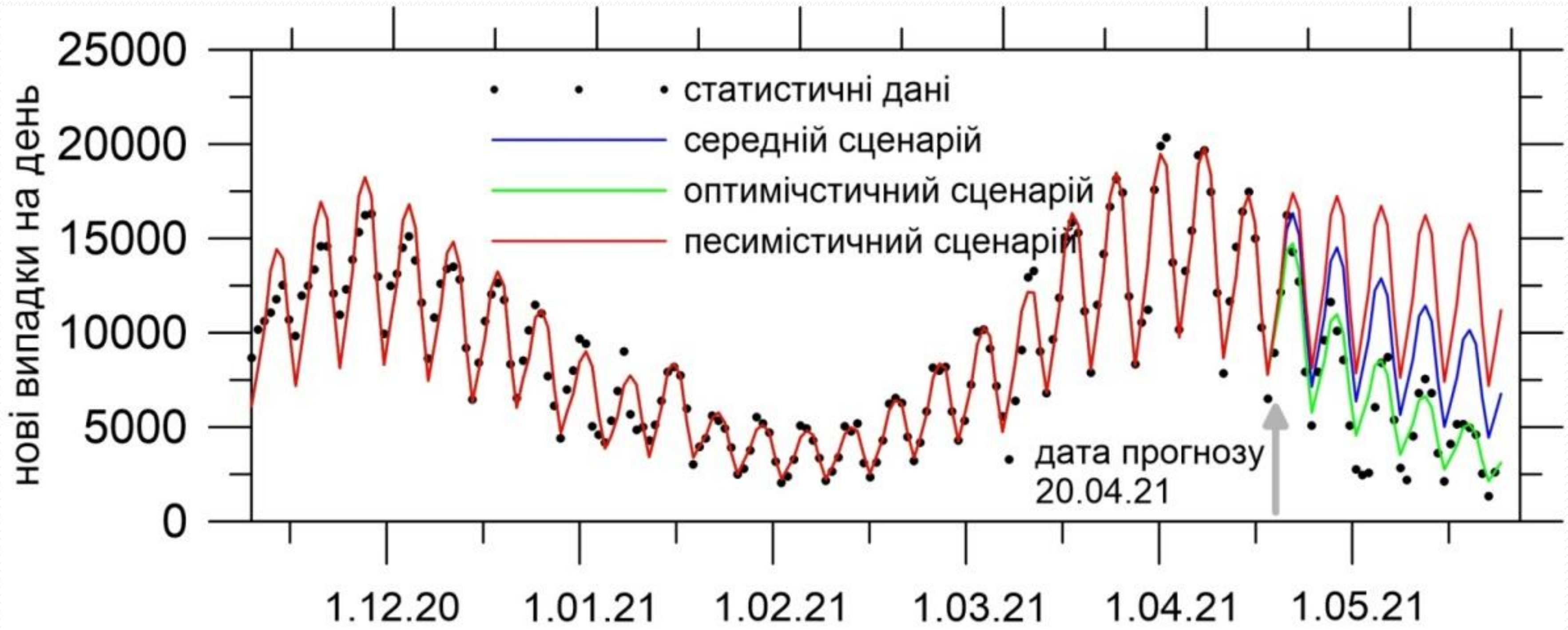
Excess mortality



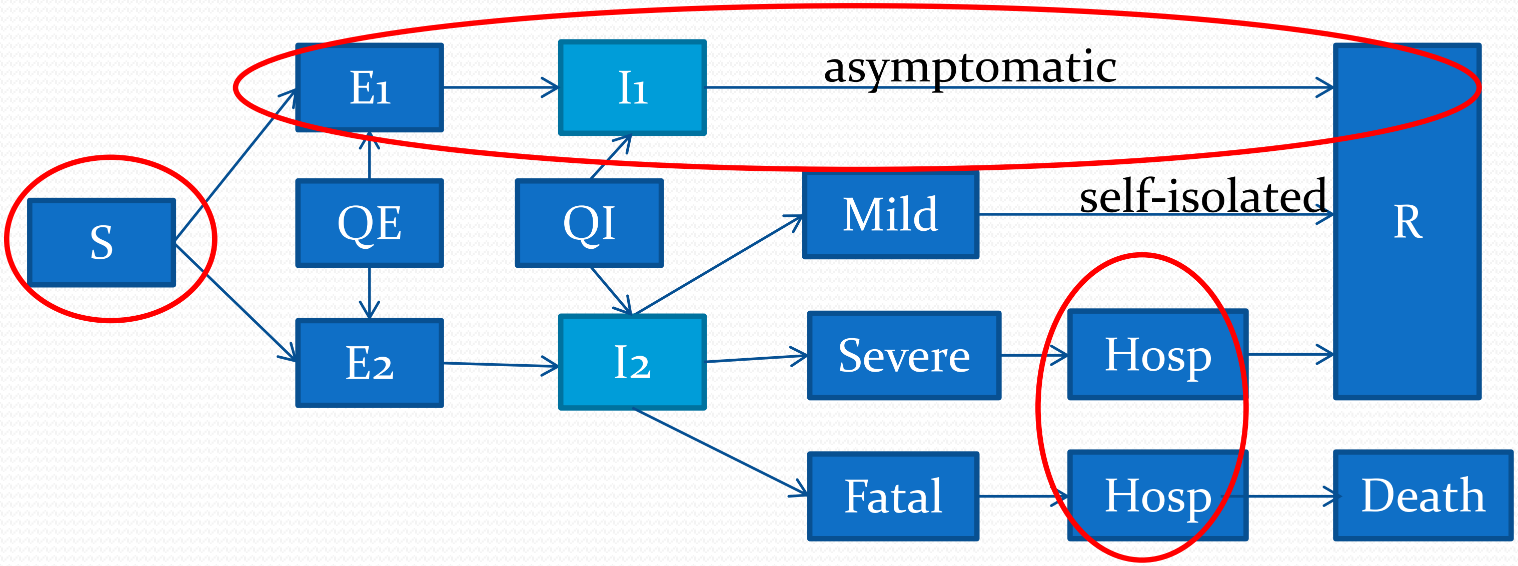
Regional mortality



Example of projection of new cases



Problems/issues



- Fraction of susceptible population, real number of infected population (solution – serological surveys, testing)
- Date of publication vs. date of registration
- Testing
- Hospitalization data

International cooperation

- **UNICEF, World Bank**
- **Epi Modelling and Analytics Technical Working Group (TWG) (WHO, KSE,UNICEF, NASU, UNDP, CDC, World Bank, PHCU)**
- **Sussex University**

Further plans

- Continue producing regular reports for the decision support
- Include data of serological surves and data about herd immunity when available
- Develop age structured model
- Develop demographic model

Age structured mathematical model

nature > scientific reports > articles > article

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Mathematical modelling of the dynamics and containment of COVID-19 in Ukraine

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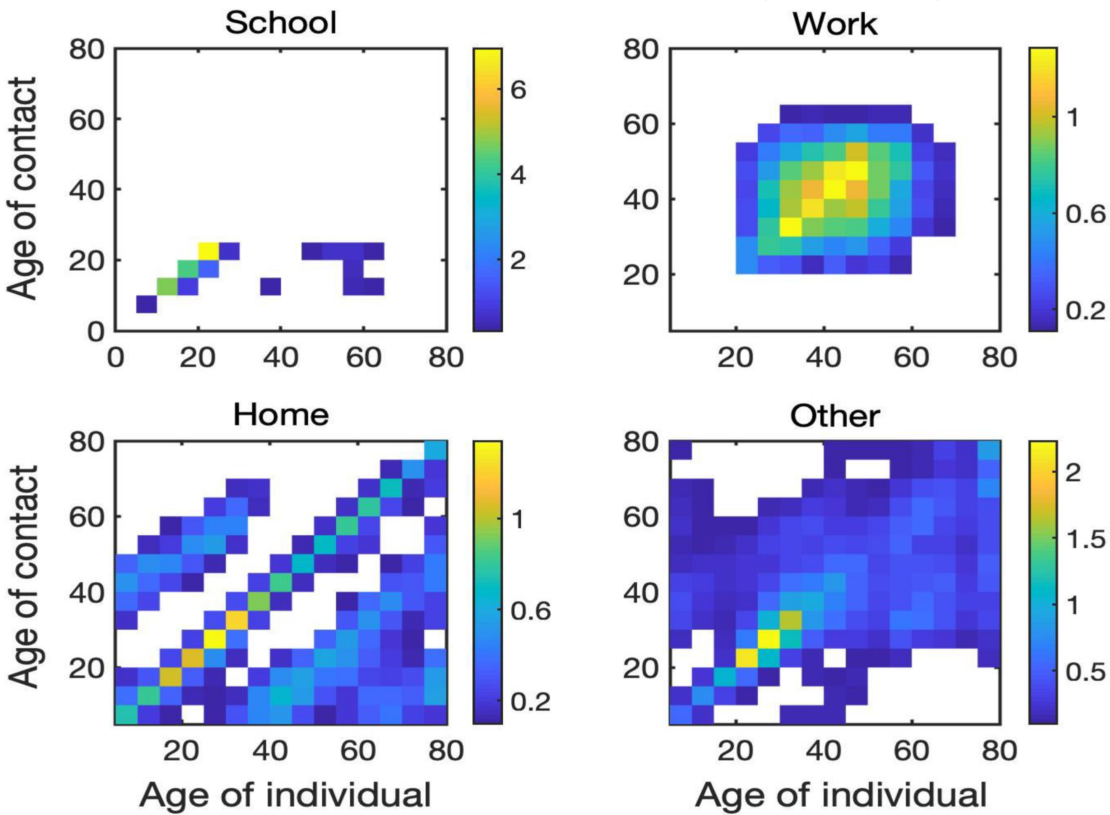

- Needs more sophisticated calibration algorithm
- May be used for simulating the quarantine measures
- May be used for the contact matrix validations
- May require additional sociological information and/or surveys