

Models in public health

SE Scientific Communication, 2019

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28. June 2019

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Background

Outbreaks:

Influenza, 2009

MERS-Cov (Middle-East Respiratory Syndrome)

Ebola, West Africa, DRC

Zika Virus, Brazil

Objective/Goal

during outbreak:

exploit all data

inform response team in real time

in general (also non outbreak situation)

allow evidence based decisions

compare/assess interventions

policy evaluation (before/after in), vaccine programmes

track of WHO targets (HIV, HCV)

Types of models

dynamic, mathematical (SIR)

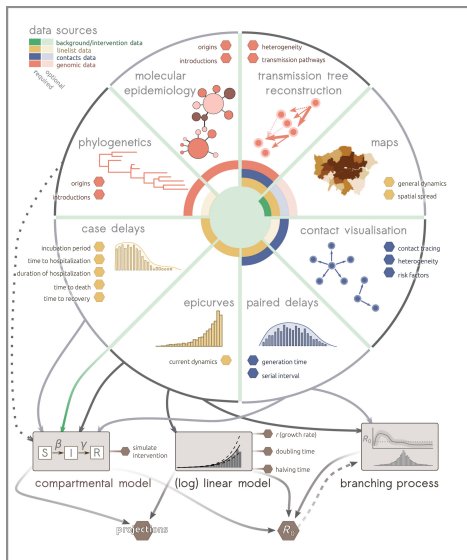
statistical (e.g. Poisson regression)

Bayesian statistics

spacial stats/models

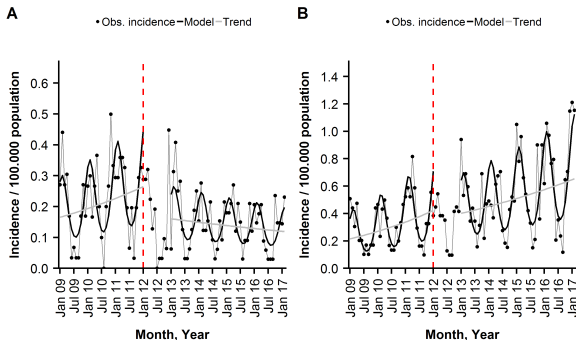
-> visualise outcome

Example of outbreak analytics workflow.



Intervention effect - Invasive Pneumococcal Disease (IPD)

Figure: Monthly incidence of (A) PCV10 ST-IPD and (B) non-PCV10 ex ST 6A-/19A-IPD, among the ≥ 50 years old, observed and modelled by a segmented negative binominal regression, Austria, January 2009-February 2017, shown are overall and seasonal trends.



Serfling-like Model

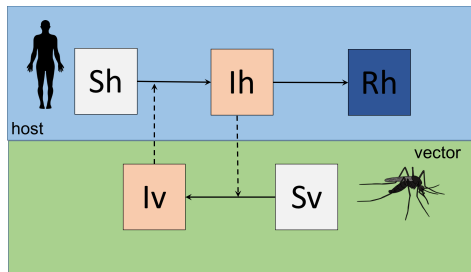
$$\begin{aligned}\log(Y_t) = & \log(pop_t) + \beta_0 + \beta_1 t + \beta_2 \sin\left(\frac{2\pi t}{12}\right) \\ & + \beta_3 \cos\left(\frac{2\pi t}{12}\right) + \beta_5 (t - t_0)^+ \\ & + \mathbb{1}_{t-t_0>0} \left[\beta_4 + \beta_6 \sin\left(\frac{2\pi t}{12}\right) + \beta_7 \cos\left(\frac{2\pi t}{12}\right) \right]\end{aligned}$$

with

$$(x)^+ = \begin{cases} x, & \text{if } x > 0, \\ 0, & \text{otherwise.} \end{cases}$$

Transmission model of Zika Virus

Vars	Description
S_h	Susceptible Humans
I_h	Infected/Infectious humans
R_h	Humans recovered from infection (with lifelong immunity)
S_v	Susceptible vectors
E_v	Exposed vectors



adapted from
<https://www.reconlearn.org/> and Ferguson et al., 2016

Transmission model of Zika Virus

Humans/Host

$$\frac{dS_h}{dt} = \mu_h N_h - \frac{\beta_h b}{N_h} S_h I_v - \mu_h S_h$$

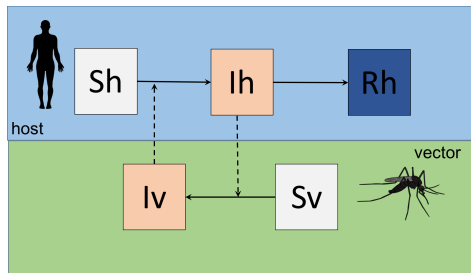
$$\frac{dI_h}{dt} = \frac{\beta_h b}{N_h} S_h I_v - (\gamma_h + \mu_h) I_h$$

$$\frac{dR_h}{dt} = \gamma_h I_h - \mu_h I_h$$

Vectors

$$\frac{dS_v}{dt} = \mu_v N_v - \frac{\beta_v b}{N_h} I_h S_v - \mu_v S_v$$

$$\frac{dI_v}{dt} = \frac{\beta_v b}{N_h} I_h S_v - \mu_v I_v$$



adapted from
<https://www.reconlearn.org/> and Ferguson et al., 2016

GO ??

a

Conclusion

Here comes the conclusion



References

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- [2] Neil M. Ferguson et al. "Countering the Zika Epidemic in Latin America". In: *Science* 353.6297 (July 22, 2016), pp. 353–354. ISSN: 0036-8075, 1095-9203. DOI: 10.1126/science.aag0219. pmid: 27417493. URL: <https://science.sciencemag.org/content/353/6297/353> (visited on 06/19/2019).
- [3] Polonsky Jonathan A. et al. "Outbreak Analytics: A Developing Data Science for Informing the Response to Emerging Pathogens". In: *Philosophical Transactions of the Royal Society B: Biological Sciences* 374.1776 (July 8, 2019), p. 20180276. DOI: 10.1098/rstb.2018.0276. URL: <https://royalsocietypublishing.org/doi/10.1098/rstb.2018.0276> (visited on 06/18/2019).
- [4] R. E. Serfling, I. L. Sherman, and W. J. Houseworth. "Excess Pneumonia-Influenza Mortality by Age and Sex in Three Major Influenza A2 Epidemics, United States, 1957-58, 1960 and 1963". In: *American Journal of Epidemiology* 86.2 (Sept. 1967), pp. 433–441. ISSN: 0002-9262. DOI: 10.1093/oxfordjournals.aje.a120753. pmid: 6058395.