

# Safety of reopening universities and colleges using a combined strategy during coronavirus disease 2019 in China: a cross-sectional study

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## Research Article

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# Abstract

**Background** There is no consensus as to when and how to reopen schools during the coronavirus disease 2019 (COVID-19) pandemic. This study aimed to evaluate the safety of reopening universities and colleges using a combined strategy in China.

**Methods** This cross-sectional study included 13,116 staffs and postgraduate students who have returned to the four campuses of the University of Science and Technology of China from 17 February (students returned from 12 May) to 2 July 2020. The returning to school was guided by a combined strategy including use of personal protective equipment, management of transportation, serological and nucleic acid tests for COVID-19, quarantine, and restrictions in and out of campus. Epidemiology history and COVID-19 related symptoms (fever, cough, and dyspnoea) were recorded in a subset of participants using an online questionnaire.

**Results** Among 13,116 participants, 4067 tested for severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) nucleic acid and no positive results were identified. Of 9049 participants who chose to conduct antibody tests, 28 (0.3%) tested positive but no one was confirmed by the additional viral nucleic acid tests. Online questionnaires were collected from 5741 participants (mean 25.1 years, 35% female). High-risk exposures and COVID-19 related symptoms were reported in 8.3% and 7.4% of participants, respectively. Comorbidities (hypertension, diabetes, chronic pulmonary disease, and chronic kidney disease) were rare (0.2%-1.5%).

**Conclusions** Using a combined strategy for COVID-19 prevention and control, safely reopening of universities and colleges in low-risk regions is possible and laboratory screening for SARS-CoV-2 infection may not be necessary. Further studies need to cautiously evaluate the safety of reopening schools, if any, in the middle- and high-risk regions.

## Background

As of 14 September 2020, coronavirus disease 2019 (COVID-19) pandemic, caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), has infected over 28 million people among most countries worldwide.[1] Many countries and regions have launched a series of restrictions on social-economic activities to avoid the spread of COVID-19. School closure is one of these and has shown a temporal association with lower COVID-19 incidence and mortality in the US.[2] These strategies play a crucial role in the control and prevention of COVID-19 but also bring tremendous burden to the society and the education system.[3] According to the UN Educational, Scientific and Cultural Organization (UNESCO), school closures are affecting 50-90% of enrolled learners worldwide since mid-March 2020.[4] Such a long period of school closures poses negative influences to students' education, social activities, and mental health,[5, 6] therefore reopening schools is an urgent need.

There is no consensus as to when and how to reopen schools during the COVID-19 pandemic. Reopening universities and colleges is especially challenging given the high risk of SARS-CoV-2 transmission due to

national or international travels and increased social contacts on campus. In consideration of potential outbreaks within schools, only a few countries and regions have reopened schools completely after the lockdown.[7] In an outbreak of COVID-19 in a high school in Israel, 13.2% students and 16.6% staff members were COVID-19 positive 10 days after reopening a high school.[8] In the US, major campus outbreaks emerged in over 750 universities and colleges and have led to some large universities being shut down again, after the reopening of over a third of universities and colleges in August.[9] However, a report from Taiwan shows that safe reopening of universities and colleges may be possible with appropriate preventive strategies, although a precondition may be the low number of COVID-19 cases in Taiwan.[10] Chinese government classified most regions as low-risk for COVID-19 on 22 Mar 2020,[11] sending a positive signal of reopening schools.

On 13 April 2020, Chinese National Health Commission and Chinese Ministry of Education jointly issued a technical plan of COVID-19 prevention and control for universities and colleges.[12] The University of Science and Technology of China (USTC) is one of the first batch in mainland China that reopened its campuses during the COVID-19 pandemic. This study aimed to describe and evaluate the effect of strategies we used to guide the reopening of USTC in the prevention and control of SARS-CoV-2 infection.

## Methods

### Study design, setting, and participants

The outbreak of COVID-19 in China occurred prior to the Spring Festival (Chinese Lunar New Year), most students and staffs have left campus during the winter break and were staying with their family. Returning to USTC was prohibited during the widespread outbreak of COVID-19. In this cross-sectional study, we described results of SARS-CoV-2 testing from 13,116 staffs and students of USTC who have returned to the four campuses in Hefei, Anhui province, China, from 17 February (students returned from 12 May) to 2 July 2020. All participants who participated the online survey provided informed consent. Informed consent was waived for other participants as this study did not collect their individual data. This study was approved by the Research Ethics Commissions of the First Affiliated Hospital of USTC.

### Strategies for COVID-19 prevention and control

While USTC reopened since 17 February 2020, school staffs were encouraged to work from home, leaving only a small number of on-duty staffs to maintain the basic operation of the school. Local staffs who had never left Hefei during the winter break and did not have COVID-19 symptoms and history of epidemiology exposure could return to work at school. Staffs who were living in other low-to-medium risk regions should return to Hefei by 5 March 2020 and quarantine themselves at home for at least 14 days

before returning to the campuses. SARS-CoV-2 nucleic acid tests and antibody tests were conducted in school hospital for staffs who returned from high-risk regions. For example, staffs who travelled to Beijing from 30 May 2020 would be tested for COVID-19 infection because of the second outbreak of COVID-19 in Beijing at the beginning of June 2020.[13]

Based on the technical plan issued by Chinese National Health Commission and Chinese Ministry of Education,[12] the COVID-19 Prevention and Control Task Force of USTC released their own implementation plan on 9 May 2020 to guide the returning of students for the 2020 spring semester. The implementation plan was reviewed and approved by Chinese Academy of Sciences and local government and has been spread to all registered students and staffs.

The returning of students was arranged in batches from 12 May 2020. The first three batches of returning were scheduled on 12, 17, and 25 May 2020 for second-year or higher grades full-time postgraduate students who were living in the local city (i.e. Hefei), Anhui province (other than Hefei), and other low-risk regions (classified by the Chinese National Health Commission.

<http://bmfw.www.gov.cn/yqfxdjc/index.html>) in mainland China, respectively. The fourth (last) batch of returning was scheduled on 28 and 30 June, and 2 July 2020 based on the schools/institutes for all enrolled postgraduate students who were living in low-risk regions for at least 14 days, and this was ensured by consecutive location data provided by Chinese communications operators with permissions of students who planned to return. USTC offers distance learning for first-year postgraduate students who have specialized courses to be completed. The returning to school is in accordance with the principle of voluntariness for all postgraduate students.

### *On the way returning to school*

Private cars are recommended for the returning to reduce the risk of exposure. For those who planned to take public transportations, a proper route should be planned to avoid middle-to-high risk regions and a medical mask must be worn throughout the trip. It is important to avoid staying in places with dense crowds and poor ventilation, and to wash hands frequently. The itinerary for public transportations taken by each student should be retained in case there is any peer traveler having COVID-19. Temperature monitoring is necessary when feeling a fever. Students who had suspect symptoms during the trip should avoid close contacts with other personals, seek for medical care at the nearest fever clinics, and notify their supervisors and family members.

### *Procedures of entering the campuses*

USTC campuses are surrounded by fences and each campus has several gates. On the scheduled date, students had their temperature tested using a digital infrared thermometer and showed the health code (i.e. a green code is required) and student card at the designated gate before entering the campus.

Students who had a fever were taken to a designated fever clinic for further evaluation.[14] After entering the campus, students were requested to check-in in a large activity centre, where the nasopharyngeal swabs or blood samples were collected for a free SARS-CoV-2 nucleic acid or antibody test. Students can choose to have either SARS-CoV-2 nucleic acid or antibody test, and those with positive antibody tests (defined below) would be given an additional SARS-CoV-2 nucleic acid test. After checking in, all students received a health kit (i.e. 20 masks, a bottle of hand sanitizer, and a handbook about self-prevention against COVID-19) and were quarantined in their own dormitories (2-4 students per room) until a negative test for SARS-CoV-2 infection was informed. Students with a positive SARS-CoV-2 nucleic acid test would be quarantined off campus for 14 days and hospitalized when necessary, and the roommates would be quarantined in the dormitory for 14 days. At the end of the quarantine, they would retest for SARS-CoV-2 nucleic acid.

### *Daily management*

Standard preventive strategies such as hand hygiene, wearing masks, and ventilation are introduced in the handbook. Dining halls, shops, laboratories, and school hospital on campus are opening as usual but social distancing is required. Students with any suspected COVID-19 symptom would be quarantined and further evaluated at a designated fever clinic. Close contacts would be quarantined until the possibility of COVID-19 infection is ruled out. Randomly in and out of the campus is prohibited. Temporarily leave the campus but not Hefei is allowed with permission of the corresponding supervisor through an online application system, and student's access card would only be valid before mid-night on the same day. For those who must leave Hefei or stay off campus for multiple days due to emergencies, a detailed itinerary of the trip, a green health code, and a new report of negative SARS-CoV-2 nucleic acid test from any qualified hospitals within the past 14 days should be provided when returning to school.

## **Data collection and definitions**

We used an online questionnaire to collect data from returned staffs and students on their demographic characteristics, history of epidemiological exposure, COVID-19 related symptoms (i.e. fever, cough, dyspnoea, fatigue, headache, and diarrhea), comorbidities, and self-reported tests for SARS-CoV-2 infection. High-risk regions in mainland China were classified according to the Chinese National Health Commission, and all countries and regions outside mainland China were considered high-risk in this study. A high-risk exposure was defined as any contacts with COVID-19 cases, overseas returnees, or people processing imported frozen meat or seafoods.

SARS-Cov-2 nucleic acid tests were conducted using real-time reverse transcription-polymerase chain reaction (RT-PCR) on nasopharyngeal swabs (BioGerm Biotech, Shanghai). Serum SARS-CoV-2 specific

antibody levels were measured with chemiluminescent kits (Kangrun Biotech, Guangzhou) for IgA, IgG, and IgM as described previously. Briefly, the purified receptor-binding domain (RBD) viral antigens were coated to magnetic particles to catch SARS-CoV-2 specific IgA, IgM, and IgG in sera. A second antibody that recognizes IgA, IgM or IgG conjugated with acridinium was used for detection of the IgA, IgM, or IgG caught by antigen, respectively. The detected chemiluminescent signal over background signal was calculated as relative light units (RLU) using a fully automatic chemical luminescent immunoanalyzer, Kaeser 1000 (Kangrun Biotech, Guangzhou). The sensitivities of RBD-specific IgA, IgM, and IgG tests were 98.6%, 96.8%, and 96.8%, and specificities 98.1%, 92.3%, and 99.8%, respectively.[15] A positive antibody test was defined as: one positive IgA, IgM, or IgG test (i.e. RLU greater than the cut-off values at 45000, 42000, and 15000, respectively) plus a suspicious RLU greater than 2/3 of the cut-off values for at least one of the other two antibodies. For individual whose antibody tests were very closed to the cut-off values, retesting for viral nucleic acid or not was determined by a panel of experts based on epidemiology history.

## Statistical analysis

Data were described as mean (standard deviation [SD]) or number (percentage) as appropriate. No between-group comparisons were conducted in this study. All data analyses were performed using Stata version 16.0 (College Station, TX).

## Role of the funding source

The funder of the study had no role in study design, data collection, data analysis, data interpretation, or writing of the report. JW had full access to all the data in the study and had final responsibility for the decision to submit for publication.

## Results

### Participants

From 17 February to 2 July 2020, a total of 13,116 staffs and postgraduate students returned to USTC in accordance to the combined strategy released by the COVID-19 Prevention and Control Task Force of USTC. Among these participants, 4067 (31%) and 9049 (69%) chose to conduct SARS-CoV-2 nucleic acid tests and antibody tests, respectively. No one tested positive for SARS-CoV-2 nucleic acid, including the 28 participants who had positive antibody tests and retested for SARS-CoV-2 nucleic acid. Positive IgG tests were found in 44 (0.5%) of 9049 participants who conducted antibody tests.

# Results of online survey

Of 13,116 participants, 5741 (43.8%) participated the online survey. Demographic and clinical characteristics of the 5741 participants were described in Table 1. The mean age was 25.0 years (SD 2.1 years), and 35% were female. A small proportion of participants lived (2.4%) or travelled (9.6%) in high-risk regions or had high-risk exposures (8.3%); 423 (7.4%) participants reported at least one COVID-19 related symptom such as fever (2.4%), cough (2.9%) and diarrhoea (2.8%), and 2.8% went to a fever clinic seeking medical attention. Comorbidities were rare among the participants (0.2%-1.5%). Three hundred and ninety-seven participants conducted both SARS-CoV-2 tests and antibody tests.

## Discussion

This study described a combined strategy for COVID-19 prevention and control in a university in China. Despite the large number of returning staffs and students (n=13,116), no evidence of infection was found based on viral nucleic acid and antibody tests. With an overall low-risk of COVID-19 in China, reopening universities and colleges is safe and feasible.

Among 13,116 staffs and postgraduate students returned to USTC, no one tested positive for COVID-19 in the health examinations on the returning days, although 8.4% of them had a history of high-risk exposures. Moreover, no new infections were reported in the USTC campuses or in Anhui province from the date of the first batch of returning to 26 August 2020, indicating that the reopening of the university is safe. The key reason for the complete prevention of COVID-19 outbreaks in this study is likely due to the overall low number of confirmed cases in China and over 80% of cases were concentrated in the epicentre Hubei, and students from Hubei and other middle-to-high risk regions were not arranged to return until these regions were re-classified as low-risk. In addition, the overall risk of COVID-19 is very low in China after resuming work and school since there have been only sporadic cases or small outbreaks of COVID-19 and no infections were reported in schools. Furthermore, it may also be due to that returned students and staffs are young (mean 25.1 years) and healthy (very low prevalence of comorbidities), as young adults are less susceptible to COVID-19.[16] Despite this, it is important to note that only a very small proportion (0.5%) of participants had a positive IgG, suggesting that most participants are still vulnerable to SARS-CoV-2 infection and that daily prevention is critically important.

All returned students were tested for SARS-CoV-2 infection in consideration of the potential of asymptomatic carriers.[17] While both serological and nucleic acid tests were provided and either method can be chose, only those with positive antibody tests were given a compulsory viral nucleic acid test. This was a trade-off between time costs and the non-prefect sensitivity of antibody tests (96.8% to 98.6%). However, false negative results were very unlikely due to the very low prevalence and incidence of COVID-19 in China at the time of reopening universities and colleges. Moreover, our recent population-based surveillance study[18] showed that asymptomatic carriers only accounted for a small proportion of

COVID-19 and had a low transmissibility even among household contacts – the main setting for transmission.[19] Indeed, we did not find any asymptomatic carriers among over thirteen thousands of returned staffs and students. Thus, in low-risk countries and regions with a mature system for COVID-19 prevention and control, such as individualized risk assessment, strict quarantine, and sufficient medical supports, laboratory testing for COVID-19 infection among school students may not be a must. By contrast, these laboratory tests may be of greater importance in countries and regions where the risk of SARS-CoV-2 infection is high.

Only postgraduate but not undergraduate students were arranged to return to school as they have no or few courses to be completed, and the limited courses were also replaced by distance learning notwithstanding. This minimizes the risk of massive outbreaks through class-based teaching. Clearly, our findings demonstrate that it is safe and feasible to reopen campuses to postgraduate students in low-risk regions in China. In the circumstance of an overall low risk of new infections and relatively mature system in COVID-19 prevention and control in China, USTC has arranged the returning of undergraduate students from 17 August 2020. As of 16 September 2020, no COVID-19 cases were found among these school students. Therefore, a complete reopening of universities and colleges in low-risk regions may also be safe.

## **Limitation of this study**

This study has several limitations. Firstly, this was a single-centre study and thus the results may not be generalised to other regions of China. The strategies used in each universities and colleges may vary but are all based on the technical plan released by Chinese National Health Commission and Chinese Ministry of Education.[12] Moreover, there have been no official reports on COVID-19 outbreaks in universities and colleges in China, suggesting a similar situation across schools in China. Secondly, the success of the combined strategy for safely reopening of universities and colleges in a low-risk region of China may not be generalised to other countries. In the United States and Brazil where new COVID-19 cases are rapidly growing, we are uncertain about either the effect or the feasibility of our strategy for COVID-19 prevention and control. Thus, more strict strategies for reopening universities and colleges need to be developed and testified for high-risk regions.

## **Conclusion**

Using a combined strategy for COVID-19 prevention and control, safely reopening of universities and colleges in low-risk regions is possible and laboratory screening for SARS-CoV-2 infections among students may not be necessary. Further studies need to cautiously evaluate the safety of reopening schools, if any, in middle- and high-risk regions.

# List Of Abbreviations

COVID-19: coronavirus disease 2019

RBD: receptor-binding domain

RLU: relative light units

SD: standard deviation

RT-PCR: real-time reverse transcription-polymerase chain reaction

SARS-CoV-2: severe acute respiratory syndrome coronavirus 2

UNESCO: the UN Educational, Scientific and Cultural Organization

USTC: the University of Science and Technology of China

## Declarations

**Ethics approval and consent to participate:** Research Ethics Commissions of the First Affiliated Hospital of USTC, and all participants who participated the online survey provided informed consent. Informed consent of other participants was waived since we only collected and reported their summary data.

**Consent for publication:** All authors approved the final version of this manuscript.

**Availability of data and materials:** All data generated or analysed during this study are included in this published article.

**Competing interests:** The authors declare no competing interests.

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**Authors contributions:** JW had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis. Study design: GC and JW. Analysis and interpretation of data: All authors. Manuscript preparation and approval: All authors.

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## Tables

**Table 1. Results of SARS-CoV-2 and specific antibody tests.**

	Number
Overall	13116
SARS-CoV-2 nucleic acid tests <sup>a</sup>	
Total	4095
Positive tests <sup>b</sup>	0
Specific antibody tests <sup>a</sup>	
Total	9049
Positive tests <sup>c</sup>	28
IgM	222
IgG	44
IgA	52

<sup>a</sup> 28 participants with positive antibody tests further conducted SARS-CoV-2 nucleic acid tests.

<sup>b</sup> A positive SARS-CoV-2 nucleic acid test was defined as a Ct value  $\leq 38$ .

<sup>c</sup> A positive antibody test was defined as one positive antibody (i.e. relative light units greater than the cut-off values at 42000, 15000, and 45000 for IgM, IgG, and IgA, respectively) plus another antibody with relative light units greater than 2/3 of its corresponding cut-off value.

**Table 2.** Demographic and clinical characteristics of study participants.

	Data (n=5741)
Age, year, mean (standard deviation)	25.1 (2.5)
Sex	
Male	3751 (65.3%)
Female	1990 (34.7%)
Occupation	
Postgraduate students	5573 (97.1%)
Staffs	168 (2.9%)
Current smoker	104 (1.8%)
Had a yellow or red health code <sup>a</sup>	57 (1.0%)
Epidemiology history	
Lived in high-risk regions <sup>b</sup>	
No	5580 (97.2%)
Yes	22 (2.4%)
Not sure	22 (0.4%)
Travelled in high-risk regions <sup>b</sup>	
No	5171 (90.1%)
Yes	552 (9.6%)
Not sure	18 (0.3%)
High-risk exposure <sup>c</sup>	
No	5243 (91.3%)
Yes	478 (8.3%)
Not sure	20 (0.4%)
Contacted wild animals	
No	5667 (98.7%)
Yes	31 (0.5%)
Not sure	43 (0.8%)
Went to a fever clinic	

No	5543 (96.6%)
Yes	162 (2.8%)
Not sure	36 (0.6%)
Symptoms	
Any symptom	423 (7.4%)
Fever (temperature $\geq 37.3^{\circ}\text{C}$ )	138 (2.4%)
Cough	166 (2.9%)
Sputum	64 (1.1%)
Dyspnoea (>30 breaths/minuter)	5 (0.1%)
Fatigue or muscle pain	38 (0.7%)
Headache	95 (1.7%)
Diarrhoea	159 (2.8%)
Comorbidities	
Hypertension	31 (0.5%)
Diabetes	9 (0.2%)
Chronic pulmonary disease	85 (1.5%)
Chronic kidney disease	10 (0.2%)
COVID-19 tests	
SARS-CoV-2 nucleic acid tests	1772 (30.9%)
Antibody tests	3572 (62.2%)
Both tests	397 (6.9%)

<sup>a</sup> A yellow health code indicates a history of close contact with COVID-19 cases within 14 days, and a red code indicates a confirmed or suspected COVID-19 case based on laboratory or clinical diagnosis.

<sup>b</sup> High-risk regions were classified according to the Chinese National Health Commission (<http://bmfw.www.gov.cn/yqfxdjcx/index.html> [in Chinese]), and all countries and regions outside mainland China were considered high-risk.

<sup>c</sup> High-risk exposure indicates any contacts with COVID-19 cases, overseas returnees, or people processing imported frozen meat or seafoods.

Data are shown as number (%) unless specified otherwise.

