University of Warwick
Msc in Mathematics of Systems

Research Study Group

Mumps Data & Model

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Data

Most recent EU outbreaks

- **UK:** 2004-2019, mainly universities. (Gupta et al. 2005)
- **Ireland:** 2009, secondary schools and unis, probably due to no-vax movements and economic issues of the gov which failed vaccine coverage.
- **Ireland:** 2019-20, due to low uptake in the 90s, quite high in some counties.

- Belgium: 2012, Ghent uni, only few cases.
- The Netherlands: 2008-10, students, might be due to previous no-vax movements.

We decided to focus on UK and possibly Ireland.

UK data and general info

- **Wales and England:** confirmed cases. Data Source.
  `4 spreadsheet: total cases recorded quarterly and total annual cases stratified per county and age-class. Separated into 1995-2012 and 2013-2019.` ✔
  `data to be used only split into the age-groups mentioned in the Model section, we could disregard the values that are NK (Not Known) or take them into account as some sort of noise?`
  - More on Epidemiology, Surveillance and Control link.
  - General info on mumps condition from NHS website
  - NHS Children vaccination coverage programme data from 2017-18
  - Mumps and risks in pregnancy link to website
- **Scotland:** we found some plots for quarterly records and for cases stratified by age structure at the following link
  `to access row data it is necessary to send a` **`FOI request.`** ⇐
  - Child vaccination and immmunisation lint to website
- **Ireland:** we have a set of pages,
  a) reported cases,

b) MMR protection

c) and some Annual reports.

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no info on how to get the raw data - ?
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Model [1]

6 age groups:

1. $0 - 4$ years (could possibly split to two groups and include the two vaccinations)
2. $5 - 9$ years
3. $10 - 14$ years
4. $15 - 19$ years
5. $20 - 29$ years
6. $30+$ years

ODE model

$$
\begin{aligned}
\frac{dS_1}{dt} =& (1-\theta\sigma)\Lambda - \sum_{j=1}^{6} \beta_1 c_{1j} S_1 I_j - d_1 S_1 - \alpha_1 S_1 \\
\frac{dI_1}{dt} =& \sum_{j=1}^{6} \beta_1 c_{1j} S_1 I_j - (d_1 + \gamma_1 + \alpha_1) I_1 \\
\frac{dR_1}{dt} =& \theta\sigma\Lambda + \gamma_1 I_1 - d_1 R_1 - \alpha_1 R_1
\end{aligned}
$$

$$
\begin{aligned}
\frac{dS_k}{dt} =& \alpha_{k-1} S_{k-1} - \sum_{j=1}^{6} \beta_k c_{kj} S_k I_j - d_k S_k - \alpha_k S_k \\
\frac{dI_k}{dt} =& \alpha_{k-1} I_{k-1} + \sum_{j=1}^{6} \beta_1 c_{1j} S_1 I_j - (d_k + \gamma_k + \alpha_k) I_k \\
\frac{dR_k}{dt} =& \alpha_{k-1} R_{k-1} + \gamma_k I_k - d_k R_k - \alpha_k R_k
\end{aligned}
$$

where $k = 2, 3, 4, 5, 6$ and $\alpha_6 = 0$. Λ = birth rate (influx of susceptibles)

θ = immunisation rate of vaccine
σ = efficacy of vaccine
β_k = probability of transmission per contact for age group k
c_{kj} = average number of contacts from age group j to age group k
d_k = natural death rate
α_k = aging rate
γ_k = recovery rate

Two doses of the MMR vaccine (88% effective after two doses):

1. within a month of 1st birthday
2. before school (3 years & 4 months)

Can have a "catch-up" MMR vaccination up to the age of 18.

- people born from 1970-1979 may have only been vaccinated against measles
- people born from 1980 to 1990 may not be protected against mumps

References

1. Zhou, L., Wang, Y., Xiao, Y., & Li, M. Y. (2019). Global dynamics of a discrete age-structured SIR epidemic model with applications to measles vaccination strategies. Mathematical biosciences, 308, 27-37.