Within and between classroom transmission patterns of seasonal influenza inform management of COVID-19 in schools

Akira Endo, Mitsuo Uchida, Adam Kucharski, Sebastian Funk

LONDON SCHOOL of HYGIENE &TROPICAL MEDICINE

The Alan Turing Institute

Summary

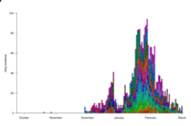
- Seasonal flu dynamics in primary schools suggests class splitting or staggered attendance has little effect on students' contact patterns
- Staggered attendance may still have benefit if students alternate daily as infected students spend only part of their infectious period at school

Backgrounds

- School reopening during outbreak is a big concern
  - Schools work as a "hub" of transmission in case of flu
  - Role of children in transmission of COVID-19 is still unknown
  - Long-term school closure affects children and families
- Management of school outbreak risk is key
  - Does class splitting or staggered attendance reduce transmission?
  - What are the best responses when there's a case in students?

Matsumoto flu data, 2014/15 season

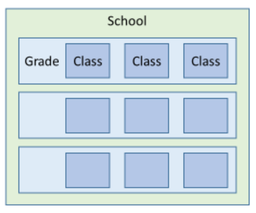
- A citywide primary school survey (~10,000 students)
  - Individual variables (grades, class, personal precautions, etc.)
  - Family composition
  - Flu episodes of HH members during 2014/15 season
  - At least student cases were RDT-positive



Hierarchical transmission rates in schools

- Force of infection $\lambda_i = \sum_j \beta_{ij} I_j$

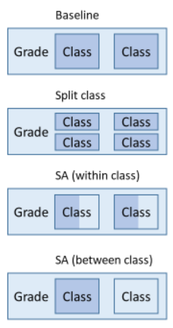
$$\beta_{ij} = \begin{cases} \beta_0 & \text{(same class, same sex)} \\ \beta_1 & \text{(same class, different sex)} \\ \beta_2 & \text{(same grade)} \\ \beta_3 & \text{(same school)} \\ \beta_4 & \text{(different school)} \end{cases}$$



School R_0 under different control measures

In a 6-year school with a mean class size (#students per class) n and the number of classes per grade m...

- Split classes: each class is divided into two classes ($n/2$, $2m$)
- Staggered attendance (within class): only half of the students in a class attend school on a single day ($n/2$, m)
- Staggered attendance (between class): only half of the classes in a grade attend school on a single day (n, $m/2$)



Results

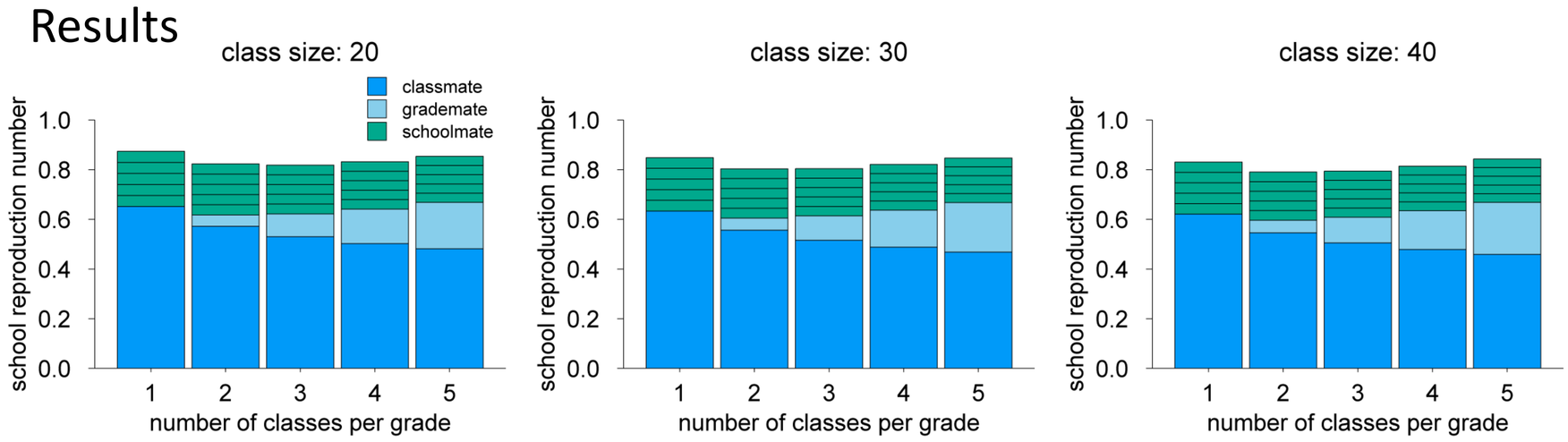


Fig 1. Estimated reproduction number within a 6-year school stratified by relationship
The average number of secondary transmissions per infectious student stratified by classroom-relationship. Classmates: those in the same class; grademates: in the same grade but not in the same class; schoolmates: not in the same grade. Transmission to schoolmates is compartmented to show transmission to each grade.

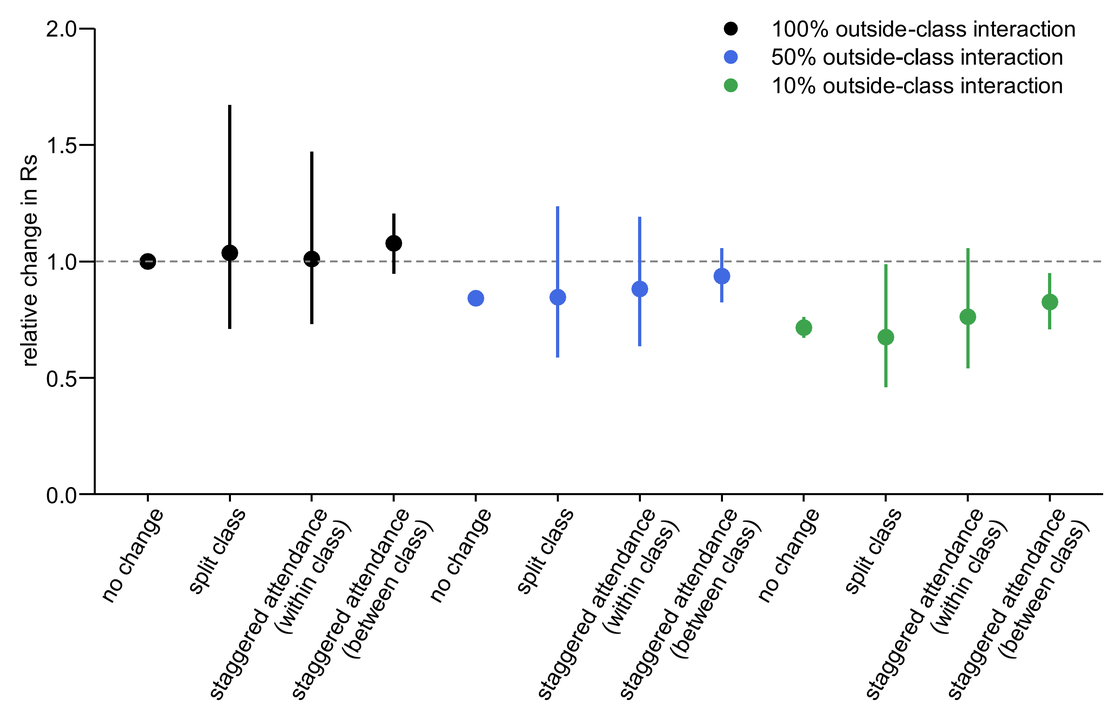


Fig 2. Predicted relative reduction in school reproduction number under control measures
Control measures changing the number of attending students and class structures are compared. "Split class": each class is divided into two; "Staggered attendance (within class)": only half of the students in each class attend on a same day; "Staggered attendance (between class)": only half of the classes attend on a same day. Reduction in transmission to students outside the class (blue: 50%, green: 10% of baseline) is also considered in combination.

Discussion

The school reproduction number of seasonal flu remained stable regardless of class sizes and the number of classes per grade. Control measures changing population structures are expected have marginal effects on contact patterns if students remain to follow the same contact behaviour during the COVID-19 outbreak. However, staggered attendance may exhibit additional benefit if students alternate daily instead of weekly; the reproduction number will be further reduced if students spend only part of their infectious period at school although the degree of this effect would depend the time-dependent profile of infection of SARS-CoV-2.

Acknowledgement: AE is supported by The Nakajima Foundation and The Alan Turing Institute. SF and AK are sponsored by the Wellcome Trust.