Expected impact of a lockdown with schools in session - France, Oct 2020

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RESUME

La pandémie de COVID-19 s'est rapidement accélérée ces dernières semaines, les hospitalisations doublant environ toutes les 2 semaines en France métropolitaine. À l'aide de modèles mathématiques stratifiés par âge et calibrés sur la trajectoire épidémique observée dans chaque région, ce rapport analyse les scénarios possibles de confinement, avec ou sans écoles ouvertes, et évalue leur impact sur la trajectoire épidémique et sur le système de santé dans les prochaines semaines. Ce rapport se concentre uniquement sur l'Île-de-France ; des analyses sur d'autres régions suivront. Les résultats numériques montrent que dans les conditions estimées pour la semaine 42 (R_{eff}=1.22), l'épidémie atteindrait le pic en fin d'année avec une demande moyenne sur le système de santé au moment du pic environ 30% inférieure à celle de la première vague. Compte tenu de l'incertitude autour de l'estimation de la tendance actuelle d'augmentation des cas, des scénarios de croissance plus rapide et avec de pic plus élevé (comparable à la première vague) restent compatibles avec les estimations et ne doivent pas être ignorés. Un confinement d'un mois avec écoles, lycées et collèges fermés réduirait la demande de pic de 29% -48%, en fonction du délai de mise en œuvre (le confinement anticipé est le plus efficace). Une réduction de 55% -74% des hospitalisations serait atteinte d'ici la fin de l'année. Le maintien des écoles ouvertes pendant le confinement conduirait à des réductions légèrement moins importantes (52% -69% d'hospitalisations en moins si les écoles sont ouvertes, 41% -60% si écoles, lycées et collèges sont ouverts), tout en maintenant le contrôle de l'épidémie dans le scenario moyen. Les fluctuations restent cependant très importantes et compatibles avec les valeurs observées lors de la première vague au moment où l'effet du confinement deviendrait visible dans les hospitalisations. Des stratégies pour maintenir l'épidémie sous contrôle lors de la levée du verrouillage doivent être planifiées pour réduire les effets de rebond.

SUMMARY

COVID-19 pandemic has rapidly accelerated in the last few weeks, with hospitalizations doubling approximately every 2 weeks in metropolitan France. Using age-stratified mathematical models calibrated to the observed epidemic trajectory in each region, this report analyzes possible scenarios of lockdown, with or without schools open, and assesses their impact on the epidemic trajectory and on the healthcare system in the following weeks. The current report focuses on Île-de-France only; analyses on other regions will follow. Numerical results show that under the conditions estimated for week 42 (R_{eff}=1.22), the epidemic is expected to peak at the end of the year with an average peak demand on the healthcare system about 30% less than what experienced during the first wave. Given the uncertainty around the estimation of the current tendency of increase of cases, scenarios of more rapid epidemic increase and higher peak (comparable to the first wave) are still compatible with expectations and should not be ignored. A 1-month lockdown with schools closed, as in March-May, would reduce the peak demand by 29%-48%, depending on the delay of implementation (early lockdown is predicted to be more efficient). A reduction of 55%-74% hospitalizations would be achieved by the end of the year. Maintaining schools open during the lockdown would lead to slightly smaller reductions (52%-69% less hospitalizations if pre-/primary schools are open, 41%-60% if all schools are open), while maintaining the control of the epidemic in the average scenario. Fluctuations, however, remain very large and compatible with the values observed in the first wave at the time when lockdown effects would become visible in the hospitalizations. Strategies to keep the epidemic under control when lifting the lockdown should be planned to reduce rebound effects.

INTRODUCTION

COVID-19 pandemic has rapidly accelerated in the last few weeks, with hospitalizations doubling approximately every 2 weeks in metropolitan France. This short report presents a scenario analysis on the impact that a lockdown, with or without schools open, may have on the current pandemic situation. It focuses on Île-de-France only. Analyses on other regions will follow.

METHODS

Model. We used the model developed by INSERM to respond to the COVID-19 pandemic[1–3]. The model was shown to capture the transmission dynamics of the epidemic in the first wave[1], was used to assess the impact of lockdown, exit strategies and reopening of schools in mid-April[1,2], and to evaluate the rate of underdetection of the test-trace-isolate strategy in the months of May-June[3]. It is based on a stochastic discrete age-stratified approach using demographic, age profile, and social contact data of the regions of mainland France, to account for age-specific contact activity and role in COVID-19 transmission. The model accounts for contacts in the population in different settings and activities. Disease progression is specific to COVID-19 and parameterized with current knowledge to include presymptomatic transmission, asymptomatic and symptomatic infections with different degrees of severity (paucisymptomatic, with mild symptoms, with severe symptoms requiring hospitalization). Four age classes are considered: [0-11), [11-19), [19-65), and 65+ years old (children, adolescents, adults, seniors). A reduced susceptibility was considered for children and adolescents, along with a reduced relative transmissibility of children, following available evidence from household studies, contact tracing investigations, and modeling works. More details are provided in Ref.[3].

Parameterization and calibration. For each region, the model integrates estimates on the number of individuals at workplaces over time, based on Google mobility data[4] and Orange cellphone mobility data[5] (**Figure 1**), accounts for students going back to school at the start of the school calendar on Sept 1, and integrates data on the adoption of preventive measures over time[3,6]. On week 42, the percentage of individuals back to work in IDF was about -20% the value in pre-pandemic conditions, compared to about -75% during lockdown (see Figure 1).

The model is fit to the different epidemic phases (pre-lockdown, lockdown, exit, summer, rentrée) using hospital admission data by region. More details on the model are provided in Refs.[1,3].

The current report focuses on Île-de-France only; analyses on other regions will follow. **Results in this report account for the epidemic situation up to week 42, estimating in IDF R_{eff} at 1.22**[7].

Lockdown scenarios. Projections for the weeks following w42 are obtained under a set of scenarios:

- *No-change scenario*, i.e. the epidemic continues to evolve as estimated in week 42 and no interventions are implemented.
- *Lockdown-like-March scenario*, assuming that a full lockdown is implemented for a duration of 4 weeks. The lockdown is as the one implemented on March 17 to curb the first wave of the pandemic, resulting in about 70-75% reduction of presence at work compared to pre-pandemic conditions[1] (Figure 1).
- *Lockdown with all schools open scenario*, assuming that the lockdown described above is applied while maintaining all schools open (pre-schools and primary schools, middle and high schools). This scenario simulates what currently applied in Ireland[8].
- *Lockdown with only pre-schools and primary schools open scenario*, assuming that the lockdown described above is applied while maintaining pre-schools and primary schools open, whereas middle and high schools are closed and adopt remote teaching.

Lockdown is implemented starting week 45, 46, or 47, in each case lasting 4 weeks (i.e. until November 29, December 6, 13). We considered an average delay of 9 days between lockdown implementation and peak in the hospitalizations, as estimated during the first wave for this region[3]. At the end of the lockdown, we consider that the epidemic situation goes back to what estimated in w42 (R_{eff}=1.22).

Universities are assumed to remain closed during the lockdown.

RESULTS

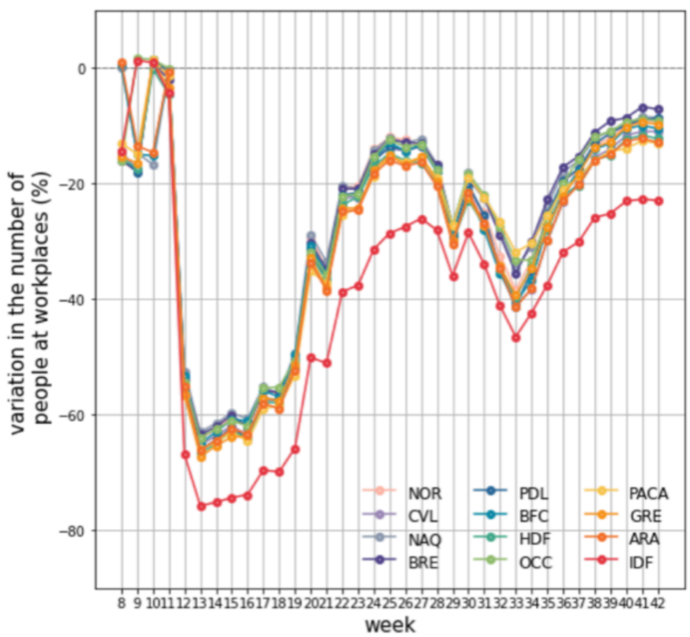

Figure 1. Estimated presence of individuals at workplaces by region and over time. Weekly estimates by region are based on Google mobility data[4] and confirmed independently with mobility data obtained from Orange cellphone data[5]. The variation is computed with respect to pre-epidemic conditions, in the months of January-February (level corresponding to zero on the vertical axis). Fluctuations reported in weeks 8-10 refer to school holidays. Lockdown led to a reduction of about 70-75% of presence at workplaces in IDF. This reduction is only about 20% in week 42.

Lockdown scenario as in March, and with schools open

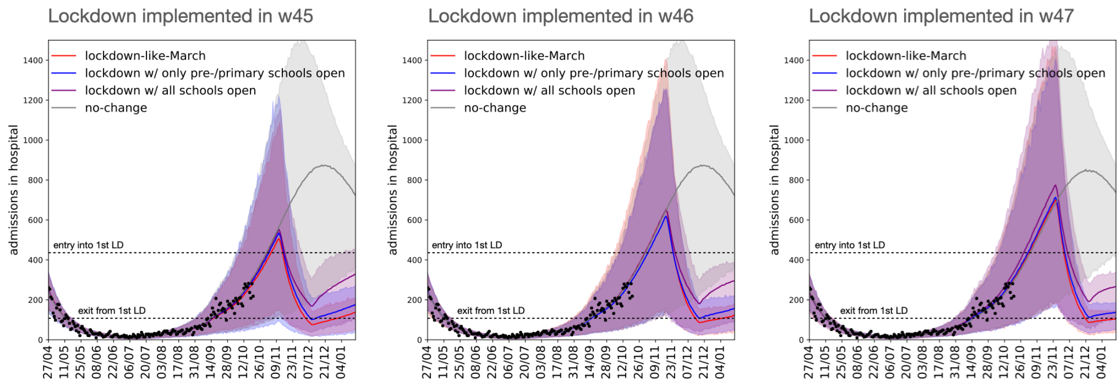

Figure 2. Epidemic trajectories for daily hospitalizations in the lockdown scenarios for Ile-de-France. Left: lockdown is implemented in week 45; center: lockdown is implemented in week 46; right: lockdown is implemented in week 47. Each curve corresponds to a different scenario: grey for the *no-change scenario*, i.e. if the situation is unchanged and the epidemic continues along the tendency estimated for week 42[7]; red for the *lockdown-like-March scenario*, i.e. applying a lockdown as in the first wave for a duration of 4 weeks; blue for the *lockdown with only pre-/primary schools open scenario*, i.e. applying a lockdown for 4 weeks while maintaining open pre-schools and primary schools, whereas middle and high schools are closed and adopt remote teaching; violet for the *lockdown with all schools open scenario*, i.e. applying a lockdown for 4 weeks while maintaining all school levels open. Lines and shaded areas for each scenario correspond to median and 95% probability ranges obtained from 200 stochastic runs of the model. Dots correspond to daily hospitalizations data. Dashed horizontal lines correspond to the level of hospital admissions registered at the entry into the first lockdown (LD in the figure) on March 17, and the one registered at the exit from the first LD on May 11.

Table 1. Expected reduction in peak demand for the healthcare system, depending on the delay of implementation. The reduction is computed with respect to the no-change scenario.

	Lockdown starting week 45	Lockdown starting week 46	Lockdown starting week 47
Reduction in peak demand of hospitalizations/ICU	48%	36%	29%

Table 2. Expected reduction in number of hospitalizations from w45 till the end of the year, depending on the lockdown implemented and the delay of implementation. The reduction is computed with respect to the no-change scenario.

	Lockdown-like-March scenario	Lockdown w/ only pre-/primary schools open	Lockdown w/ all schools open
Lockdown starting week 45	74%	69%	60%
Lockdown starting week 46	63%	62%	53%
Lockdown starting week 47	55%	52%	41%

KEY FINDINGS

- Assuming that the epidemic follows the trend estimated for w42 with no further change, the trajectory is expected to peak at the end of the year reaching ~1,000 hospitalizations per day, i.e. about 30% less than the peak of the first wave. A similar impact is expected in ICU admissions compared to the first wave. Given the uncertainty around the estimation of the current tendency of increase of cases, more rapid scenarios with earlier and higher peaks (comparable to the first wave) are compatible with expectations and should not be ignored.

- A 1-month lockdown, implemented as in March-May, would be able to strongly suppress the epidemic, reduce the peak demand on the healthcare system by 29%-48%, and reduce the number of hospitalizations till the end of the year by 55%-74%, depending on the delay of implementation. Fluctuations, however, remain very large and compatible with the values observed in the first wave.
- The earlier the lockdown is implemented, the larger are its effects in suppressing the epidemic in a short period of time. This is increasingly important given the large uncertainty. Here we considered 1-month lockdowns, to be lifted around the start of the Christmas season. Longer durations can be further explored.
- Maintaining the schools open during the lockdown would slightly lower the expected reductions (52%-69% in the number of hospitalizations till the end of the year if pre-/primary schools are open, and 41%-60% if all schools are open, depending on the delay of implementation). This is explained by the estimated small increase of R_{eff} once pre-/primary schools are open during the lockdown (+9% compared to lockdown with schools closed, R_{eff}=0.62), and all schools are open (+33%). These estimates depend on the assumptions of the model (see limitations).
- Our simulations do not consider that the test-trace-isolate (TTI) strategy during the second lockdown will be more efficient than during the first wave. The additional slowing down effect of TTI may be useful in compensating for a partial compliance that could be expected in the second lockdown due to 'coronavirus fatigue'.
- The model assumes that Universities remain closed during the lockdown and adopt remote learning.

MAIN LIMITATIONS

- Model calibration is done on mobility and hospitalization data up to week 42, leading for IDF to R_{eff}=1.22 in w42[7], and does not consider further accelerations e.g. due to weather conditions, or possible slowing down effects induced by the curfew implemented in IDF in w43.
- These findings apply to IDF and cannot be transposed to other regions. The application of the lockdown to other regions will depend on (i) current epidemic context (in terms of incidence and R_t), and (ii) immunity of the population gained during the first wave. Analyses for other regions will follow.
- The simulated lockdown is like the one implemented in March-May (plus the opening of different school levels). Additional scenarios proposing softer versions of the lockdown (e.g. allowing a larger portion of the population to go to work) or a limited compliance to lockdown due to increased 'coronavirus fatigue' will follow.

- Transmission in children (<10y) is estimated to be lower than in other age classes according to a synthesis of evidence[2], however the reduced transmissibility has not been quantified yet. Here we assume that transmissibility in children is about half the transmissibility of adolescents[3]. An exploration of the transmissibility of children was performed in Ref.[2]. This remains a key unknown to evaluate the impact of measures linked to schools.
- The model accounts for the increased number of contacts by students on transport due to open schools compared to a lockdown-like-March scenario, however it is not able to account for induced effects, such as parents accompanying children to schools.
- This report does not focus on the optimal exit strategies[1] to be implemented after a possible second lockdown. Results assume that after the lockdown the epidemic would be characterized by the same R_{eff} as before the lockdown was implemented.

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