Expected impact of lockdown in Île-de-France and possible exit strategies

Summary of Di Domenico, Pullano, Sabbatini, Boëlle, and Colizza, 2020

1 Summary

The paper proposes a compartmental model to model the covid-19 epidemic in Ile-de-France. Interactions between the age groups are define with an interactions matrix, and policies are implemented by changing this matrix. The authors evaluate several strategies to lift confinment. The results show that whatever the strategy, without testing the epidemic peak overruns ICU beds by a factor of at least 10.

For a given group the model is represented in figure 3, most of the parameters are dependent on the age group (see table **??**). The states are :

- S Sain
- E Exposed
- I_p Infectious in the prodromic phase
- I_a Asymptomatic Infectious
- I_{ps} Paucysymptomatic Infectious (very mild symptoms)
- I_{ms} Symptomatic Infectious with mild symptoms
- I_{ss} Symptomatic Infectious with severe symptoms
- I_H Hosptitalized
- ICU Intensive care
- R Recovered
- D Dead

Every transition is clearly described in the model and the parameters depends on the age group, except for transition from S to E. The paper doesn't describe this (or at least I didn't find it), but we can infer it based on classical compartemental models Blackwood and Childs, 2018. The population is split in three groups (c) $[0,18]$, (a) $]18,65[$, and (s) $[65,)$. Interactions between the groups depend on a contact matrix modulating the reproduction rate R_0. We can assume that :

$$\frac{\partial S_{(g)}}{\partial t} = S\beta \sum_{g' \in \{(c),(a),(s)\}} C_{(g),(g')} \frac{I_{(g')}}{N_{(g')}} \tag{1}$$

For any age group (g). Here, C is the contact matrix and $C_{(g),(g')}$ is the average number of contact between people of two groups per units of time, β is probability of transmission between two individuals per unit of time. The authors finally consider that individuals with sever symptoms reduce there interactions by 75%

Based on this model, the authors test three sets of interventions, mild, moderate and strict, the set up for each one is summarized in table 3. Those interventions are implemented by weighting the contact matrices of the corresponding to the interactions.

Results show that enven the strict set of interventions is not sufficient to keep the second peak under the number of ICU beds in Ile-de-France. The authors propose to implement case isolation. Meaning that we can test and find a certain pecentage of cases and isolate them. They show that the peak reduced under the capacity of ICU beds for strict + 25% case isolation or moderate + 50% case isolation. These two scenarios predict however the occupation of more than 1,000 beds in ICU for several months, also beyond summer. Lifting the lockdown 1 month later would achieve a reduction below 1,000 occupied beds likely in June. Even with cases isolation, mild interventions are not sufficient.

2 Outakes

- We could use this modelisation.

  Takes into account age related measures.

  Takes into account closing non-essential business.

- Adjusting the number isolated cases to the reasonable number of cases could give a good idea of the effectiveness of interventions.

- Contact matrices may be hard to retreive.

References

Blackwood, J. C., & Childs, L. M. (2018). An introduction to compartmental modeling for the budding infectious disease modeler. *Letters in Biomathematics*, *5*(1), 195–221. doi:10.1080/23737867.2018.1509026. eprint: https://doi.org/10.1080/23737867.2018.1509026

Di Domenico, L., Pullano, G., Sabbatini, C. E., Boëlle, P.-Y., & Colizza, V. (2020). Expected impact of lockdown in île-de-france and possible exit strategies. *medRxiv*. doi:10.1101/2020.04.13.20063933. eprint: https://www.medrxiv.org/content/early/2020/04/17/2020.04.13.20063933.full.pdf

3 Supplementary material

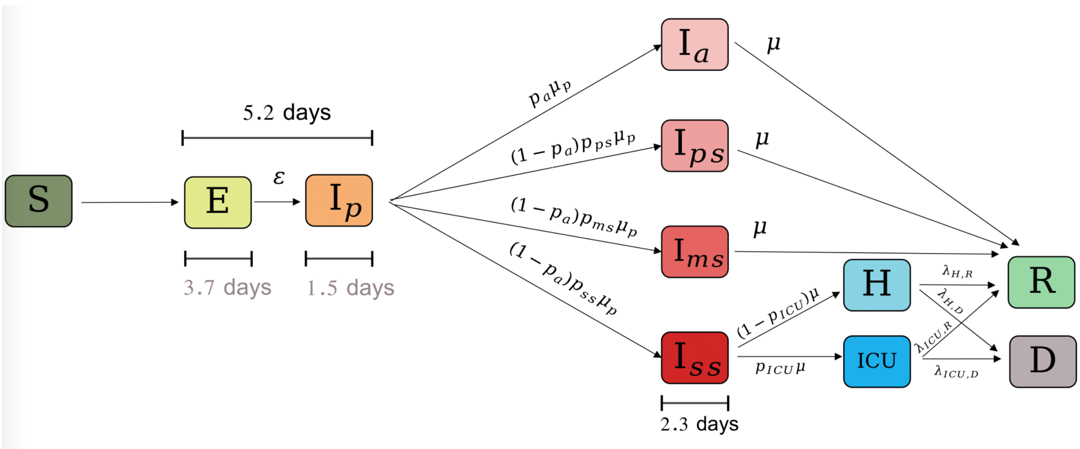

Figure 1: Model

Variable	Description	Value	Source
θ^{-1}	Incubation period	5.2d	[1]
μ_p^{-1}	Duration of prodromal phase	1.5d, computed as the fraction of pre-symptomatic transmission events out of pre-symptomatic plus symptomatic transmission events.	[2]
ϵ^{-1}	Latency period	$\theta^{-1} - \mu_p^{-1}$	-
p_a	Probability of being asymptomatic	0.2, 05	[3]
p_{ps}	If symptomatic, probability of being paucisymptomatic	1 for children 0.2 for adults, seniors	[4]
p_{ms}	If symptomatic, probability of developing mild symptoms	0 for children 0.7 for adults 0.6 for seniors	[4]
p_{ss}	If symptomatic, probability of developing severe symptoms	0 for children 0.1 for adults 0.2 for seniors	[4–6]
s	Serial interval	7.5d	[7]
μ^{-1}	Infectious period for I_a, I_{ps}, I_{ms} , I_{ss}	$s - \theta^{-1}$	-
r_β	Relative infectiousness of I_p, I_a, I_{ps}	0.51	[8]
p_{ICU}	If severe symptoms, probability of going in ICU	0 for children 0.36 for adults 0.2 for seniors	[9]
$\lambda_{H,R}$	If hospitalized, daily rate entering in R	0 for children 0.072 for adults 0.022 for seniors	[9]
$\lambda_{H,D}$	If hospitalized, daily rate entering in D	0 for children 0.0042 for adults 0.014 for seniors	[9]
$\lambda_{ICU,R}$	If in ICU, daily rate entering in R	0 for children 0.05 for adults 0.036 for seniors	[9]
$\lambda_{ICU,D}$	If in ICU, daily rate entering in D	0 for children 0.0074 for adults 0.029 for seniors	[9]

Figure 2: Parameters

	Children contacts in transports	**Telework**	**Senior isolation**	**Closure of non-essential business**
Lockdown	0%	95%	90%	100%
Mild	100%	75%	75%	0%
Moderate	50%	75%	75%	50%
Strict	0%	75%	75%	100%

Table 1: Settings of interventions

Variable	Description	Value	Source
θ^{-1}	Incubation period	5.2d	[1]
μ_p^{-1}	Duration of prodromal phase	1.5d, computed as the fraction of pre-symptomatic transmission events out of pre-symptomatic plus symptomatic transmission events.	[2]
ϵ^{-1}	Latency period	$\theta^{-1} - \mu_p^{-1}$	-
p_a	Probability of being asymptomatic	0.2, 05	[3]
p_{ps}	If symptomatic, probability of being paucisymptomatic	1 for children 0.2 for adults, seniors	[4]
p_{ms}	If symptomatic, probability of developing mild symptoms	0 for children 0.7 for adults 0.6 for seniors	[4]
p_{ss}	If symptomatic, probability of developing severe symptoms	0 for children 0.1 for adults 0.2 for seniors	[4–6]
s	Serial interval	7.5d	[7]
μ^{-1}	Infectious period for I_a, I_{ps}, I_{ms} , I_{ss}	$s - \theta^{-1}$	-
r_β	Relative infectiousness of I_p, I_a, I_{ps}	0.51	[8]
p_{ICU}	If severe symptoms, probability of going in ICU	0 for children 0.36 for adults 0.2 for seniors	[9]
$\lambda_{H,R}$	If hospitalized, daily rate entering in R	0 for children 0.072 for adults 0.022 for seniors	[9]
$\lambda_{H,D}$	If hospitalized, daily rate entering in D	0 for children 0.0042 for adults 0.014 for seniors	[9]
$\lambda_{ICU,R}$	If in ICU, daily rate entering in R	0 for children 0.05 for adults 0.036 for seniors	[9]
$\lambda_{ICU,D}$	If in ICU, daily rate entering in D	0 for children 0.0074 for adults 0.029 for seniors	[9]

Figure 3: Parameters