



Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

Elsevier hereby grants permission to make all its COVID-19-related research that is available on the COVID-19 resource centre - including this research content - immediately available in PubMed Central and other publicly funded repositories, such as the WHO COVID database with rights for unrestricted research re-use and analyses in any form or by any means with acknowledgement of the original source. These permissions are granted for free by Elsevier for as long as the COVID-19 resource centre remains active.



## Disparities in high schools' vaccination coverage (COVID-19). A natural experiment in the Province of Quebec

Alice Morissette<sup>a,b</sup>, Gabrielle Lefebvre<sup>b</sup>, Claude Bacque-Dion<sup>c</sup>, Richard Bélanger<sup>a,c</sup>,  
Frédéric Cazalais-Asselin<sup>b</sup>, Benoît Lalonde<sup>b,e</sup>, André Dontigny<sup>b</sup>, Scott T. Leatherdale<sup>d</sup>,  
Slim Haddad<sup>a,b,c,\*</sup>

<sup>a</sup> Faculté de médecine, Université Laval, Québec City, Quebec, Canada

<sup>b</sup> Direction de santé publique du CIUSSSCN, Québec City, Quebec, Canada

<sup>c</sup> Projet COMPASS-Québec, Centre de recherche VITAM, CIUSSSCN et Université Laval C.P., Québec City, Quebec, Canada

<sup>d</sup> School of Public Health Sciences, University of Waterloo, Waterloo, Ontario, Canada

<sup>e</sup> Département de géographie, Université Laval, Québec City, Quebec, Canada

### ARTICLE INFO

#### Keywords:

COVID-19  
teenagers' vaccination uptake  
School-based vaccination program  
Social inequalities

### ABSTRACT

Teenagers' vaccination has become crucial to limit the COVID-19 transmission in the population. To increase the vaccination rate of this age group, a school-based vaccination campaign was launched in Québec, Canada from June 7 to 18, 2021. This study aimed to analyze trajectories of vaccination coverage over time among students attending 37 high schools. The study explored whether school-based vaccination campaigns contributed to the progression of the vaccination coverage and attenuated disparities in vaccination coverage across schools.

On average, first dose coverage quickly increased from 30.6% to 81.5% between June 6 and 18, 2021, after the launch of the campaign. As of August 13, 2021, first dose coverage had reached 87.9% and 64.9% for the second dose coverage. Public schools with poorer student populations had 6.5 points of percentage lower first dose vaccination rates (95%CI 0.3%; 12.6%) compared to other schools. A higher level of concern related to the pandemic among students was associated with a 4.3 points of percentage increased coverage (95%CI 0.7%; 8.0%). The initial uneven distribution in first dose coverage decreased dramatically by the end of the campaign. Similar trends were observed for the second dose, although between schools' inequality at the end of the period of observation was significantly larger.

The school-based vaccination campaign might have initially contributed to a prompt rise in vaccination coverage and helped the disadvantaged schools to reach similar vaccination coverage as seen in other schools. In addition to being an efficient way to achieve rapidly high vaccination coverage, the school-based approach might contribute to increase equity in vaccination distribution.

### 1. Introduction

On May 5, 2021, Health Canada expanded the eligibility for the PFIZER-BioNTech vaccine and approved its use within 12 to 15 year olds (More et al., 2021). In Québec, teenagers aged 12–17 have been eligible to receive the PFIZER-BioNTech vaccine for free in vaccination centers since May 25, 2021. A school-based vaccination campaign was launched during the weeks of June 7–11 and June 14–18, 2021 where all students attending a private and public school in Québec had access to a mobile vaccination clinic at their school or transportation to a vaccination center from their school (Bordeleau, 2021). Initially, 8 weeks between

the 2 doses was requested, however since July 15, 2021, teenagers can receive both doses 4 weeks apart in vaccination clinics only. (Normandin, 2021) At the beginning of the campaign, the Quebec Minister of Health aimed to ensure that at least 75% (Cousineau and Pavic, 2021) of 12–17 year-olds received 2 doses of vaccine before the start of the 2021 school year (September) to consider reducing school-specific pandemic restrictions.

Achieving those objectives relies to some extent on both the ability to reach the target populations and their level of compliance to vaccination. School-based approach have repeatedly been alleged to significantly increase the vaccination coverage among students for vaccines

\* Corresponding author at: Faculté de médecine, Université Laval, Québec City, Quebec, Canada.

E-mail address: [slim.haddad@fmed.ulaval.ca](mailto:slim.haddad@fmed.ulaval.ca) (S. Haddad).

<https://doi.org/10.1016/j.ypmed.2022.107056>

Received 18 September 2021; Received in revised form 29 March 2022; Accepted 15 April 2022

Available online 20 April 2022

0091-7435/© 2022 Elsevier Inc. All rights reserved.

other than COVID-19. (Feldstein et al., 2020; Ward et al., 2010; Perman et al., 2017; Kaul et al., 2019; Benjamin-Chung et al., 2020) It is considered the baseline approach when a high vaccination coverage among children and teenagers must be reached to reduce illness spread in communities. For instance, in 2017, this effective approach was used in 60% of the World Health Organization (WHO) member states for the delivery of routine vaccines, with tetanus and diphtheria vaccines being the most common (Feldstein et al., 2020). The pediatricians and family physicians of Oregon, in the United States, consider vaccination in a school setting to be even more efficient during outbreaks since it allows to reach a large population in a short period of time (Fiala et al., 2013).

Another advantage of school-based vaccine administration (SBA) lies in their possible ability to attenuate social inequalities in vaccination coverage. Previous studies suggest that lower socioeconomic status is linked to unwillingness to get vaccinated (Simonson et al., 2021; Barry, 2021; Galanis et al., 2021). However, a study examining the uptake of a school-based HPV vaccination program in England suggests that with this approach, the level of deprivation does not appear to be associated with vaccination coverage (Fisher et al., 2014). On the other hand, in a context where immunization is offered on a voluntary basis, promptly immunizing a large segment of youths requires a high level of adherence to immunization among students and parents. Parent's attitude towards vaccination represents a key predictive factor in relation to children vaccination. A meta-analysis on parent's willingness to vaccinate their children against COVID-19 reported that some of the major predictors of vaccine acceptance were higher socio-economic status, higher level of knowledge and higher level of concern towards COVID-19 (Galanis et al., 2021). Therefore, one might expect that vaccination coverage of a school at any given time would likely be impacted by these contextual factors.

This study aims to explore trajectories of vaccination coverage (first and second dose) over time among high school students in the region of Québec City, Québec. It first focusses on the possible contribution of the school-based approach implemented to: (i) the progression of vaccine coverage among teenagers, (ii) reduce the disparities in the vaccination coverage among schools. The ongoing natural experiment in Québec offers an interesting opportunity to compare the vaccination coverage among schools prior to the launch of the school-based campaign in June with the coverage following this campaign. It also permits to compare the vaccination coverage of the first and second dose since students did not have access to a school-based vaccination program for their second dose. The study also tests the above-mentioned hypotheses of the associations between schools' vaccination coverage, and their student: (i) attitudes towards vaccines and COVID19; (ii) socioeconomic level.

## 2. Methods

### 2.1. Design

This is a prospective cohort study that uses data from a convenience sample of 37 secondary schools located in the Region of Québec City. School-level vaccination coverage for first and second dose was computed at six time-points; prior to the launch of the school campaign (June 6), and post-campaign approximately every 2 weeks until mid-August. Eligible schools were private and public schools offering regular curricula to students that also had participated in the 2021 wave of the COMPASS study in Québec. COMPASS is a prospective cohort study designed to collect student- and school-level health behaviour data annually across Canada (Leatherdale et al., 2014). Among participating schools in Québec, 29 public and 8 private schools ( $n = 37$ ) were included in this study. Given that the unit of observation is the school, the student population of the 37 schools ( $n = 28,966$ ) was used to measure the vaccination coverage in these schools whereas the student population that participated to the COMPASS study ( $n = 21,626$ ) was used for the analysis that were based on student responses collected in the COMPASS survey: (i) support to immunization; (ii) level of concern;

(iii) level of knowledge.

### 2.2. Measures

The unit of observation is the school. The percentage of students immunized at a given time is the dependent variable. Vaccination coverage for each dose was derived from the regional health authority databases. School-level covariates are time-invariant variables extracted from the 2021 COMPASS-Québec database. Data was collected in May 2021 through an online Qualtrics® survey (Reel et al., 2020). Each student responded to a set of questions (Leatherdale et al., 2014) assessing: (i) supportive attitudes towards vaccines ( $N = 4$  questions); (ii) knowledge of COVID-19 disease transmission and symptoms ( $N = 5$  questions); and (iii) worries/concerns about COVID-19 ( $N = 5$  questions). The Quebec Ministry of Education uses the index IMSE to classify the socio-economic environment of public schools on a scale from 1 to 10 considering the proportion of households where the mother does not have a diploma, certificate or degree and the proportion of families where parents are unemployed. (Government of Canada, 2021) Due to sample size limitations, continuous variables were dichotomized afterward through a median split procedure. As a result, each school was classified in the lower or higher group for each variable. With regards to socio-economic status, schools were classified into 3 groups: (i) private schools; (ii) less-disadvantaged public schools; (iii) more-disadvantaged public schools.

### 2.3. Analyses

All analyses were performed with STATA version 15 (Stata, 2021). Schools were used as the unit of analysis. For the first dose, a growth curve model (GCM) was used to estimate the possible influence of covariates on the initial values and the rate of growth. The regression model was a right-censored tobit multilevel model (metobit procedure). A random slope on time allowed schools to have distinct rates of growth. Considering the second vaccine dose was administered 8 weeks after the first dose, follow-up was limited for an appropriate estimation of a GCM for the second dose, and a cross-sectional analysis was performed for the final time point (wave 6). Inequality at a given point of time was assessed through Lorenz curves and Gini coefficients. Gini coefficients are bootstrapped to estimate standard errors and compare differences in coverage at various time points, as well as the distribution of school.

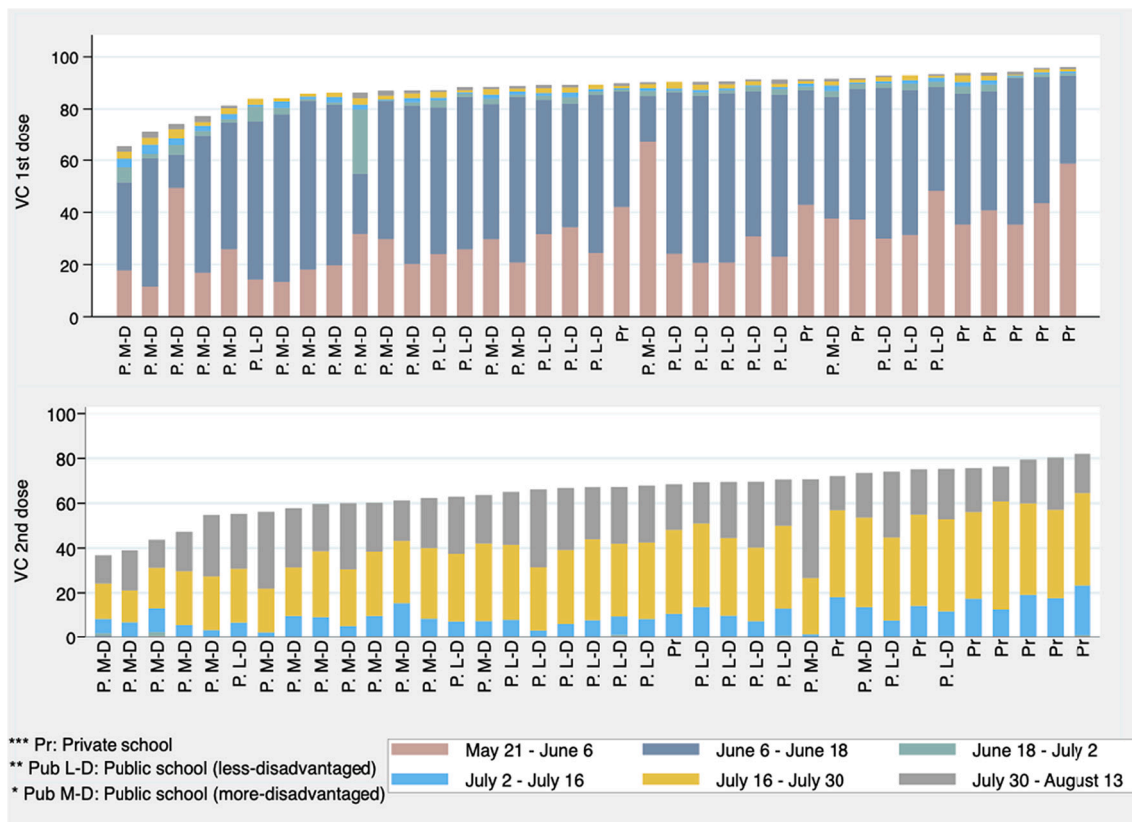
### 2.4. Ethical clearance

Access to the vaccination coverage by school was granted by the Public health Department of the of the Centre intégré universitaire de santé et de services sociaux de la Capitale-Nationale (CIUSS-CN). All COMPASS study procedures received ethics approval from the University of Waterloo Research Ethics Board (ORE 30118), the Research Ethics Review Board of the CIUSS-CN (#MP-13-2017-1264), and all participating school board review panels.

## 3. Results

### 3.1. Trends

On June 6, 2021, vaccination coverage averaged 30.6% (median: 29.8% IQR: 16.4 points of percentage, min: 11.6% max: 67.1%) among high schools in the Québec City region. The progression of coverage was fast but irregular; the most important rate of growth was observed immediately after the inception of the school vaccination campaign (Figs. 1 and 2). After June 18, 2021, vaccine uptake started to plateau. As of August 13, 2021, the average vaccination coverage in high schools was 87.9% (median: 89.3% IQR: 5.3 points of percentage, min = 65.3% max = 96.0%) for the first dose and 64.9% (median: 67.2% IQR: 12.1 points of percentage, min = 36.7% max = 82.0%) for the second dose.



**Fig. 1.** Vaccination coverage by school.

Each bar corresponds to the vaccination coverage of a school. Schools identified as “Pub. M-D” are more disadvantaged public schools, those identified as “Pub. L-D” are less disadvantaged public schools and those identified as “pr” are private schools. Each color represents the school-level vaccination coverage acquired during a certain period. The superior and inferior panels respectively correspond to the vaccination coverage for the 1st and 2nd dose.

The recommended vaccination coverage of 75.0% had not yet been reached in 3 schools for the first dose. There was a slight increase in second dose vaccination coverage between July 2–16, 2021, likely indicating the beginning of second dose administration to students who had received their first dose 8 weeks earlier. A more significant increase in the vaccination uptake began between July 16–30, 2021, which corresponds to the weeks following the reduction in the time required between the 2 doses. At the end of the observation period, 7 out of the 37 schools being examined had reached the vaccination coverage of 75%, 6 of which were private schools.

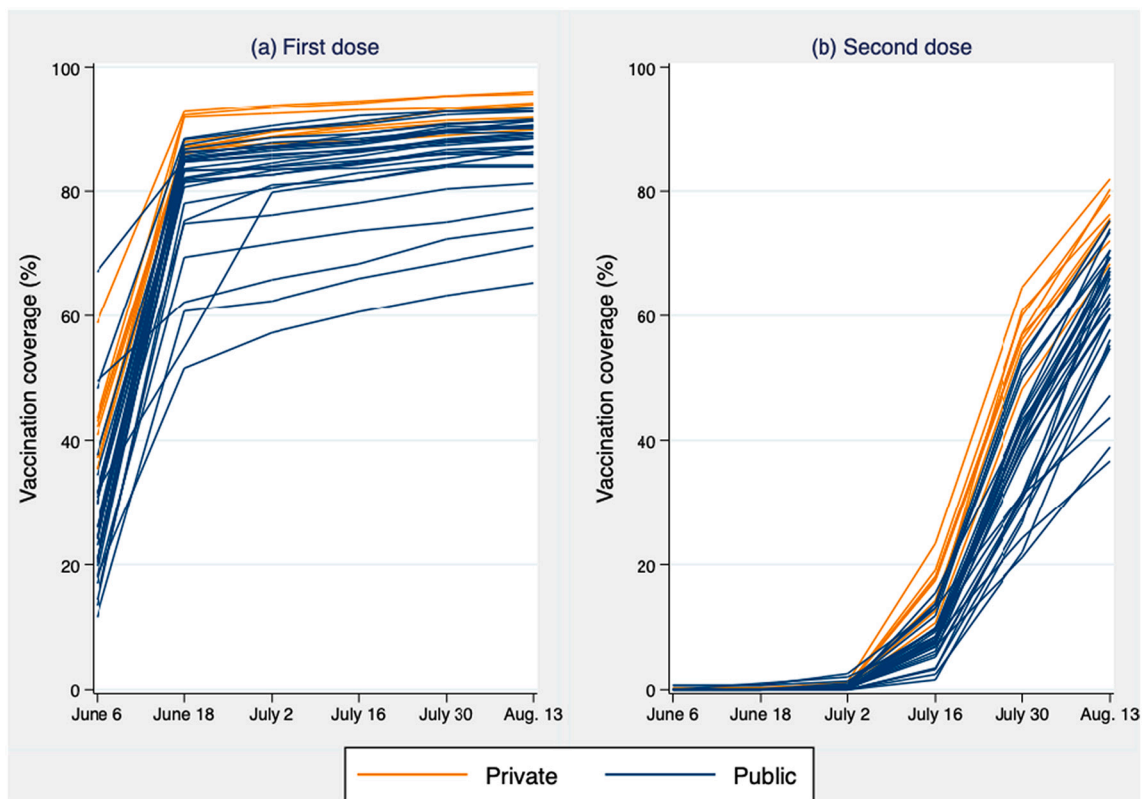
**3.2. Factors associated with vaccination coverage**

School trajectories tend to be highly heterogeneous with regards to the first dose (Fig. 2). By the end of the observation period, the difference in average school-level vaccination coverage between private schools and more-disadvantaged public schools was 12.7 points of percentage (95%CI 8.5%; 17.0%) and the difference between private schools and less disadvantaged public schools was 6.7 points of percentage (95%CI 3.1%; 10.2%). Vaccination coverage was 6.8 points of percentage (95%CI 3.2%; 10.4%) higher in schools where students were more willing to be vaccinated, 7.6 points of percentage (95%CI 4.2%; 11.1%) higher in schools where students were more knowledgeable about COVID-19, and 6.2 points of percentage (95%CI 2.6%; 9.7%) higher in schools where students reported greater levels of concern about COVID-19.

Table 1 presents the results of the growth curve model. By including random intercept, units are allowed to have different initial coverage values, and by including random slopes, units are allowed to have distinct rates of growth. In this case, the random intercept is highly

significant, but the variance in random slopes is negligible. This suggests that after adjusting for confounding, initial coverage values are distinct across schools and the rate of progression of coverage is comparable across schools overall. The model also suggests that being a more disadvantaged public school contributes to lower the school-level vaccination coverage of 6.5 points of percentage in average compared to private schools (Estimate = -6.5 points of percentage (95%CI 0.3%; 12.6%)) and 4.9 points of percentage compared to less disadvantaged public schools (Estimate = -4.9 points of percentage (95%CI 0.8%; 9.0%)), although there is not much of a difference between private schools and less disadvantaged public schools. School-level vaccination coverage also tends to increase by 4.3 points of percentage in average when the students reported greater concerns about COVID-19, compared to schools where the students were less concerned (Estimate = +4.3 points of percentage (95%CI 0.7%; 0.8%)). However, the model did not demonstrate significant associations between the students’ levels of knowledge of COVID-19 or supportive attitudes towards vaccination.

Associated factors were comparable for receiving the first and second dose at the end of the observation period (Table 1). However, the magnitude of the association between vaccination coverage and school status here is almost double the association estimated for the first dose: on average, the adjusted coverage rate in disadvantaged schools is 8.6 points of percentage lower than in less disadvantaged public schools (Estimate = - 8.6 points of percentage (95%CI 3.4%; 13.7%)) and 11.1 points lower than in private schools (Estimate = -11.1 points of percentage (95%CI 3.1%; 19.0%)). Finally, greater concerns for COVID-19 among the student population was associated with higher level of coverage of 7.1 points of percentage in average (Estimate = +7.1 points of percentage (95%CI 2.3%; 12.0%)).



**Fig. 2.** Vaccination coverage trajectories by school. Each line corresponds to the progression of the school-level vaccination coverage for the 1st (left) and 2nd (right) dose observed for each of the 37 schools. Orange lines represent private schools whereas the blue lines correspond to public schools.

**Table 1**  
Factors associated with schools' vaccination coverage.\*

Model		M1:Growth curve model; wave 1 to wave 6 Dependent variable: vaccination coverage - First dose			M2:Cross-sectional at wave 6 (Aug. 13) Dependent variable: vaccination coverage - Second dose		
		95% CI			95% CI		
		Estimate*	Low	High	Estimate*	Low	High
Wave	Baseline: June 06 (wave 1)						
	June 18 (wave 2)	0.509	0.486	0.532			
	July 02 (wave 3)	0.534	0.511	0.557			
	July 16 (wave 4)	0.548	0.525	0.571			
	July 30 (wave 5)	0.565	0.542	0.588			
	Aug. 13 (wave 6)	0.573	0.550	0.596			
School status	Ref group: Public school - more disadvantaged						
	Less disadvantaged public	0.049	0.008	0.090	0.086	0.034	0.137
	Private	0.065	0.003	0.126	0.111	0.031	0.190
Student's reaction to COVID-19	Higher support to vaccination (Ref group: lower support)	0.020	-0.022	0.062	0.029	-0.027	0.084
	Higher level of concern (Ref group: lower concern)	0.043	0.007	0.080	0.071	0.023	0.120
	Higher level of knowledge (Ref group lower knowledge)	0.039	-0.002	0.080	0.049	-0.005	0.102
Intercept		0.183	0.123	0.242	0.469	0.393	0.545

M1: n = 222 observations, corresponding to 37 schools observed for 6 periods each.

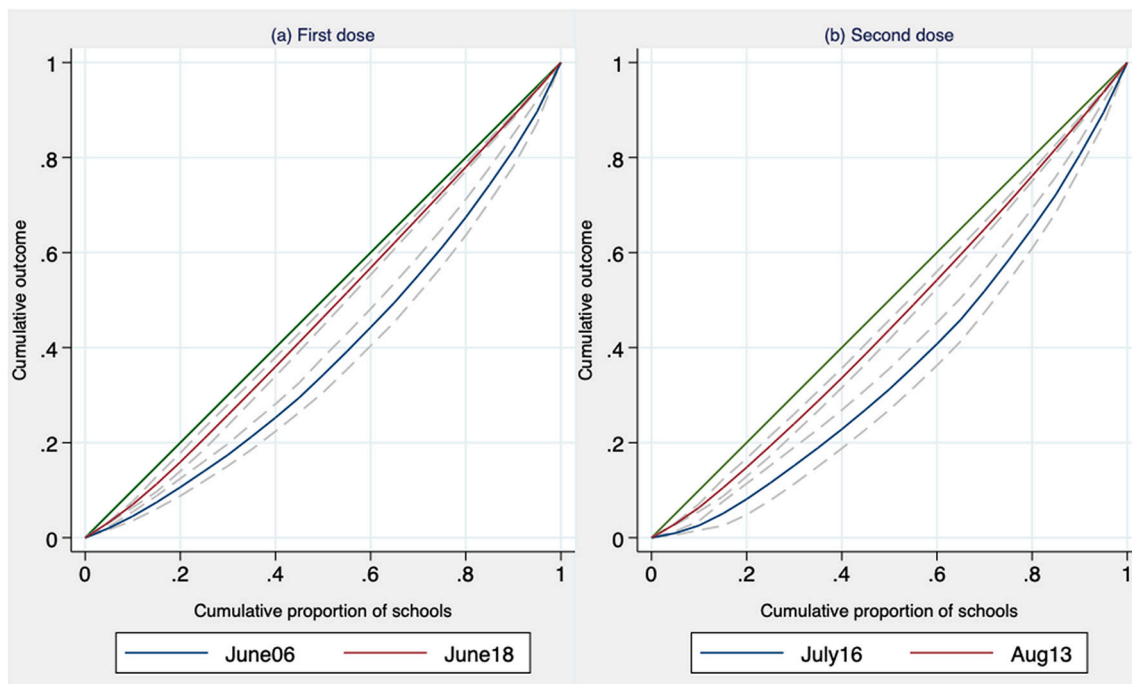
M2: n = 37 observations, corresponding to 37 schools observed on August 13, 2021.

\* Each estimate reflects the marginal change in vaccination coverage expressed in numerical value, in response to a marginal change in each explanatory variable. Other covariates are assumed to be held constant.

### 3.3. Inequalities in schools' vaccination coverage

Lorenz curves provide a graphical representation of the distribution of the vaccination coverage levels across the schools. The left panel of Fig. 3 reveals an uneven distribution on June 6, 2021, when the school-

based program was launched (the farther the Lorenz curve is from the 45 degrees line, the more unequal the distribution is). The inequality between schools has almost disappeared by the next wave. This was also confirmed by the sharp drop in the coefficient of Gini (Table 2) before and after the school-based intervention. The Gini coefficient continued



**Fig. 3.** Evolution of the inequality in vaccination coverage within the population of schools. Lorenz curves. The green line is the diagonal. For the 1st dose (left) the blue and the red curves are the Lorenz curves representing the inequalities in the vaccination coverage among schools as of June 6 and June 18 respectively. The dotted curves correspond to the confidence intervals. For the 2nd dose, the Lorenz curves illustrate the inequalities in the vaccination coverage as of July 16 (blue) and August 13 (red).

**Table 2**  
Evolution of the inequality in vaccination coverage between schools. Gini coefficients across waves.

Wave	First dose			Second dose		
	Gini coefficient*	95% CI		Gini coefficient*	95% CI	
		Low	High		Low	High
June 06 (wave 1)	0.222	0.199	0.246			
June 18 (wave 2)	0.057	0.045	0.070			
July 02 (wave 3)	0.046	0.037	0.056			
July 16 (wave 4)	0.043	0.034	0.051	0.268	0.242	0.293
July 30 (wave 5)	0.039	0.031	0.047	0.156	0.149	0.164
Aug. 13 (wave 6)	0.037	0.030	0.044	0.090	0.080	0.100
Contrasts						
G(wave2)-G(wave1)	-0.165	-0.192	-0.138			
G(wave6)-G(wave2)	-0.020	-0.034	-0.006			
G(wave6)-G(wave4)				-0.178	-0.205	-0.150

\* The first 6 lines represent the Gini coefficients for each period with their corresponding confidence interval. The contrasts correspond to the difference between the Gini coefficient of 2 periods.

to decrease gradually until the end of the observation period. As for the second dose, the inequality between schools dropped markedly during the period covering the 3 last waves. Observed disparities remained high by August 13, 2021; the Gini coefficient was estimated at 0.09 (95%CI 0.080; 0.10). The inequalities on August 13 were approximately 2.5 times greater for the second dose compared to the first dose, and their difference of 0.052 (95%CI 0.040; 0.065).

**4. Discussion**

Overall, high schools in the Québec City region reached a high vaccination coverage for both doses before the beginning of the school year. This reflects the responsiveness to vaccination in the Québec youth population. The highest vaccination rate was observed during the school-based vaccination program for the first dose, which contributed to achieve the vaccination coverage target of 75% very rapidly. Private

schools had a higher vaccination coverage than more disadvantaged public schools: 6.5 points of percentage higher for the first dose and 11.1 points higher for the second dose. Additionally, schools where students reported greater concerns about COVID-19 also had higher vaccination coverage than those where students were less worried: 4.3 points of percentage higher for the first dose and 7.1 points higher for the second dose.

Overall, our data suggest that following a provincial initiative to increase student vaccination rates have contributed to reach rapidly a high vaccination coverage in the high schools of the Québec City region. The program worked very well initially to increase student vaccination rates at a school-level, even in disadvantaged schools, which reflects the responsiveness to vaccination in the Québec youth population. Nonetheless, school status and students' levels of concern towards the pandemic seem to be significantly associated with vaccination coverage unlike students' levels of knowledge and willingness to vaccinate.

Private and less disadvantaged schools as well as schools where students reported having great concerns towards COVID-19 tended to have a higher vaccination coverage.

This study provides support for a more active approach for the vaccine distribution as these findings suggest that this approach may accelerate the vaccine uptake and reduce inequalities in vaccination coverage among high schools. The most significant increase in the vaccination coverage, regardless of school type, was immediately after the inception of the school vaccination campaign. Significant increases were not observed for the second dose where students were required to take the initiative to go to a vaccination clinic. As shown by the Lorenz curves and the Gini coefficients, the reduction of the inequalities in the vaccination coverage among high schools was more significant for the first dose than for the second one. For instance, on August 13, 2021, the Gini coefficient representing the inequalities between the vaccination coverage of private schools and more-disadvantaged public schools was approximately 2.5 times greater for the second dose. The reduction of the inequalities observed with the vaccination in schools for the first dose is consistent with evidence from a study on a school-based HPV vaccination program in England where the level of deprivation did not appear to be markedly associated with vaccination coverage (Fisher et al., 2014). School-based vaccination campaigns are well-established in most of the WHO country members since it has shown to be effective at reducing the transmission of many epidemic diseases such as hepatitis, HPV, meningitis, influenza, rubella, and varicella zoster (Feldstein et al., 2020; Ward et al., 2010; Overview of Canadian School-Based Immunization Programs, 2021). This approach lowers virus transmission in communities and protects vulnerable groups such as elderly and people suffering with immunodeficiency by increasing the vaccination coverage among students (Ward et al., 2010). Evidence shows that students represent a key vector in virus spread as they are in contact with many other students who have not been exposed to these viruses before (Ward et al., 2010). Moreover, physicians suggest that teenagers are often uninformed about the importance of immunization and underestimate the danger of preventable diseases (Oster et al., 2005) which increases their risk of spreading viruses in their community. Therefore, it is crucial in an outbreak situation such as COVID-19 to facilitate the vaccination of this high-risk population. For instance, in the United States, where the COVID-19 vaccination uptake among 12–17 year-olds is much lower, experts are encouraging local health services and school districts to offer vaccination in schools, considering the effectiveness of school-based approaches to increase vaccination coverage (Centers for Disease Control and Prevention, 2021; Murthy et al., 2021).

This study has some limitations. Notably, definitive conclusions about the value of the school-based vaccination campaigns cannot be made from our findings. An additional limitation is the low number of observations which limits the extent of the analysis. Supplementary observations would have allowed consideration of more covariates such as students' gender, source of information on COVID-19, or the number of COVID-19 outbreaks within a school. Another limitation is that "adequately vaccinated" students who contracted COVID-19 and thus received a single dose of vaccine were not considered in the vaccination coverage for the second dose. There is also limitation in the generalizability of the results since the study took place in a favorable setting where the authorities strongly encouraged the vaccination. The

population of the province of Québec is usually supportive of vaccines (Dubé et al., 2018). Future research may consider reproducing this study in a similar or a less favorable context.

## 5. Conclusions

In exceptional circumstances such as the COVID-19 pandemic, mass mobilization of vaccines allows populations to reach a high vaccination coverage in a short period of time. In only a few weeks, students involved in this study reached the same level of vaccination coverage as the adult population who began to get vaccinated 5 weeks prior. In addition to being an efficient way to achieve rapidly high vaccination coverage, the school-based approach contributes to equity in health care. It follows the logic of proportionate universalism as it focuses on increasing the vaccination coverage of the schools with the greatest needs. Provided that other studies can confirm the results observed in schools in the Québec City region, these findings encourage the continuation of the actions led by the COVID-19 vaccination teams in neighborhoods, businesses, or other environments where poorly vaccinated populations are concentrated.

## Author contributions

Conceptualization: AM, RB, SL, SH; Methodology AM, SH. Investigation, Data collection, Data curation: AM, GL, CBD, FCA, BL, SH. Analysis: AM GL SH. Funding acquisition: SH RB SL AD. Supervision: SH RB AD. Writing, Original draft preparation: AM, SH. Writing, Reviewing & Editing: All authors.

## Declaration of interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

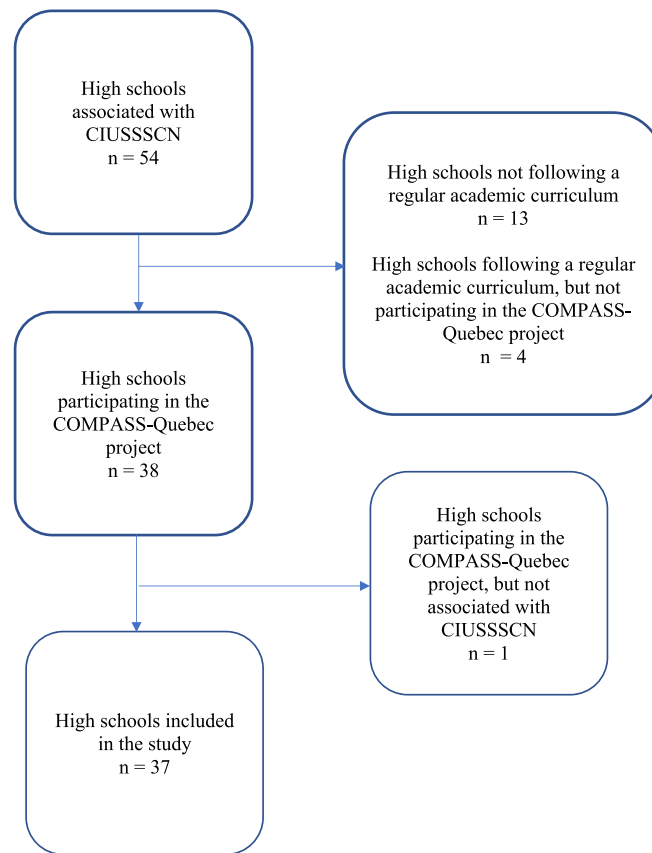
## Acknowledgment

The authors wish to thank their collaborators from the Public Health Department of the CIUSSS de la Capitale-Nationale and the COMPASS project. They would like to thank especially M. Mélanie St-Onge and Guillaume Haemmerli, from the Public Health Surveillance team for their support, and M. Alle Butler who gently revised previous versions of the text.

The COMPASS study has been supported by a bridge grant from the CIHR Institute of Nutrition, Metabolism and Diabetes (INMD) through the "Obesity – Interventions to Prevent or Treat" priority funding awards (OOP-110788; awarded to SL), an operating grant from the CIHR Institute of Population and Public Health (IPPH) (MOP-114875; awarded to SL), a CIHR project grant (PJT-148562; awarded to SL), a CIHR bridge grant (PJT-149092; awarded to KP/SL), a CIHR project grant (PJT-159693; awarded to KP), and by a research funding arrangement with Health Canada (#1617-HQ-000012; contract awarded to SL). The COMPASS-Quebec project additionally benefits from funding from the Ministère de la Santé et des Services sociaux of the province of Québec, and the Direction régionale de santé publique du CIUSSS de la Capitale-Nationale.

## Appendix A. Appendix

Flowchart



## References

- Barry, V., 2021. Patterns in COVID-19 vaccination coverage, by social vulnerability and urbanicity — United States, December 14, 2020–May 1, 2021. *MMWR Morb. Mortal. Wkly Rep.* 70. <https://doi.org/10.15585/mmwr.mm7022e1>.
- Benjamin-Chung, J., Arnold, B.F., Kennedy, C.J., et al., 2020. Evaluation of a city-wide school-located influenza vaccination program in Oakland, California, with respect to vaccination coverage, school absences, and laboratory-confirmed influenza: a matched cohort study. *PLoS Med.* 17 (8), e1003238 <https://doi.org/10.1371/journal.pmed.1003238>.
- Bordeleau, S., 2021. Québec donne le coup d'envoi pour la vaccination des 12 à 17 ans | Coronavirus. Radio-Canada.ca. Accessed September 4. <https://ici.radio-canada.ca/nouvelle/1794779/covid-vaccination-jeunes-ecoles-dube-roberge>.
- Centers for Disease Control and Prevention, 2021. Considerations for Planning School-Located Vaccination Clinics | CDC. Published August 25. Accessed September 13, 2021. <https://www.cdc.gov/vaccines/covid-19/planning/school-located-clinics.html>.
- Cousineau, M., Pavic, C., 2021. Consultez le taux de vaccination dans chaque école secondaire de Montréal. Le Devoir. Accessed September 4. <https://www.ledevoir.com/societe/sante/620754/les-donnees-de-la-vaccination-dans-les-ecoles-secondaires>.
- Dubé, E., Kiely, M., Ouakki, M., 2018. Enquête québécoise sur la vaccination contre la grippe saisonnière, le pneumocoque, le zona et sur les déterminants de la vaccination. *INSPQ*. Accessed September 8, 2021. <https://www.inspq.qc.ca/publications/2564>.
- Feldstein, L.R., Fox, G., Shefer, A., Conklin, L.M., Ward, K., 2020. School-based delivery of routinely recommended vaccines and opportunities to check vaccination status at school, a global summary. *Vaccine.* 38 (3), 680–689. <https://doi.org/10.1016/j.vaccine.2019.10.054>.
- Fiala, S.C., Cieslak, P.R., DeBess, E.E., Young, C.M., Winthrop, K.L., Stevenson, E.B., 2013. Physician attitudes regarding school-located vaccination clinics. *J. Sch. Health* 83 (5), 299–305. <https://doi.org/10.1111/josh.12031>.
- Fisher, H., Audrey, S., Mytton, J.A., Hickman, M., Trotter, C., 2014. Examining inequalities in the uptake of the school-based HPV vaccination programme in England: a retrospective cohort study. *J. Public Health (Oxf)*. 36 (1), 36–45. <https://doi.org/10.1093/pubmed/ftt042>.
- Galanis, P., Vraka, I., Siskou, O., Konstantakopoulou, O., Katsiroumpa, A., Kaitelidou, D., 2021. Willingness and Influential Factors of Parents to Vaccinate Their Children against the COVID-19: A Systematic Review and Meta-Analysis. <https://doi.org/10.1101/2021.08.25.21262586>, 2021.08.25.21262586.
- Government of Canada, 2021. Indices of Disadvantaged - Open Government Portal. Accessed December 28. <https://open.canada.ca/data/en/dataset/004de02c-19f1-4da0-9af8-33f893e41972>.
- Kaul, S., Do, T.Q.N., Hsu, E., Schmeler, K.M., Montealegre, J.R., Rodriguez, A.M., 2019. School-based human papillomavirus vaccination program for increasing vaccine uptake in an underserved area in Texas. *Papillomavirus Res.* 8, 100189 <https://doi.org/10.1016/j.pvr.2019.100189>.
- Leatherdale, S.T., Brown, K.S., Carson, V., et al., 2014. The COMPASS study: a longitudinal hierarchical research platform for evaluating natural experiments related to changes in school-level programs, policies and built environment resources. *BMC Public Health* 14 (1), 331. <https://doi.org/10.1186/1471-2458-14-331>.
- More, D., et al., 2021. Le vaccin contre la COVID-19 pour les enfants | Société canadienne de pédiatrie. Accessed September 4. <https://www.cps.ca/fr/documents/position/le-vaccin-contre-la-covid-19-pour-les-enfants>.
- Murthy, B.P., Zell, E., Saelee, R., et al., 2021. COVID-19 Vaccination Coverage among Adolescents Aged 12–17 Years — United States, December 14, 2020–July 31, 2021. Accessed September 12. <https://stacks.cdc.gov/view/cdc/109318>.
- Normandin, P., 2021. Les 12 à 17 ans peuvent devancer à quatre semaines leur deuxième dose | La Presse. Accessed September 4. <https://www.lapresse.ca/covid-19/2021-07-15/vaccination/les-12-a-17-ans-peuvent-devancer-a-quatre-semaines-leur-deuxieme-dose.php>.
- Oster, N.V., McPhillips-Tangum, C.A., Averhoff, F., Howell, K., 2005. Barriers to adolescent immunization: a survey of family physicians and pediatricians. *J. Am. Board Fam. Pract.* 18 (1), 13–19. <https://doi.org/10.3122/jabfm.18.1.13>.
- Overview of Canadian School-Based Immunization Programs, 2021. CANVax. Accessed September 5. <https://www.canvax.ca/brief/overview-canadian-school-based-immunization-programs>.
- Perman, S., Turner, S., Ramsay, A.I.G., Baim-Lance, A., Utley, M., Fulop, N.J., 2017. School-based vaccination programmes: a systematic review of the evidence on organisation and delivery in high income countries. *BMC Public Health* 17 (1), 252. <https://doi.org/10.1186/s12889-017-4168-0>.
- Reel, B., Battista, K., Leatherdale, S.T., 2020. COMPASS protocol changes and recruitment for online survey implementation during the COVID-19 pandemic. *Compas Syst.* 7, 1–12. Published December 14. Accessed September 8, 2021. <http://uwaterloo.ca/compass-system/publications/compass-protocol-changes-and-recruitment-online-survey>.



Simonson, M.D., Chwe, H., Lazer, D., et al., 2021. The COVID States Project #49: Vaccinating America's Youth. Published online May 4, 7. University of Waterloo. Stata, 2021. Software for Statistics and Data Science. Accessed September 4. <https://www.stata.com/>.

Ward, K.F., Menzies, R.I., Quinn, H.E., Campbell-Lloyd, S., 2010. School-based vaccination in NSW. N S W Public Health Bull. 21 (9–10), 237–242. <https://doi.org/10.1071/NB10046>.