

Effects of School-Based Preventive Measures on COVID-19 Incidence, Hong Kong, 2022

Tim K. Tsang, Xiaotong Huang, Min Whui Fong, Can Wang, Eric H.Y. Lau, Peng Wu, Benjamin J. Cowling

We show that school closures reduced COVID-19 incidence rates in children by 31%–46% in Hong Kong in 2022. After school reopening accompanied by mask mandates, daily rapid testing, and vaccination requirements, school-reported cases correlated with community incidence rates. Safe school reopening is possible when appropriate preventive measures are used.

After 2 years of minimal incidence of SARS-CoV-2 infections in Hong Kong, the Omicron BA.2 variant began to spread in January 2022. The resulting 5th COVID-19 wave in Hong Kong's population of 7.3 million persons resulted in >1 million cases and >9,000 deaths during February–April 2022, despite high overall vaccine coverage (1). After a low point of <200 cases/day in mid-May, the number of cases resurged, resulting in a 6th wave beginning in June 2022.

Schools in Hong Kong were intermittently closed throughout the 5th wave, and online learning began in February 2022. The summer holiday (conventionally 6 weeks during mid-July–August) was rescheduled to March and April, with a shorter 2-week summer holiday at the end of August. Schools resumed in-person learning in May 2022, and a range of public health and social measures were imposed to reduce COVID-19 transmission risk among staff and students (Table 1; Appendix Tables 1, 2, <https://wwwnc.cdc.gov/EID/article/29/9/22-1897-App1.pdf>), including mask wearing, requiring negative results of daily self-administered rapid antigen tests (RAT) (Appendix

Table 3) for staff and students before entering school, reducing class sizes and lesson durations, and fulfilling certain vaccination requirements.

School closures or class dismissals can cause substantial harm, such as negatively affecting education, social and emotional development, and physical and mental health of children and young persons (2,3). Hence, rigorous evaluation of public health effects of school-based measures are needed to guide disease control and prevention policies. We analyzed epidemiologic and school-reported data to determine the effects of school-based measures on COVID-19 transmission in Hong Kong during 2022.

The Study

The study was approved by the Institutional Review Board of the University of Hong Kong. We analyzed COVID-19 data reported to the Hong Kong Centre for Health Protection that included PCR-confirmed cases during January 1–November 22, 2022, and RAT-confirmed cases during February 26–November 22, 2022. Confirmative PCR was administered for RAT-confirmed cases reported during June 7–August 28, 2022. We found that age-specific incidence rate ratios for infections in children compared with adults (>18 years of age) in the 6th wave were slightly higher than in the 5th wave (Figure 1).

We divided the study period into 3 segments: school closure, summer holiday, and normal school days (days other than closures and holidays). We stratified cases into 4 age groups: 2–5 years (preschool/kindergarten students), 6–11 years (primary school students), 12–17 years (secondary school students), and ≥18 years (adults). We used a Poisson generalized additive regression model, adjusting for time trend of COVID-19 cases and including the age groups and study periods (Appendix), to determine the effects of school closure and

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Table 1. Summary of territorywide preventive measures implemented during the 5th and 6th waves of the COVID-19 outbreak in Hong Kong evaluated in study of effects of school-based preventive measures on COVID-19 incidence, 2022

Preventive measures	Focus	Period
Masks		
A person must wear a mask at all times when entering or attending school.	School staff, students	2020 Jan 23–2023 Feb 28
School closure		
Suspend face-to-face classes and on-campus activities	Kindergarten and primary school students	2022 Jan 14–2022 Apr 18
Allow some mask-wearing activities on a half-day basis	Students in secondary schools Kindergarten, primary school, and secondary school students	2022 Jan 24–2022 Apr 28 2022 May 19–2022 Oct 31
Resume half-day nonacademic extracurricular activities for those who received 2 vaccine doses >14 d apart	Students in primary schools	2022 Oct 25–2023 Feb 14
Resume half-day nonacademic extracurricular activities for those who received 3 vaccine doses >14 d apart	Students in secondary schools	2022 Oct 1–2023 Jan 31
Resume whole-day face-to-face classes if ≥90% of vaccination-eligible students (entire school or at individual class level) received >2 vaccine doses >14 d apart	Students in secondary schools	2022 Nov 1–2023 Jan 31
Resume whole-day face-to-face classes if ≥70% of vaccination-eligible students (entire school or at individual class level) received >2 vaccine doses >14 d apart	Students in primary schools	2022 Dec 1–2023 Feb 14
Resume whole-day face-to-face classes	Students in secondary schools	Beginning 2023 Feb 1
Resume whole-day face-to-face classes	Students in primary schools	Beginning 2023 Feb 15
COVID-19 tests		
Daily rapid antigen test result is required before returning to school for work or lessons	School staff and students	2022 Apr 19–2023 Mar 15
Vaccine pass		
A valid vaccine pass is required for school entry	School staff, students 12–17 years of age	2022 Feb 23–2022 Dec 29
Vaccination		
≥1 dose	Students 5–11 years of age School staff, students 12–17 years of age	2022 Sep 30–2022 Nov 29 2022 Feb 24–2022 Jun 29
≥2 doses	Students 5–11 years of age School staff, students 12–17 years of age	2022 Nov 30–2023 Feb 15 2022 Jun 30–2022 Nov 29
≥3 doses	School staff, students 12–17 years of age	2022 Nov 30–2023 Feb 1

summer holiday on COVID-19 transmission in school-age children.

During normal school days (Table 2), the COVID-19 incidence rate for kindergarten students was 24% (95% CI 22%–25%), for primary school students was 34% (95% CI 32%–35%), and for secondary school students was 19% (95% CI 18%–20%) higher than for adults, suggesting that school-age children had a higher infection risk than adults during normal school days. During the 5th-wave school closure, the incidence rate for kindergarten students was 31% (95% CI 29%–32%), for primary students was 42% (95% CI 41%–43%), and for secondary students was 46% (95% CI 46%–47%) lower than for adults. During the summer holiday when most schools were closed during the 6th wave, the COVID-19 incidence rate for kindergarten students was 12% (95% CI 9%–15%), for primary students was 28% (95% CI 26%–30%), and for secondary students was 32% (95% CI 30%–34%) lower than for adults. Assuming that school-based interventions had no effect on adults, effectiveness of school closure on reducing COVID-19 transmission

was 31%–46% during the 5th wave and 12%–32% during the 6th wave.

We collected school-related data from daily press conferences and press releases, including numbers of school-reported cases (students and staff), class suspensions, and schools reporting ≥1 case during periods of in-person learning (Appendix). Excluding summer holidays, weekly case numbers in the community were highly correlated with weekly numbers of school-reported student and staff cases (Pearson correlation coefficient $r = 0.77$, 95% CI 0.54–0.89), schools reporting ≥1 case ($r = 0.75$; 95% CI 0.51–0.88), and ≥2 cases of class suspension ($r = 0.81$, 95% CI 0.61–0.91) (Figure 2). Among 299 suspected school clusters, defined as schools that reported ≥2 COVID-19 cases within 7 days, a total of 66 (22%) had >5 cases and 22 (7%) had >10 cases. The largest suspected cluster recorded 53 cases in a secondary school that had ≈750 students and ≈75 staff. The second-largest suspected cluster had 35 cases in an international school that had ≈960 primary and secondary students.

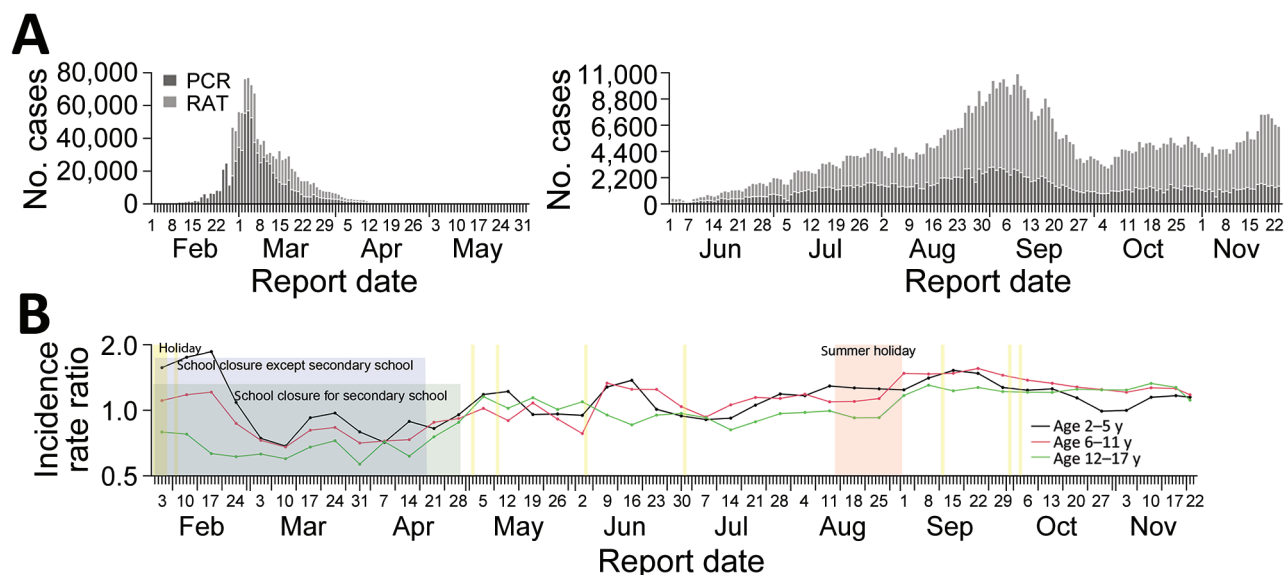


Figure 1. Epidemiology of 5th and 6th COVID-19 outbreak waves, Hong Kong, 2022, evaluated in study of effects of school-based preventive measures on COVID-19 incidence. A) Epidemic curves of 5th (February–April 2022, left) and 6th (beginning in June 2022, right) COVID-19 waves according to reporting date and test type. B) Incidence rate ratios of school-age children in kindergarten (age 2–5 y), primary schools (age 6–11 y), and secondary schools (age 12–17 y) in the 5th and 6th COVID-19 waves. Referent was adults (age ≥ 18 y). Yellow shading indicates a school holiday. RAT, rapid antigen test.

Conclusions

We found that school-age children had a higher SARS-CoV-2 infection risk than adults in Hong Kong, consistent with another study suggesting that children were more susceptible to Omicron variants compared with adults (4). School closure and summer holiday effectively reduced incidence rates in school-age children during the 5th and 6th COVID-19 waves, aligning with modeling and

simulation studies demonstrating the effectiveness of school closure in reducing COVID-19 transmission (5–7). We noted that the reduction in incidence rates for school-age children during school closure in the 5th wave was greater than that during the summer holiday in the 6th wave. Potential explanations for those results are that schools might not have been completely closed during summer holiday, possibly increasing the number of contacts between children; that Omicron BA.4/BA.5 variants were more prevalent during the 6th wave (Appendix Figure 1); or that higher ascertainment rates existed among students who had RAT used to detect COVID-19.

The strong positive correlation between school-reported data and community case numbers after school reopening indicated school reopening did not cause abnormal increases in community COVID-19 incidence. The largest suspected school cluster had 53 COVID-19 cases, comparable to other superspreading events, such as the 67-case cluster caused by Omicron BA.1 and 167-case cluster caused by Omicron BA.2 in January 2022 (8). Those results suggest that school reopening did not pose additional superspreading risks in school settings.

The first limitation of our study is that some school-reported COVID-19 infections could have originated elsewhere in the community, such as at home, instead of in schools. Although students

Table 2. Incidence rate and incidence rate ratio estimates according to the Poisson generalized additive regression model in study of effects of school-based preventive measures on COVID-19 incidence, Hong Kong, 2022*

Period and age group	Incidence rate†	IRR (95% CI)
Normal school days		
Age, y		
≥18	169	Referent
2–5	204	1.24 (1.22–1.25)
6–11	220	1.34 (1.32–1.35)
12–17	196	1.19 (1.18–1.2)
School closure		
Age, y		
≥18	727	Referent
2–5	622	0.69 (0.68–0.71)
6–11	560	0.58 (0.57–0.59)
12–17	461	0.54 (0.53–0.54)
Summer holiday		
Age, y		
≥18	292	Referent
2–5	370	0.88 (0.85–0.91)
6–11	324	0.72 (0.7–0.74)
12–17	275	0.68 (0.66–0.7)

*Adjusted for the time trend of COVID-19 cases. IRR, incidence rate ratio.

†Per 1,000 person-years.

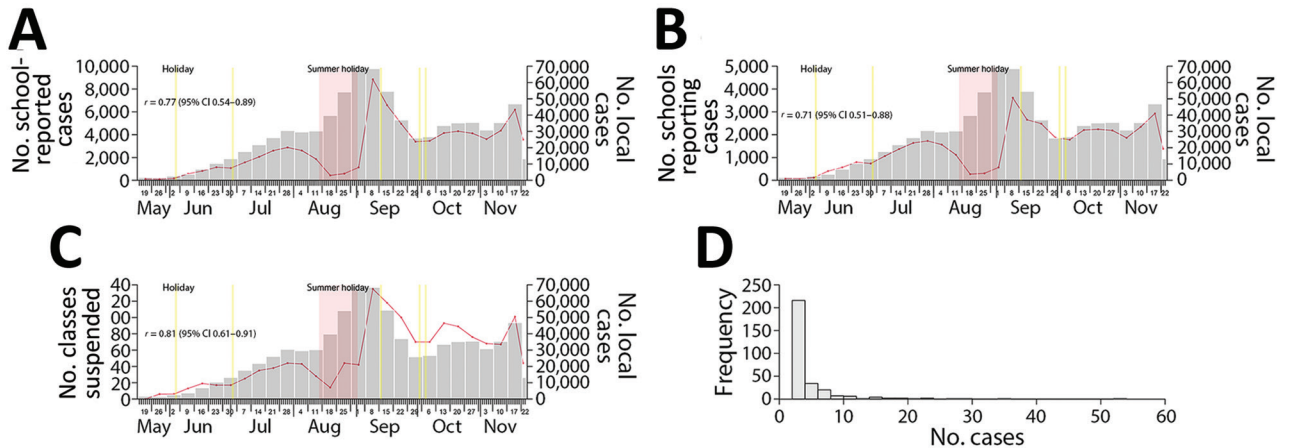


Figure 2. School-reported data during the 6th COVID-19 wave, Hong Kong, 2022, evaluated in study of effects of school-based preventive measures on COVID-19 incidence. A) Weekly numbers of school-reported cases during the 6th wave, beginning in June 2022. B) Weekly number of schools reporting ≥ 1 case during the 6th wave. C) Weekly number of class suspensions (classes with ≥ 2 COVID-19 cases) during the 6th wave. Yellow shading indicates school holiday; red shading indicates summer holiday. Pearson correlation coefficient r and 95% CI were calculated for data reported weekly. D) Distribution of 299 suspected school clusters of COVID-19 by size of cluster (no. cases). A school cluster was defined as a school that reported ≥ 2 cases within 7 days. Scales for the y-axes in panels A–C differ substantially to underscore patterns but do not permit direct comparisons.

and staff were required to conduct daily rapid tests and report positive results to schools and the government, underreporting cannot be ruled out. Second, we extracted school outbreak data from press conferences; thus, some details could have been missed. Third, we cannot exclude the possibility that some schools did not fully adhere to guidelines, particularly regarding class size and lesson duration; however, we lacked school-level data to account for that possibility. Fourth, our analysis did not account for changes in dominant virus strains (Omicron BA.2 in the 5th wave, Omicron BA.5 in the 6th wave). Finally, we considered school-based measures as a collective package and were unable to determine individual effects of specific measures on COVID-19 transmission.

In summary, we evaluated school closure and school reopening accompanied by multilayer school-based preventive measures for COVID-19 in Hong Kong, which was informative as a guide for implementing and relaxing those measures. Our results might not be directly generalizable for other respiratory pathogens because of differences in transmission and intervention effectiveness. However, our results are consistent with modeling studies suggesting that safe school reopening is possible when appropriate alternative school-based preventive measures are used (9–12). If resurgence in case numbers or emergence of variants with higher transmissibility in children occurs, school closure remains an option to reduce transmission among children.

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EID Podcast

Economic Burden of Reported Lyme Disease in High-Incidence Areas, United States, 2014–2016

As the most commonly reported vector-borne disease in the United States, Lyme disease represents a significant economic burden to individual people and US society. While approximately 476,000 cases of Lyme disease are diagnosed in the United States annually, comprehensive economic evaluations are lacking. Using a cost-of-illness analysis, researchers uncovered a substantial financial burden that underscores the need for effective prevention methods to reduce the incidence of Lyme disease in the US.

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Appendix

Additional Methods

Data Extraction

School-reported data were extracted from daily press conferences during May 16–September 23, 2022. After September 23, 2022, daily press conference were canceled, and we extracted the relevant information from daily press releases. Age-specific case data were obtained from the Hong Kong Centre of Health Protection; data were available until November 22, 2022. Numbers of cases (without age information) were obtained from daily press releases until November 22, 2022. We obtained population incidence denominators for age groups from the Census and Statistics department of the Hong Kong Special Administrative Region government.

Poisson Generalized Additive Regression Model

To determine the effects of school closure on COVID-19 incidence rates in school-age children, we fitted a Poisson generalized additive regression model adjusting for time trend of cases. Denoting case numbers at week t for age group i (1 = adults ≥ 18 years of age, 2 = kindergarten students 2–5 years of age, 3 = primary students 6–11 years of age, 4 = secondary students 12–17 years of age) as X_{it} , population size of the age group i as P_{it} , and time period as T_i (1 = baseline period, 2 = school closure, 3 = summer holiday), we have

$$\begin{aligned} \log(X_{it}) &= \log(P_{it}) + \beta_{11} \times I(i = 2) + \beta_{12} \times I(i = 3) + \beta_{14} \times I(i = 4) \\ &+ \beta_{21} \times I(i = 2 \&t \in T_2) + \beta_{22} \times I(i = 3 \&t \in T_2) + \beta_{23} \times I(i = 4 \&t \in T_2) \\ &+ \beta_{31} \times I(i = 2 \&t \in T_3) + \beta_{32} \times I(i = 3 \&t \in T_3) + \beta_{33} \times I(i = 4 \&t \in T_3). \end{aligned}$$

The incidence rate ratio for kindergarten students is indicated by exponential of β_{11} , $\exp(\beta_{11})$, primary students by $\exp(\beta_{12})$, and secondary students by $\exp(\beta_{13})$ compared with adults in the baseline period. Compared with adults in school closure, the incidence rate ratio for kindergarten students is indicated by $\exp(\beta_{21})$, primary students by $\exp(\beta_{22})$, and secondary students by $\exp(\beta_{23})$. Compared with adults in summery holiday, the incidence rate ratio for kindergarten students is indicated by $\exp(\beta_{31})$, primary students by $\exp(\beta_{32})$, and secondary students by $\exp(\beta_{33})$.

Appendix Table 1. School-based control measures since 2022

Action date	Action	Announcement	Sources
2022 Jan 14	Primary schools, kindergartens, and kindergarten/child care centers should suspend face-to-face classes and on-campus activities by this Friday until their Lunar New Year holidays end	2022 Jan 11	https://www.news.gov.hk/eng/2022/01/20220111/20220111_104753_827.html?type=category&name=covid19&tl=t
2022 Jan 24	All secondary schools should suspend face-to-face classes and all on-campus activities on or before January 24 until their Chinese New Year holidays.	2022 Jan 20	https://www.news.gov.hk/eng/2022/01/20220120/20220120_122040_196.html?type=category&name=covid19&tl=t
2022 Feb 8	Schools across the city will continue to suspend face-to-face classes until February 21, 2022	2022 Jan 27	https://www.news.gov.hk/eng/2022/01/20220127/20220127_184401_063.html?type=category&name=covid19&tl=t
2022 Feb 14	All kindergartens, primary schools, secondary schools and tutorial schools will continue the suspension of face-to-face classes and on-campus activities until March 6.	2022 Feb 14	https://www.news.gov.hk/eng/2022/02/20220214/20220214_174151_936.html?type=category&name=covid19&tl=t
2022 Mar 1	Summer holiday start from March or April	2022 Feb 22	https://www.news.gov.hk/chi/2022/02/20220222/20220222_193732_757.html?type=category&name=covid19&tl=t
2022 Apr 19	Chief Executive Carrie Lam today announced that primary schools, international schools, and kindergartens may resume face-to-face classes as early as April 19 after the Easter holidays. Secondary schools may restart in-person classes after the examinations of the 2022 Hong Kong Diploma of Secondary Education Examination core subjects are completed.	2022 Mar 21	https://www.news.gov.hk/eng/2022/03/20220321/20220321_124717_054.html?type=category&name=covid19&tl=t
2022 Apr 19	The Government today announced that schools will resume face-to-face classes in phases after the Easter holidays. All school staff, teachers, and students are required to conduct COVID-19 rapid antigen tests (RATs) daily and only those who have obtained a negative result will be allowed to enter the schools.	2022 Apr 11	https://www.news.gov.hk/eng/2022/04/20220411/20220411_120620_439.html?type=category&name=covid19&tl=t
2022 May 19	The Education Bureau announced today the updated arrangements concerning antiepidemic measures in schools; it will relax conditions for students to participate in maskwearing activities on a half-day basis. Such activities include speech days, parents' days, open days, and campus visits. However, students must still follow antiepidemic rules while attending the events.	2022 May 19	https://www.news.gov.hk/eng/2022/05/20220519/20220519_174157_317.html?type=category&name=covid19&tl=t
2022 Jun 17	All teachers, school staff, and students have to complete an RAT every school day and obtain a negative test result before returning to school for work or lessons.	2022 Jun 17	https://www.news.gov.hk/eng/2022/06/20220617/20220617_150957_812.html?type=category&name=covid19&tl=t

Appendix Table 2. Vaccination requirements for entering schools during 2022*

Date	Focus	Age, y	School type	Action	Remarks	Sources
2022 Feb 24	Staff	≥18	Kindergartens, primary and secondary schools, tutorial schools	From February 24, apart from those who are exempted, all teaching and nonteaching staff, people providing on-campus services and school visitors will be required to present vaccination records of at least the first COVID-19 vaccine dose before their entry into school premises. The above measures will still be enforced during suspension of face-to-face classes. For those exempted personnel, such as those who are unfit for vaccination due to health reasons, they are still required to conduct COVID-19 tests once every three days.	Announced on 2022 Jan 20. The arrangement does not apply to students.	https://www.info.gov.hk/gia/general/202202/14/P2022021400639.htm ; https://www.news.gov.hk/eng/2022/01/20220120/20220120_194630_073.html
2022 Feb 24	Staff, students	≥12	NA	From February 24, persons ≥12 years of age with ≥1 COVID-19 vaccination dose will be permitted to enter specified premises.	Announced on 2022 Jan 21.	https://www.news.gov.hk/eng/2022/02/20220221/20220221_153338_846.html

Date	Focus	Age, y	School type	Action	Remarks	Sources
2022 Apr 21	Staff	≥18	Kindergartens, primary and secondary schools, tutorial schools	Teachers and school staff directly employed by schools who have received only one dose should receive the second dose before April 21.	Announced on 2022 Jan 20. The arrangement does not apply to students.	https://www.news.gov.hk/eng/2022/01/20220120/20220120_194630_073.html
2022 Apr 30	Students	12–17	NA	During the second stage from April 30 to June 29, if persons 12–17 years of age have received their first dose of COVID-19 vaccine for <6 months, their vaccine pass remains valid. However, if they have received their first dose ≥6 months ago, they will need to receive a second dose to continue to use the vaccine pass.	Announced on 2022 Mar 4.	https://www.news.gov.hk/eng/2022/03/20220304/20220304_210043_224.html
2022 Jun 30	Students	12–17	NA	Starting from the third stage from June 30, if persons 12–17 years of age have received their second dose of COVID-19 vaccine <9 months ago, they can still use the Vaccine Pass. If they have received their second dose for >9 months ago, they are required to receive a third dose to continue to use the vaccine pass.	Announced on 2022 Mar 4.	https://www.news.gov.hk/eng/2022/03/20220304/20220304_210043_224.html
2022 Aug 5	NA	NA	NA	All teachers and school staff directly employed by the schools to meet the requirements of the Vaccine Pass, and ≥90% of the total number of students eligible for vaccination to receive 2 doses of vaccine >14 d apart.		https://www.news.gov.hk/eng/2022/08/20220805/20220805_164616_433.html
2022 Aug 5	Students	NA	NA	Secondary or primary school students who have received two jab doses >14 d apart may attend nonacademic extracurricular activities at school after lessons or during the other half-day of a school day.		https://www.news.gov.hk/eng/2022/08/20220805/20220805_164616_433.html
2022 Sep 30	Students	5–11	NA	Starting from September 30, children 5–11 years of age are required to have received at least the first dose within 3 months to comply with the vaccination requirements under the Vaccine Pass for entering specified premises (Note). If they received their first dose 3 months ago or earlier, they are required to receive the second dose to continue to be eligible to use the Vaccine Pass.	Announced on 2022 Sep 8	https://www.info.gov.hk/gia/general/202209/08/P2022090800481.htm?fontSize=1
2022 Sep 30	NA	≥12	NA	Starting from September 30, the grace period for persons ≥12 years of age to receive the third dose after the second dose will be shortened from the original 6 months to 5 months. For those who had received the second dose within 5 months, their Vaccine Pass is still valid, but they must receive the third dose within 5 months after receiving the second dose (instead of the original 6 months) to continue using the Vaccine Pass afterwards.	Announced on 2022 Sep 8	https://www.info.gov.hk/gia/general/202209/08/P2022090800481.htm?fontSize=1
2022 Nov 30	Students	5–11	NA	Starting from November 30, the vaccination requirement for all children 5–11 years of age under the Vaccine Pass will have to receive the second dose.	Announced on 2022 Sep 8	https://www.info.gov.hk/gia/general/202209/08/P2022090800481.htm?fontSize=1
2022 Nov 30	NA	≥12	NA	Starting from November 30, persons ≥12 years of age are required to have received the third dose to meet the vaccination requirements under the Vaccine Pass.	Announced on 2022 Sep 8	https://www.info.gov.hk/gia/general/202209/08/P2022090800481.htm?fontSize=1

*NA, not applicable.

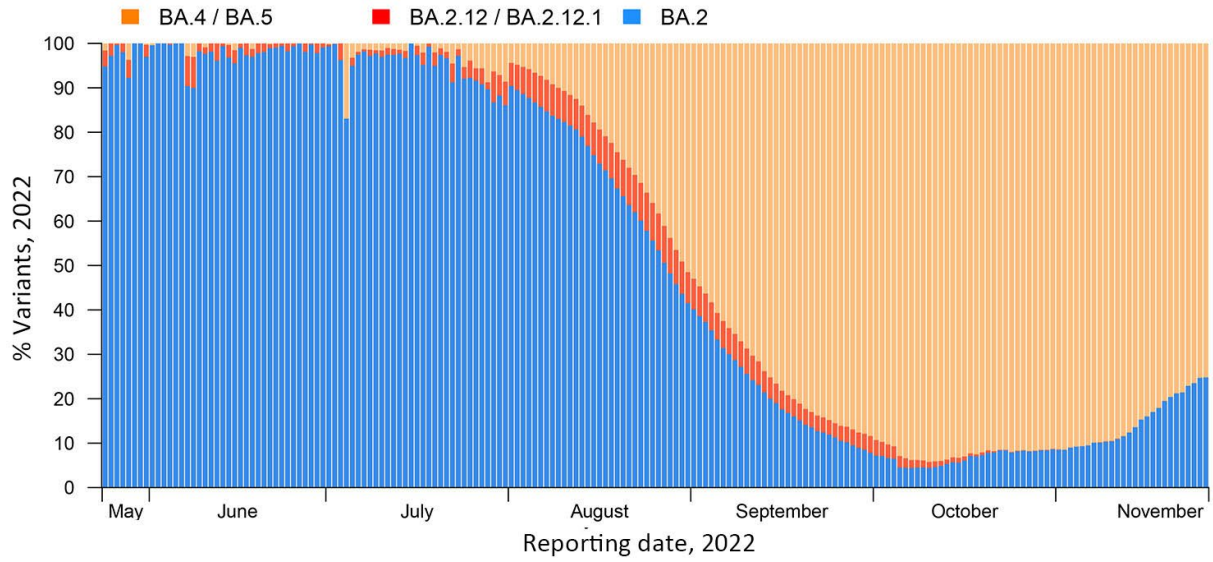
Appendix Table 3. Summary of rapid tests available in Hong Kong and their sensitivity and specificity provided by manufacturer*

Brand name	Manufacturer	Web sites	Sensitivity, %	Specificity, %
AESKU.RAPID SARS-CoV-2	AESKU.Diagnostics	https://eshop.medifasthk.com/en/AESKU-COVID-19-Rapid-Antigen-Test-2-Tests	100	98.00
AESKU.RAPID SARS-CoV-2	AESKU.Diagnostics	https://www.aesku.com/index.php/diagnostics/aesku-rapid-sars-cov-2-antigen-tests	100	98
AESKU.RAPID SARS-CoV-2	AESKU.Diagnostics	https://www.aesku.com/index.php/diagnostics/aesku-rapid-sars-cov-2-antigen-tests	100	98
Aichek, COVID-19 Antigen Home Test	Hangzhou Aichek Medical Technology	https://www.consumer.org.hk/tc/rapid_antigen_test_search	NA	NA
FIATest, SARS-CoV-2 Antigen Rapid Test Cassette(Nasopharyngeal Swab)	Hangzhou All Test Biotech	https://www.custom-monoclonalantibody.com/sale-2991704-high-quality-microalbumin-test-use-by-fiatest-fluorescence-immunoassay-analyzer-in-human-whole-blood.html	NA	NA
ALLTest, SARS-CoV-2 Antigen Rapid Test (Nasal Swab) (INCP-502-N)	Hangzhou AllTest Biotech	https://www.maskwholesale.eu/rapid-tests/alltest-corona-antigen-nasal-swab-rapid-test_292_1314/	95.40	99.40
Biosynex Autotest Antigenique COVID-19 Ag	Biosynex	https://www.biosynex.com/products/pharmacy/diagnosis/self-tests/biosynex-covid-19-ag-bss-self-test/?lang=en	97.20	100
BioTeke SARS-CoV-2 Antigen Test Kit	BioTeke Corporation (Wuxi)	https://www.hktvmall.com/hktv/en/main/Milan-Store/s/H0257001/Personal-Care-%26-Health/Personal-Care-%26-Health/Health/Self-Test-Kits/BIOTEKE-Covid19-Test-Kit-SARSCoV2-Antigen-Rapid-Test-Kit-Omicron-Delta-3pc-Random-Box/p/H0257001_S_BIOTEKE-3?scrollTo=descriptionsTab	95	99.28
BIOUHAN, SARS-CoV-2 Antigen Rapid Test (Colloidal Gold Method)	Biohit Healthcare (Hefei)	https://www.biouhan.com/AgCC/index.aspx	96.12	99.49
Clungene, COVID-19 Antigen Rapid Test	Hangzhou Clungene Biotech	https://www.hansagt24.com/en/covid-19-antigen-rapid-test-for-professional-use/80-clungene-covid-19-antigen-rapid-test-cassette.html	98	99.70
CO-Check SARS-CoV-2 Antigen LFIA Test	Sanwa BioTech (三和生物科 技)	https://www.tga.gov.au/resources/covid-19-test-kits/co-check-sars-cov-2-antigen-lfia-test-poct	NA	NA
Coretests, COVID-19 Ag Test	Core Technology	https://patika1.hu/CoreTest-COVID-19-Antigen-teszt-orr-1x	95.11	100
Coronavirus (2019-nCoV)- Antigentest-	Beijing Hotgen Biotech	http://www.hotgen.com.cn/zl1.html	90.70	100
Hotgen Novel Coronavirus 2019 n-CoV Antigen Test (for self-testing use)	Beijing Hotgen Biotech	https://www.dr-operation.de/en/hotgen-coronavirus-rapid-test/	95.37	99.13
COVID-19 / influenza A virus / influenza B virus Antigen test kit (colloidal gold)	Xiamen Hopegen Medical Technology	https://www.shoptest.com/covid19-test-hopegen321.html	96	99
Covid-19 Antigen CARD Kit	GeFosun Diagnostics (Shanghai)	https://eshop.pasioncare.com/en/products/fosun-diagnostics-covid-19-antigen-card-kit-2	96.75	98.26
COVID-19 Antigen Nasal Test Kit	Assure Tech. (Hangzhou)	https://www.assuretech-product.com/search/COVID.html	96.80	99.80
COVID-19 Antigen Rapid Detection Kit (Colloidal Gold)	Pro-med (Beijing) Technology	https://www.consumer.org.hk/tc/rapid_antigen_test_search	NA	NA
COVID-19 Antigen Rapid Test	Beijing North Institute of Biotechnology	https://www.consumer.org.hk/tc/rapid_antigen_test_search	94.70	99
COVID-19 Antigen Rapid Test	Shenzhen Everbest Machinery Industry	https://cem-instruments.de/products/covid-19-antigen-schnelltest/	92.73	100
COVID-19 Antigen Rapid Test Kit	Beijing Kewei Clinical Diagnostic Reagent	http://en.keweidiagnostic.com/index.php?m = content&c = index&a = show&catid = 200&id = 184	96.18	100
COVID-19 Antigen Rapid Test Kit (Colloidal Gold)	AmonMed	http://en.amonmed.com/	95.05	99.55

Brand name	Manufacturer	Web sites	Sensitivity, %	Specificity, %
COVID-19 Antigen Rapid Test Kit (Colloidal gold)	Xiamen AmonMed Biotechnology	https://www.consumer.org.hk/tc/rapid_antigen_test_search	100	99.55
FIATest, COVID-19 Antigen Test Cassette	Hangzhou AllTest Biotech	https://www.alltests.com.cn/Home/ProductInfo/385	NA	NA
Flowflex SARS-CoV-2 Antigen Rapid Test	Acon Biotech (Hangzhou)	https://www.aconbio.com/en/ACON/Rapidtest/	97.22	99.71
fluorecare, SARS-CoV-2 Antigen Test Kit (Colloidal Gold Chromatographic Immunoassay)	Shenzhen Microprofit Biotech	https://www.sasa.com.hk/SalePage/Index/268951	92.93	100
Fosun Covid-19 Ag CARD	Fosun Diagnostics (Shanghai)	https://eshop.pasioncare.com/en/products/fosun-diagnostics-covid-19-antigen-card-kit-2	96.75	98.26
Hecin, 2019-nCoV Antigen Test Kit (colloidal gold method)	Guangdong Hecin	https://hplushk.com/products/hecin	97.09	99.78
iClean, COVID-19 Ag Rapid Test Kit (Colloidal Gold)	Huachenyang (Shenzhen) Technology	https://www.linkedin.com/pulse/iclean-covid-19-antigen-rapid-test-listed-eu-common-list-ivy-peng/	91	100
INDICAID COVID-19 Rapid Antigen Test	Phase Scientific	https://www.intecasi.com/rapid-sars-cov-2-antigen-test-nasal-swab-for-self-testing-use_p55.html	93.64	100
Medomics, SARS-CoV-2 Antigen Rapid Test (LFIA)	Jiangsu Medomics Medical Technology	https://www.medomics-dx.net/product/SARS-CoV-2-Antigen-Test-Kit-%28LFIA%29-Home-Use-Single-Pack-492.html	97.73	99.51
Novel Coronavirus (SARS-Cov-2) Antigen Rapid Test Device (nasal swab)	Hangzhou Realy Tech	https://www.takemycovidtest.com.au/products/p/covid-19-rapid-home-test-kit-1-pack-sxr9t	95.38	99.99
One Step Test for SARS-CoV-2 Antigen (Colloidal Gold)	GETEIN Biotech	https://leo-shop.de/produkt/getein-schnelltest/	97.06	98.71
GP One Step Test for SARS-CoV-2 Antigen	GETEIN Biotech	http://www.medical.iap.com.hk/index.php?route=product/product&product_id=196	97	98.7
Panbio COVID-19 Antigen Self-Test	Abbott Rapid Diagnostics	https://www.globalpointofcare.abbott/www/en/products-solutions.html	98.10	100
Rapid COVID-19 Antigen Self-Test	Healgen Scientific	https://www.quadratech.co.uk/product/healgen-rapid-covid-19-antigen-self-test-single-cassette-ce-marked-15min-nasal-swab/	97.25	98.73
Rapid SARS-CoV-2 Antigen Test	InTec PRODUCTS	https://www.intecasi.com/rapid-sars-cov-2-antigen-test-nasal-swab-for-self-testing-use_p55.html	93.64	100
RightSign, COVID-19 Antigen Rapid Test Cassette (Nasal Swab)	Hangzhou Biotest Biotech	https://hygiene100.de/produkt/rightsign-hangzhou-biotest-biotech-covid-19-antigen-rapid-test-cassette-nasal-swab/	93.75	99.12
Roche, SARS-CoV-2 Antigen Self Test Nasal	SD. Biosensor	https://diagnostics.roche.com/gb/en/products/params/sars-cov-2-antigen-self-test-nasal.html#productSpecs	91.10	99.60
Roche, SARS-CoV-2 Rapid Antigen Test Nasal	SD. Biosensor	https://diagnostics.roche.com/global/en/products/params/sars-cov-2-rapid-antigen-test.html	95.50	99.20
YHLO GLINE-2019-nCoV Ag	Shenzhen Watmind Medical	https://www.mblbio.com/e/products/ivd/list/YH-G86247E.html	96.93	99.25
SARS-CoV-2 Ag Self-Test Kit (Nasal Swab)	Shenzhen Watmind Medical	https://www.hktvmail.com/hktv/en/main/SUN-TONE-RETAIL-SOLUTIONS-LIMITED/s/H8612001/Personal-Care-%26-Health/Personal-Care-%26-Health/Health/Self-Test-Kits/COVID-SelfTest-Kit-Nasal-Swab-1-kit-15minTEST-RATtest-Omicron-Delta-CE-Ctsensitivity/p/H8612001_S_AQ_Adult_1kit	95.70	100
SARS-CoV-2 and Influenza A+B Antigen Combo Rapid Test (Nasal Swab)	Hangzhou AllTest Biotech	https://www.alltests.com.cn/Home/product	97.60	99.70
SARS-CoV-2 Antigen Assay Kit (Collodial Gold Method)	Zybio	https://mybio.ie/products/zybio-sars-cov-2-antigen-assay-kit-home-self-test-188-unit-case-ce-ivd-certified	88.79	99.04
SARS-CoV-2 Antigen Rapid Test Cassette	Hangzhou Sejoy	https://rapidtest-lab.com/en/termek/sejoy-sars-cov-2-antigen-nasal-rapid-test/	97.9	99.99

Brand name	Manufacturer	Web sites	Sensitivity, %	Specificity, %
SARS-CoV-2 Antigen Rapid Test Device	Zhuhai Encode Medical Engineering	https://www.consumer.org.hk/tc/rapid_antigen_test_search	95	100
SARS-CoV-2 Antigen Rapid Test Kit	Labnovation	https://www.consumer.org.hk/tc/rapid_antigen_test_search	94	100
SARS-CoV-2 Antigen Rapid Test Kits for Self-testing (Colloidal Gold Immunochromatography)	Beijing Lepu Medical Technology	https://en.lepumedical.com/lepu-medicals-sars-cov-2-antigen-rapid-test-acquir.html	95.90	100
SARS-CoV-2 Virus Antigen Detection Kit (colloidal gold method)	BGI	NA	NA	NA
Savewo, COVID-19(SARS-CoV-2) Antigen Test Kit (Colloidal Gold)	Anhui Deepblue Medical Technology	https://www.mdd.gov.hk/tc/whats-new/rapid-antigen-tests-covid-19/index.html#gallery_tb1_3-2	96.40	99.80
Skypro, Rapid COVID-19 Antigen Test (Colloidal Gold)/ Nasal Swab	Anbio (Xiamen) Biotechnology	https://skypro.com.hk/?p=5962&lang=en	98	100
Verino Pro SARS-CoV-2 Ag Rapid Test	VivaChek Biotech (Hangzhou)	https://www.anjoycycle.com/en/products/verino-pro-rapid-antigenic-test-sars-cov-2-ag	97.42	99.99
Wondfo, Wondfo 2019-nCoV Antigen Test (Lateral Flow Method)	Guangzhou Wondfo	https://www.abingdonhealth.com/products/covid-19-antigen-self-test/	91.63	99.84
YHLO, GLINE-2019-nCoV Ag	Shenzhen YHLO Biotech	https://www.lyreco.com/webshop/ENHK/yhlo-gline-2019-ncov-ag-rapid-antigen-test-single-test-product-00000000016214462.html	96.38	99.56
Dynamiker SARS-CoV-2 Ag Rapid Test	Dynamiker Biotechnology (Tianjin) Co.,Ltd	https://covid-19-diagnostics.jrc.ec.europa.eu/devices/detail/2533	95.7	99.1
Jinwofu Novel Coronavirus (SARS-CoV-2) Antigen Rapid Test Kit	Jinwofu Bioengineering Technology Co., Ltd	https://bjjwf.cn/en/h-pd-36.html	96.71	99.73
Roche SARS-CoV-2 Rapid Antigen Test Nasal	SD Biosensor	https://diagnostics.roche.com/global/en/products/params/sars-cov-2-rapid-antigen-nasal-test.html#productSpecs	89.6	99.1
Roche SARS-CoV-2 Antigen Self Test Nasal	SD Biosensor	https://diagnostics.roche.com/global/en/products/params/sars-cov-2-antigen-self-test-nasal.html	95.8	100

*NA, not available.



Appendix Figure 1. Percentages of SARS-CoV-2 Omicron BA.2 and BA.4/BA.5 variants during the 6th wave of the COVID-19 outbreak in Hong Kong in 2022.