



IS COUNTRY *VITALAND* ADEQUATELY PREPARED FOR AN INFLUENZA PANDEMIC?

JASPER ARENDS

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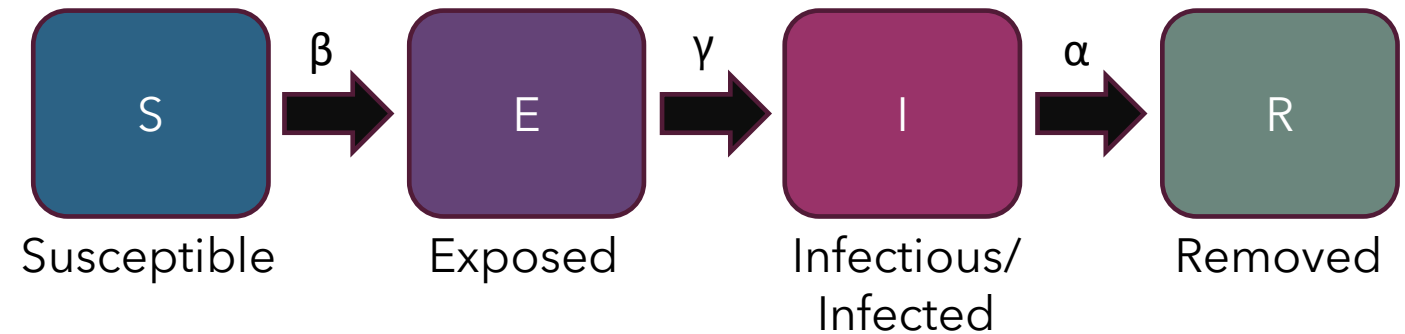


PROBLEM STATEMENT

- Influenza outbreak
- Vaccines for 20% of population
- Model impact of measures
 - Vaccinations
 - Closing of schools
- Based on data from previous pandemic

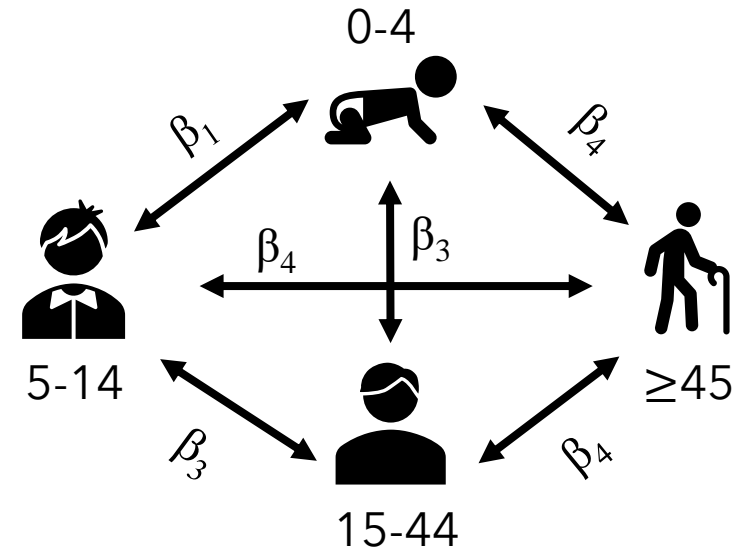
MODEL

- β - contact matrix, describing interactions between and within the age group
- γ - parameter connected with latency period length
- α - parameter connected with infectious period length



CONTACT MATRICES/PARAMETERS

	Matrix 1	Matrix 2	Matrix 3
β_1	$0.12 \cdot 10^{-4}$	$0.13 \cdot 10^{-4}$	$0.53 \cdot 10^{-4}$
β_2	$0.44 \cdot 10^{-4}$	$0.47 \cdot 10^{-4}$	$0.46 \cdot 10^{-4}$
β_3	$5.68 \cdot 10^{-4}$	$0.08 \cdot 10^{-4}$	$6.68 \cdot 10^{-4}$
β_4	$1.63 \cdot 10^{-4}$	$0.03 \cdot 10^{-4}$	$1.90 \cdot 10^{-4}$

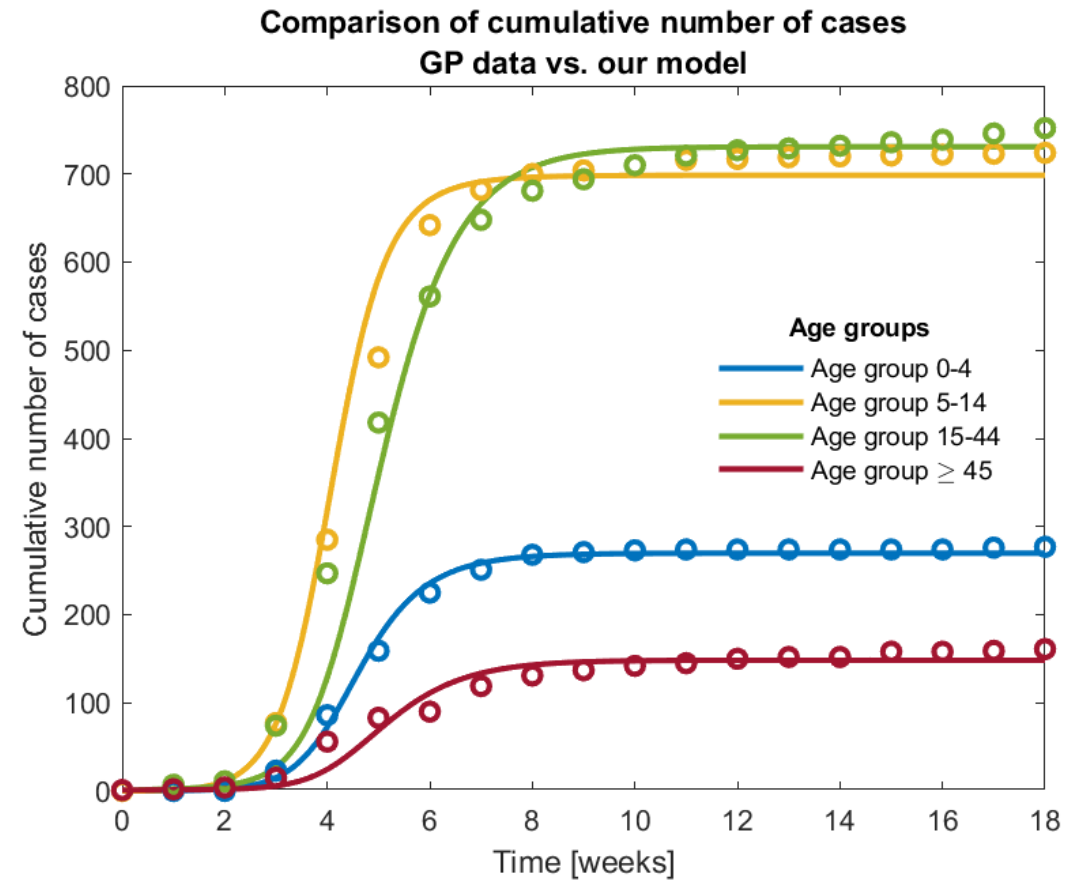


ASSUMPTIONS

- Based on the **scarcity of data**
 - The GP data reflects well the age distribution and number of infections in each age group
- Based on **expert knowledge**
 - Latent and infectious period length
 - Similarity to other flu outbreaks
- Based on **short period of time considered**
 - Contact matrix does not change in time
 - No immunity loss and reinfections
 - No change in population size and age structure

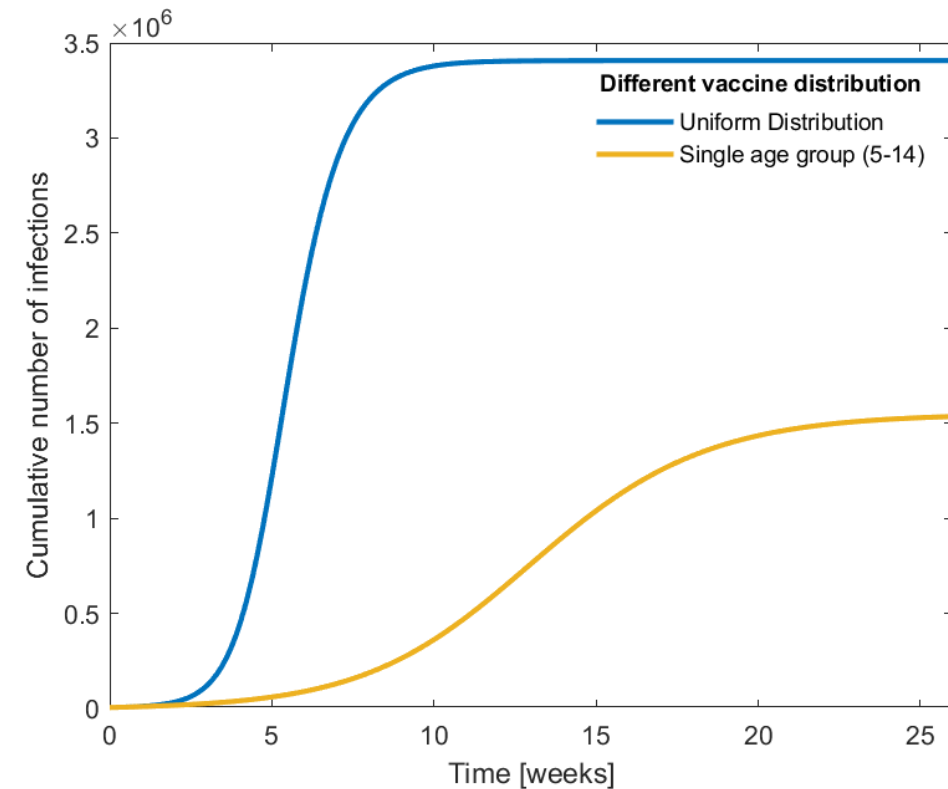
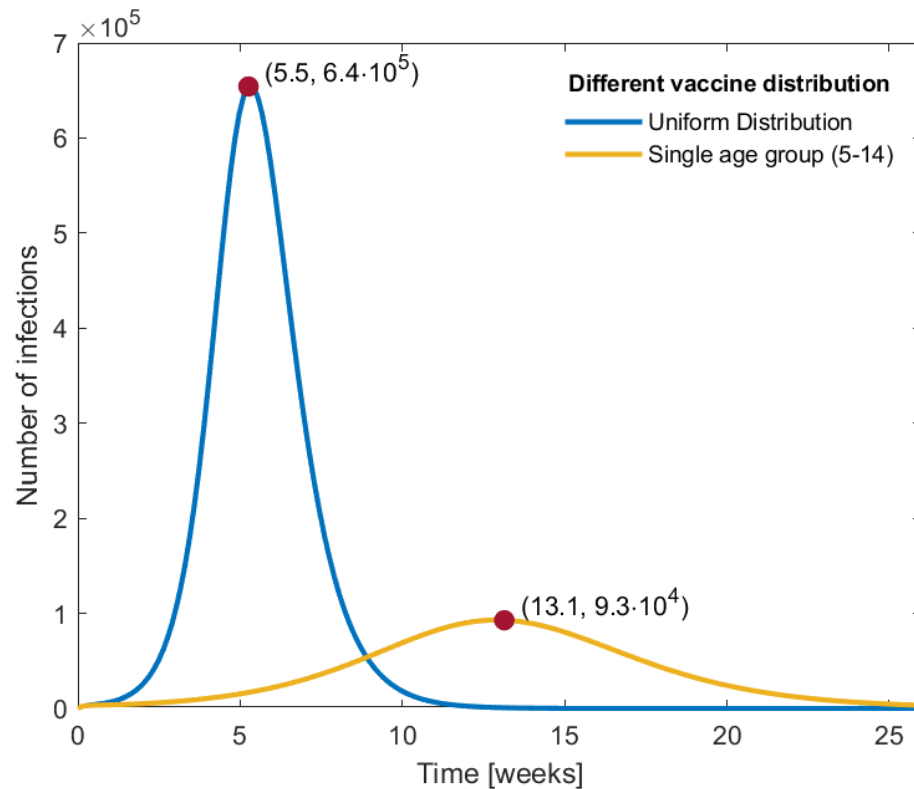
FITTING

	Matrix 1	Matrix 2	Matrix 3
Fit Error (RMSE)	72.8699	80.3447	85.5511

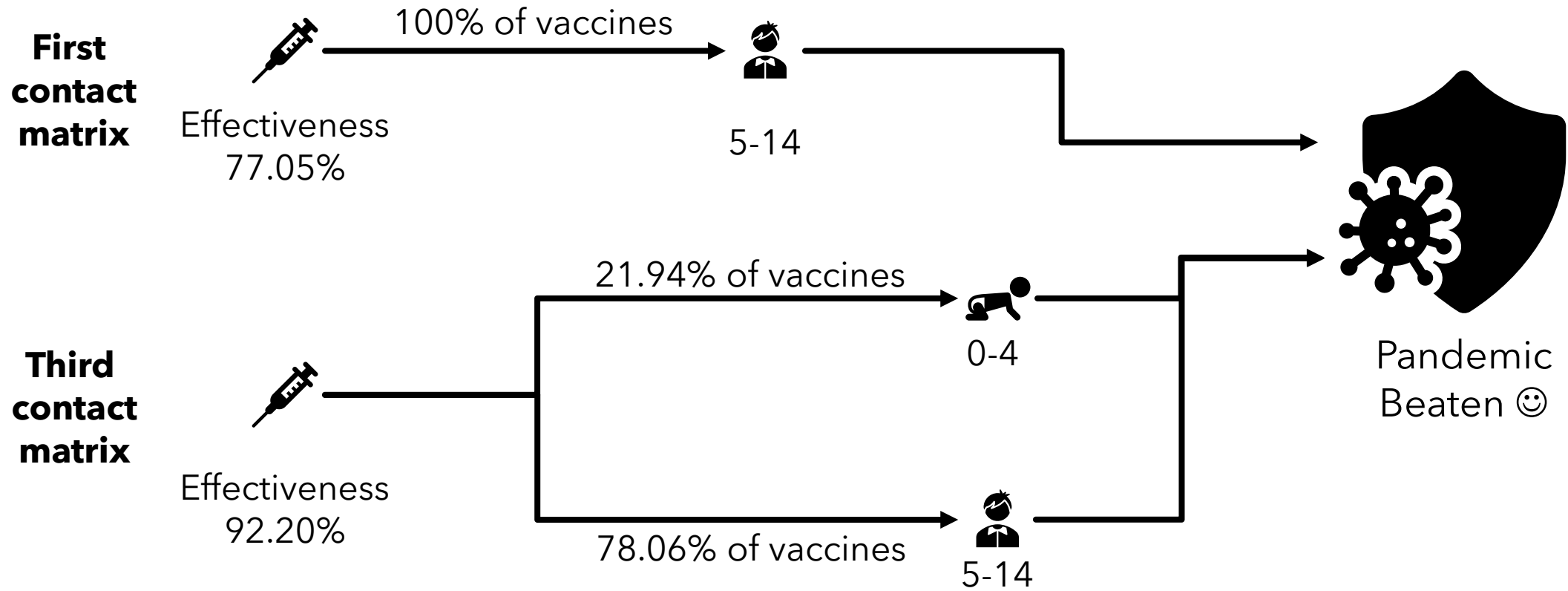


VACCINES DISTRIBUTION

Different vaccine distribution strategies

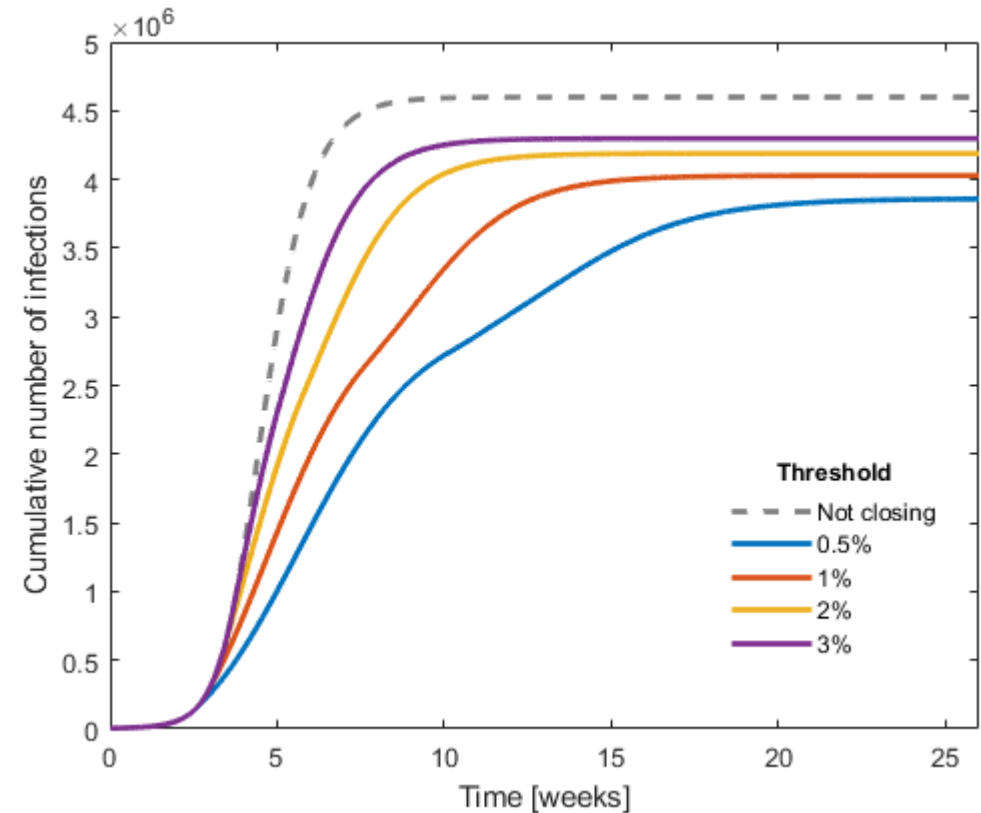
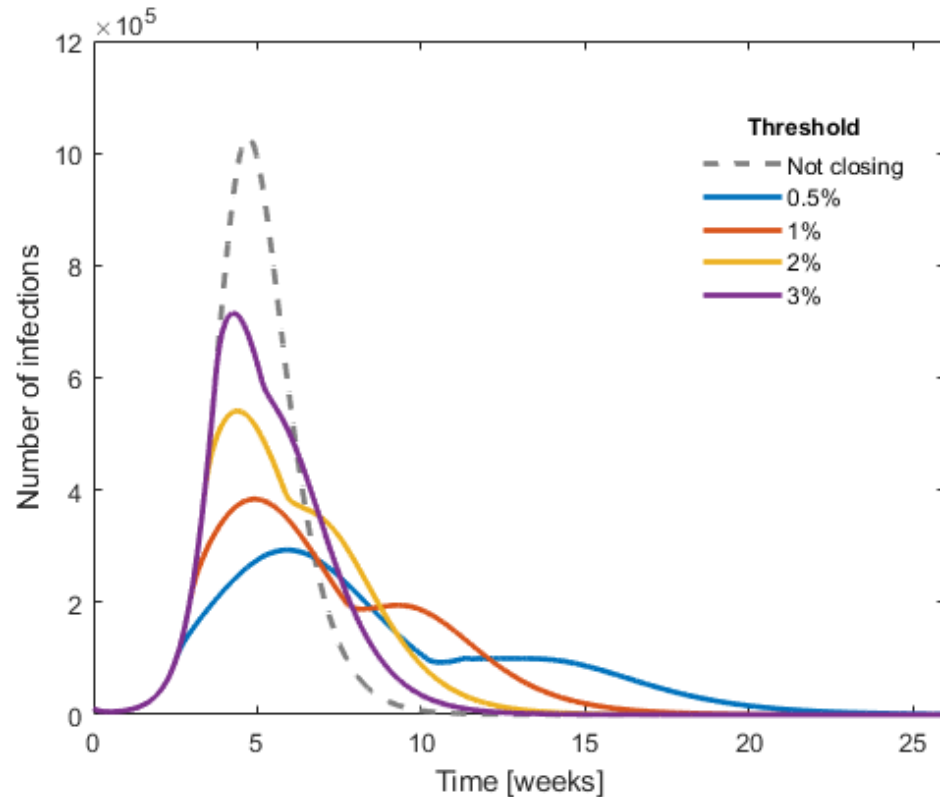


EFFECTIVENESS OF THE VACCINE



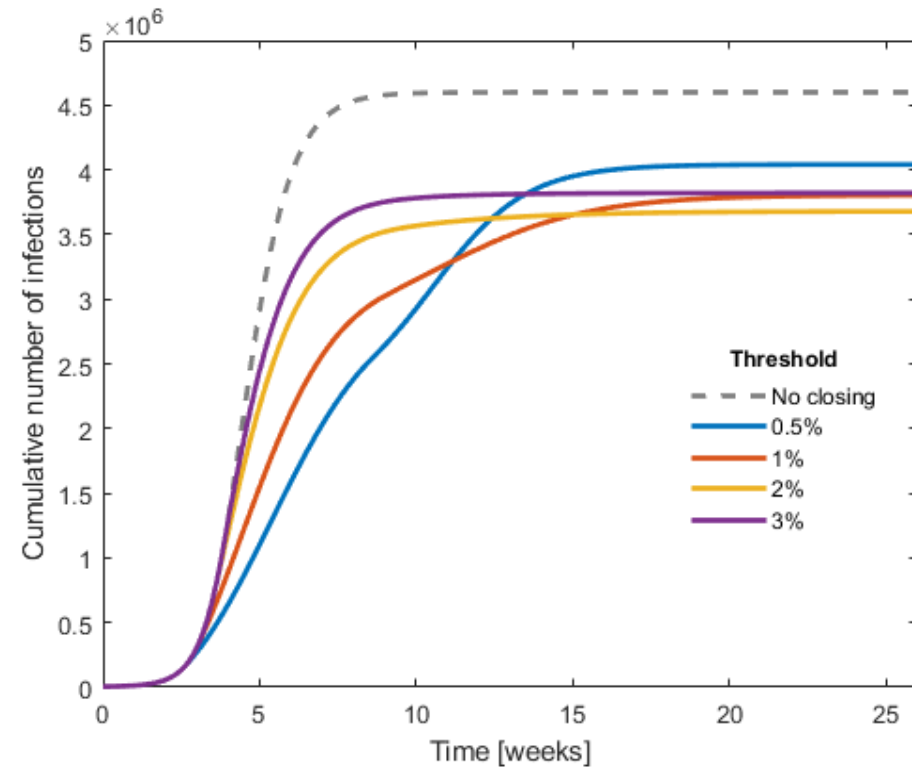
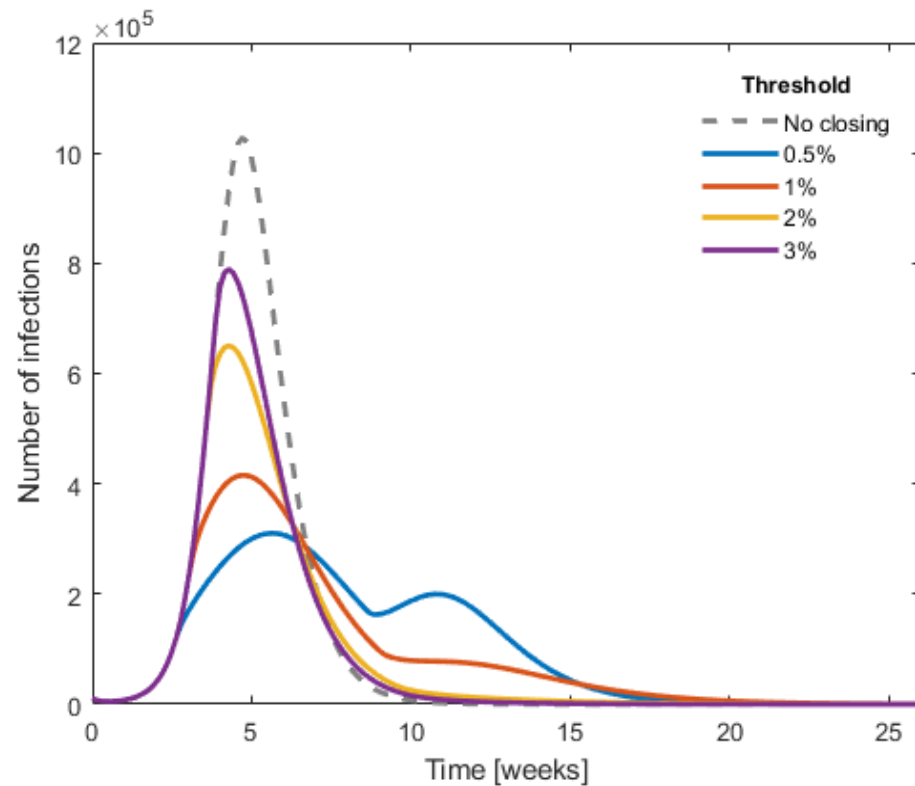
CLOSING SCHOOLS

The schools close when the number of infections surpasses a threshold



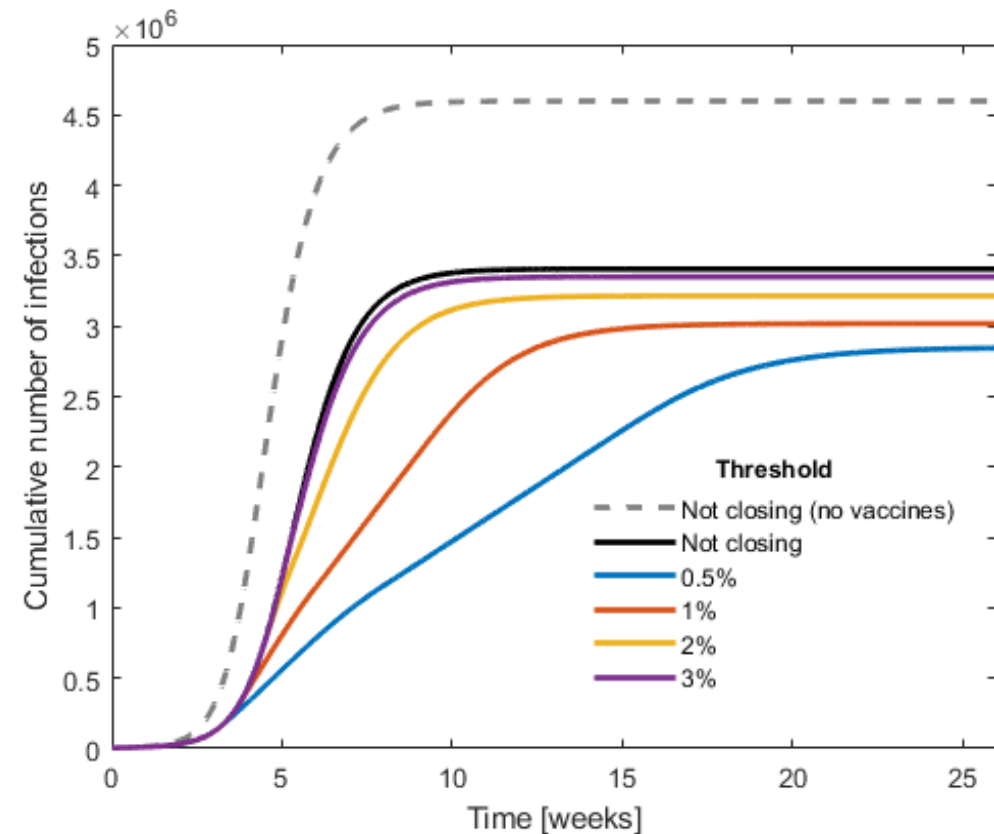
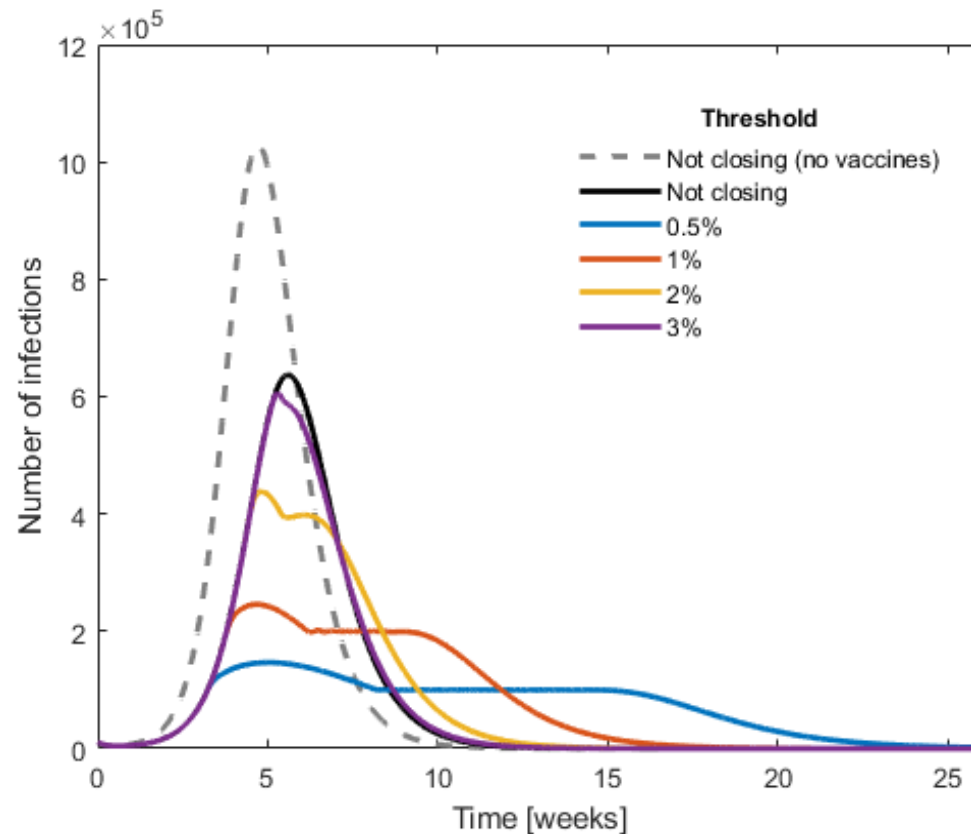
CLOSING SCHOOLS FOR SIX WEEKS

The schools close for six weeks when the number of infections surpasses a threshold



COMBINING STRATEGIES

Combining vaccinations and closure of schools when the number of infections surpasses a threshold



KEY CONCLUSIONS

- Uniform distribution of vaccines → not enough vaccines (required **57-59%** coverage)
- Closing nurseries and schools too late → little change
- Optimal distribution of the vaccine **depends** on its effectiveness
- Vaccination of the **5-14 age group** → most effective
- Threshold for school closure → **2%**

RECOMMENDATIONS

- Continue data collection
 - Contact
 - Recovery and deaths
- Recovered → susceptible
- Moment of vaccination
 - Additional compartment
- Refine age groups



THANK YOU FOR YOUR ATTENTION!

Require eff

Distribution	0-4	5-14	15-44	≥45
M_1	7.05%	0	1600	0
M_2	80.85%	0	1200	0
M_3	92.20%	351	1249	0

For 5-14 group

M_2

β_1	0.0013
β_2	0.0027
β_3	0.0008
β_4	0.0003

Better fit

$$\begin{cases} S_j'(t) = -\sum_{i=1}^4 \beta_{ij} S_j(t) \frac{I_i(t)}{N} \\ E_j'(t) = \sum_{i=1}^4 \beta_{ij} S_j(t) \frac{I_i(t)}{N} - \gamma E_j(t) \\ I_j'(t) = \gamma E_j(t) - \alpha I_j(t) \\ C_j'(t) = \rho \alpha I_j(t) \end{cases}$$

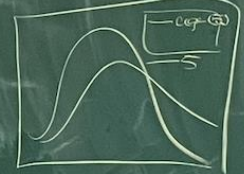


	M_1	M_2	M_3
β_1	0.0012		0.0053
β_2	0.0044		0.0046
β_3	56826		10^4
β_4	1.631		10^4
R_0	2.3452		652

Immunity threshold $1 - \frac{1}{R_0}$

- Opening
- Problem statement ✓
→ Introduce topic ✓
→ CP data ✓
→ Example of Research Question ✓
- Model
→ Compartment graphic ✓
→ Contact matrices + parameters ✓
→ People graphic
- Assumptions → People graphic
- Fit CP... least squares ✓
- Vaccines: Immunity threshold ✓
→ uniform
→ single age group
 $M_1 \quad M_2$

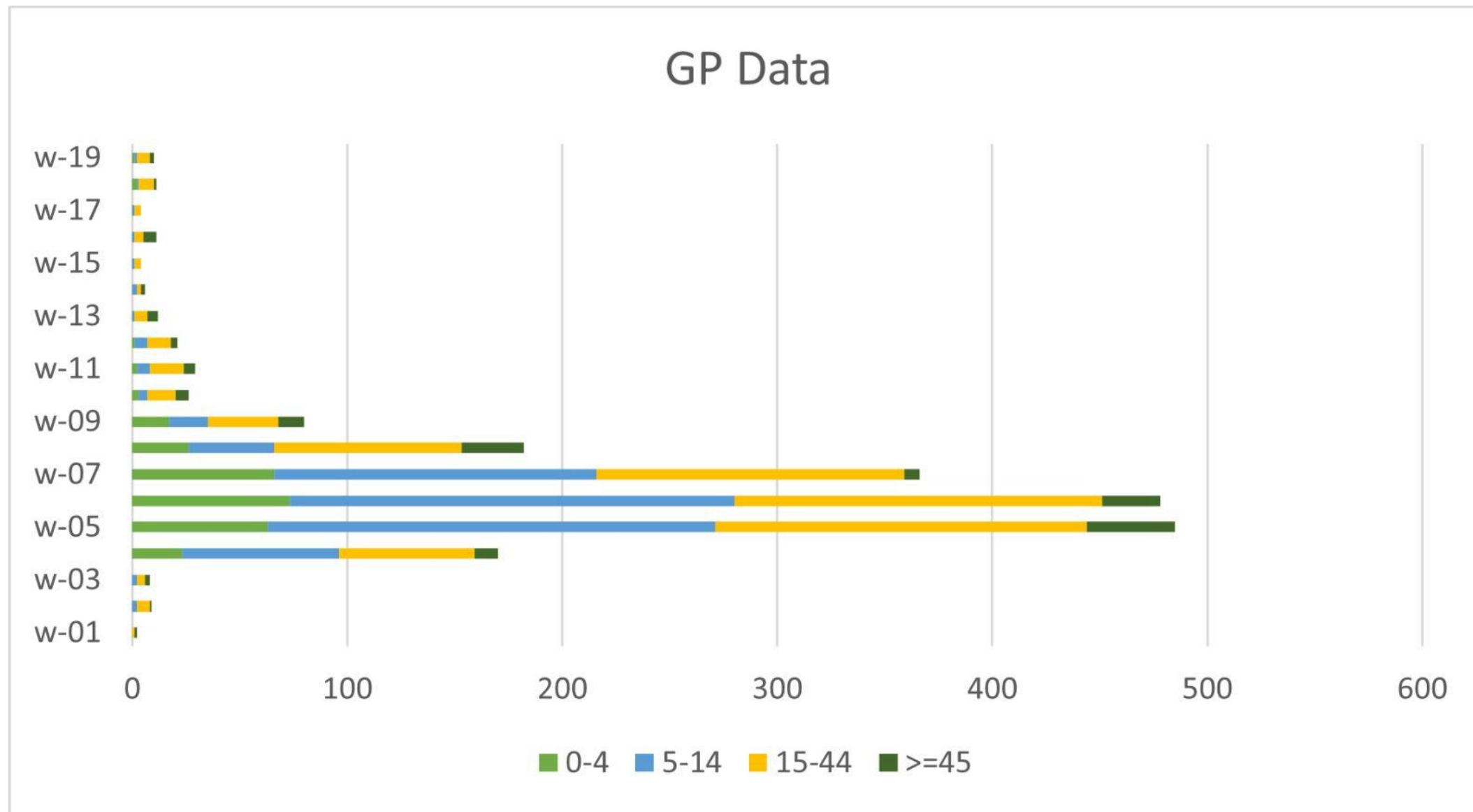
- Effectiveness of Vaccines
- Closing schools
→ above threshold
→ summary statistic
- Closing 6 classes week
- Closing school + vaccine
- Summarize key
- Recommendations



Vaccinate 0-4	Vaccinate 5-14	Vaccinate 15-44	Vaccinate 45-64
$S_j(0) = \begin{bmatrix} 0 \\ 1630 \\ 3467 - \frac{1}{0.45} \\ 1834 - \frac{1}{0.45} \end{bmatrix}$	$S_j(0) = \begin{bmatrix} 349 \\ 90 \\ 3467 - \frac{1}{0.45} \\ 1834 - \frac{1}{0.45} \end{bmatrix}$	$S_j(0) = \begin{bmatrix} 349 \\ 1630 \\ 1867 - \frac{1}{0.45} \\ 1834 - \frac{1}{0.45} \end{bmatrix}$	$S_j(0) = \begin{bmatrix} 349 \\ 1630 \\ 1867 - \frac{1}{0.45} \\ 1834 - \frac{1}{0.45} \end{bmatrix}$
Wasted vaccine			
$R_{eff}^{M_1} = 2.2235$	$R_{eff}^{M_2} = 2.5$		
$R_{eff}^{M_3} = 2.51$			
$R_{eff}^{M_4} = 2.3237$			

DURATION OF PANDEMIC

<i>Duration [weeks]</i>	No closing	0.5%	1%	2%	3%
Threshold	9.82	21.0	16.2	13.0	11.5
Threshold + vaccination	10.9	22.5	15.9	12.4	11.2
6 consecutive weeks	9.82	15.1	18.3	11.6	10.1
<i>Peak size [10^5]</i>					
Threshold	10.3	2.93	3.84	5.41	7.15
Threshold + vaccination	6.36	1.47	2.46	4.38	6.06
6 consecutive weeks	3.43	4.12	4.98	7.15	9.60
<i>Total no. of infections [10^6]</i>					
Threshold	4.60	3.86	4.03	4.19	4.30
Threshold + vaccination	3.41	2.84	3.02	3.22	3.35
6 consecutive weeks	3.96	3.81	3.69	3.74	4.08



MODEL EQUATIONS

- $S' = -\beta SI$
- $E' = \beta SI - \gamma E$
- $I' = \gamma E - \alpha I$
- $R' = \alpha I$

Where,

S = Number of Susceptible people

E = Number of Exposed people

I = Number of Infectious people

R = Number of Recovered people

β = Contact matrix, describing interactions between and within the age group

γ = parameter connected with latency period length

α = parameter connected with infectious period length