ICUBAM - Modeling with SIR type models

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and in interaction with all the ICUBAM team.
ICUBAM - Modeling with SIR type models

• ongoing project

• on unfortunately ongoing data...
Basic **SIR model**

compartment model

flow chart:

- **S**: Susceptible
- **I**: Infected
- **R**: Removed (recovered or deceased)

Flow arrows:
- $\beta$: Contact rate from S to I
- $\omega$: Natural recovery rate from I to R
Grand Est region

Simple SIR model
National public data
(Santé Publique France)

Blue: current number of hospitalized patients
Gray: cumulative number of deaths
Green: cumulative number of returned to home
underlying dynamics

DATA
Ile-de-France

Public data
*(Santé publique France)*

Simple SIR model
SEIR type model calibrated on ICUBAM data (alone)

ICUBAM data:
for each participating Intensive Care Unit (ICU) - in the Grand Est région, almost all ICUs -, for each day, since March 18 for most ICUs

• Current number of patients in the ICU
• Cumulative number of deceased cases
• Cumulative number of discharged beds (patients sent back to ‘normal’ hospital bed, then for most back home)
Public official data (Santé Publique France) vs. ICUBAM data

Data collecting: Different modalities
Intensive care: Not exactly the same category (only reanimation beds for ICUBAM)
SEIR type model on ICUBAM data

\[
\begin{align*}
\Delta S(t) &= -\beta \frac{I(t)S(t)}{N} \\
\Delta I(t) &= \beta \frac{I(t)S(t)}{N} - \omega_{ic}I(t) - \omega_{ir}I(t) \\
\Delta C(t) &= \omega_{ic}I(t) - \omega_{cx}C(t) \\
\Delta X(t) &= \omega_{cx}C(t)
\end{align*}
\]
SEIR model

SIR + Incubation compartment (Exposed state)

Underlying dynamics

DATA

X (R or D)
\[ \Delta S(t) = -\beta \frac{E_t S_t}{N}; \]
\[ \Delta E(t) = +\beta \frac{E_t S_t}{N} - \omega_{ei} E_t \]
\[ \Delta I(t) = \omega_{ei} E_t - \omega_{ic} I_t - \omega_{ir} I_t \]
\[ \Delta C_1(t) = \omega_{ic} I_t - \omega_{cc} C_{1t} \]
\[ \Delta C_2(t) = \omega_{cc} C_{1t} - \omega_{cx} C_{2t} \]
\[ \Delta X(t) = \omega_{cx} C_{2t} \]

Large distribution of time spent in ICU
Here: extension of time distribution by having an additional compartment within the ICU one

Underlying dynamics

\( X \) (R or D)
\( \omega_x \)
\( \omega_r \)
\( \omega_{icu} \)
\( \omega_{12} \)

DATA

ICU_2
ICU_1
Calibration of the model on each Département
Optimization over:
{ $\beta$; rates ($\omega$...); initial conditions }
Fit on data ≤ April 27
Prediction for the two following days
Colored zones: 95% credible regions
Fit on data ≤ April 27
Prediction for the two following days

Colored zones: 95% credible regions
ICUBAM   Modeling - under progress

• Back to the future
  Prediction that could have been made at earlier stages (before the peaks)

• Scenarios after the end of the lockdown

• Model: Coupling several Départements
ICUBAM project

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