Predicted school-specific reproductive number for Delta given the vaccination context in France

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The aim of this report is to provide school-specific estimates of the reproductive number computed for the Delta variant in the French context. Detailed methods can be found in the following paper, that considers the context of median vaccination coverage reached in Europe [1]:

Colosi et al. *Screening and vaccination against COVID-19 to minimize school closure*
https://www.medrxiv.org/content/10.1101/2021.08.15.21261243v2

Epidemic context and vaccination scenario

In France, teachers not belonging to at risk categories were offered vaccination starting May 24, 2021 [2]. Adults in the 18-59 age class reached 89% vaccination coverage (full vaccination) by late November 2021. Vaccination was opened to adolescents on June 15, 2021 [3], and 77% vaccination coverage (full vaccination) was reached by late November 2021. Data from [4] (**Figure 1**).

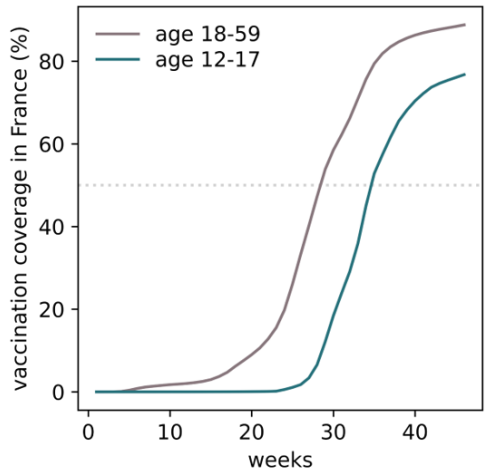

Figure 1. Vaccination coverage over time in adolescents (12-17 years old) and adults (18-59 years old) in metropolitan France. Complete vaccination is shown here. Data from [4]. Overseas territories are excluded.

We developed an agent-based model of SARS-CoV-2 transmission in school. We used empirical contact data in a primary and a secondary school, and data from pilot screenings in schools during the 2021 spring Alpha wave in France to estimate the school-specific reproductive number during the Alpha wave. We then considered a 2021-2022 winter scenario due to the Delta variant initialized with 25% natural immunity in the population, 89% of teachers vaccinated, and 77% of adolescents vaccinated, according to the observed coverage in France.

Estimate of the effective reproduction number for Delta under vaccination coverage for France

The transmissibility β^{Delta} per contact per unit time for Delta was estimated from the maximum likelihood estimate $\beta_{MLE} = \beta^{Alpha}$, accounting for the transmissibility advantage of the Delta variant [5]. The corresponding school-specific R was estimated from simulated outbreaks under the above immunity conditions, and considering the ST+Qc protocol with mask mandate (i.e. symptom-based testing and isolation of the case triggering the quarantine of the class), reproducing the protocol that was implemented by the Ministry of Education up to 29/11/2021 [6].

The estimated values of R in each school setting due to the Delta variant are (**Figure 2**):

- R^{Delta} = 1.66 (95%CI 1.60-1.71) in the primary school;
- R^{Delta} = 0.57 (95%CI 0.55-0.59) in the secondary school.

Considering the sensitivity inclusion criteria (i.e. relaxing the constraint on minimum adherence) led to slightly higher estimates (**Figure 2)**:

- R^{Delta} = 1.70 (95%CI 1.66-1.75) in the primary school;
- R^{Delta} = 0.58 (95%CI 0.57-0.60) in the secondary school.

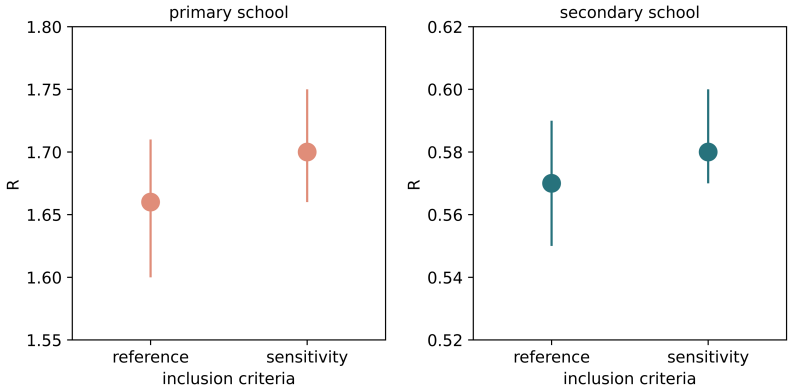

Figure 2. Estimates of the effective reproductive number for the Delta variant in the primary school and secondary school for the main set of inclusion criteria and the one tested for sensitivity.

The individual-level variation in SARS-CoV-2 transmission potential estimated for Delta in the two schools is shown in **Figure 3.** We quantified a large individual-level variation in SARS-CoV-2 transmission in both schools, corresponding to an overdispersion parameter k estimated to be 0.56 (95% CI 0.51-0.61) in the primary and 0.66 (95% CI 0.48-0.83) in the secondary school. Individual variation was smaller in the secondary school where a certain percentage of students were protected by vaccination.

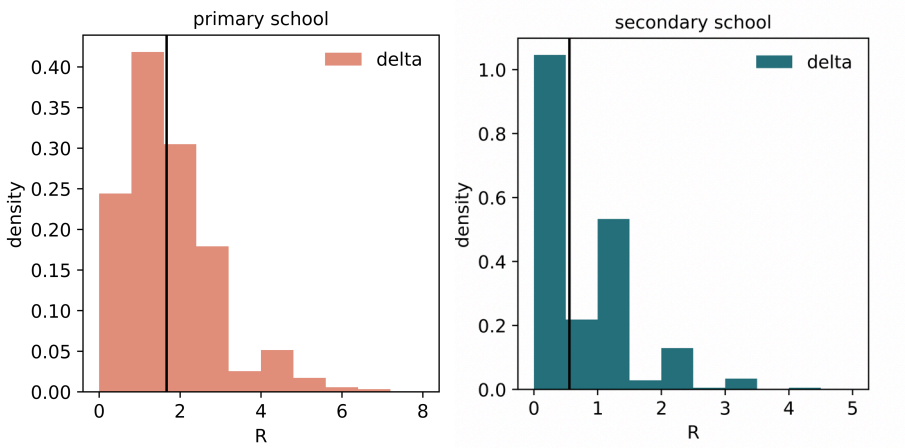

Figure 3. Probability distribution of the effective reproductive number *R* for the Delta variant in primary and secondary school. Probability distribution of the effective reproductive number in the primary school and secondary school for the reference criteria under the immunity profile of the fall/winter Delta wave scenario, the reactive class closure protocol (ST+Qc), and the mandatory use of masks. Vertical lines correspond to the estimated mean value for each school setting. The dispersion parameter k was estimated to be 0.56 (95% CI 0.51-0.61) and 0.66 (95% CI 0.48-0.83) in the primary and secondary schools, respectively. This is in line with the estimates obtained from observed transmission pairs during Delta outbreaks in the community [7], [8].

Implications

Accounting for the transmissibility advantage of the Delta variant and vaccination coverage in France, we estimated a school-specific R^{Delta} between 1.66 (1.60 -1.71) and 1.70 (1.66-1.75) in the primary school, and 0.57 (0.55-0.59) and 0.58 (0.57-0.60) in the secondary school (for both inclusion criteria, **Figure 2**). High vaccination coverage of adolescents has a great protective impact, bringing the school-specific R below one. However, the predicted highly-overdispersed offspring distribution suggests that –together with highly likely extinctions– chains of transmissions in schools are relatively rare but possible.

We estimated a higher transmissibility in the school compared to the community during the Alpha 2021 spring wave in France. This suggests that repeated contacts in dense classrooms, with mask mandate except during sport and lunch, favor transmission in absence of screening protocols, with potentially high overdispersion [9]. These findings align with available evidence of increased transmission in the population if schools are open [10], [11]. The more contagious Delta variant and the absence of protection from vaccination currently put children at higher risk compared to adolescents. A disproportionately higher viral circulation is observed in children that is further sustained by transmission at school, resulting in a higher risk of infection for students' household members [12] and a rapid transmission in the community [13].

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