



COVID-19 and schools: what is the risk of contagion? Results of a rapid-antigen-test-based screening campaign in Florence, Italy



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ARTICLE INFO

Article history:

Received 11 May 2021

Revised 10 September 2021

Accepted 15 September 2021

Keywords:

COVID-19

Swab

Molecular test

Schools

Screening

Children

Teachers

Florence

Italy

ABSTRACT

Introduction: In the coronavirus disease 2019 era, debate around the risk of contagion in school is intense in Italy. The Department of Welfare and Health of Florence promoted a screening campaign with rapid antigen tests for all students and school personnel. The aim of this study was to assess the circulation of severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2) in the school setting by means of mass screening in every primary and middle school in Florence.

Methods: All students and school personnel at primary and middle schools in Florence were asked to take part. The campaign started on 16 November 2020 and was completed on 12 February 2021. If a subject had a positive result on rapid antigen testing, a molecular test was performed to confirm the result.

Results: In total, 18,414 subjects were tested: 15,233 students (82.7%) and 3181 school personnel (17.3%). The rapid antigen test gave a positive result in 27 cases (0.15%). Of these, only 14 tests were confirmed to be positive on molecular testing. These results show a very low number of cases of SARS-CoV-2 among the study subjects (0.08%).

Conclusions: These results show that the spread of SARS-CoV-2 in the school setting was low in Florence during the screening period.

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Introduction

On 11 March 2020, the World Health Organization declared the outbreak of severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2) as a pandemic (World Health Organization, 2020). Even before this announcement, many countries had imposed restrictions on citizens to limit spread of the virus. The main measures taken were the promotion of physical distancing; the closure of borders between different regions; the cancellation of public events; and the closure of schools, universities and other edu-

cational institutions. Italy was one of the first Western countries to be severely affected by the pandemic, and the region of Tuscany was mildly affected during the first wave (Lastrucci et al., 2021). In the Province of Prato in May 2020, the seroprevalence of SARS-CoV-2 antibodies in a representative sample of health-care workers, people involved in essential support services and people who worked from home were 4.1%, 1.4% and 1.0%, respectively (Lastrucci et al., 2020). As part of the containment measures for the coronavirus disease 2019 (COVID-19) pandemic, the Italian Government announced complete closure of all schools and educational facilities on 4 March 2020 (Decree of the President of the Council of Ministers, 2020), and they remained closed until the end of the school year which usually corresponds with the beginning of the summer season. The re-opening of schools in Italy was ap-

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proved for the beginning of the new school year (2020–21) on 14 September 2020. Despite some regions deciding to postpone the date of reopening, most regions, including Tuscany, allowed schools to open on that date. With the re-opening of schools, several rules were introduced and adopted by students and school personnel, such as the mandatory use of facemasks, social distancing, minimal interaction between classes, and staggered entrance times among different classes and schools. Moreover, any student or member of school personnel who had a fever (temperature $>37.5^{\circ}\text{C}$) or presented any flu-like symptoms or any other symptoms consistent with COVID-19 was not allowed to go to school and had to be tested for SARS-CoV-2. In the case of a positive test result, the whole class had to be quarantined (Ministry of Health, n.d.). On 13 November 2020, Tuscany was declared a 'red zone' and, according to the regulations of that period, high schools (for students aged 14–19 years) and second- and third-year classes at middle schools (for students aged 12–13 years) were closed (Ministry of Health, 2020). Therefore, from mid-November 2020, only primary school students and students in the first year at middle school (students aged 5–11) were attending classes in school. This situation lasted until 11 January 2021 when Tuscany was declared a 'yellow zone' (Ministry of Health, 2021). Subsequently, middle schools were fully re-opened for second- and third-year classes, in addition to the students in first-year classes, while high schools remained closed.

In order to keep schools safe, to monitor the spread of SARS-CoV-2 in schools in Florence (Tuscany), and to evaluate the preventive measures adopted, the Department of Welfare and Health ('Assessorato al Welfare e sanità, accoglienza e integrazione') of the City of Florence promoted mass screening with rapid antigen tests for all students and school personnel, who were asked to participate on a voluntary basis. The aim of this study was to assess the circulation of SARS-CoV-2 in the school setting by means of mass screening from November 2020 to February 2021 in every primary and middle school in Florence.

Methods

Mass screening

The mass screening, promoted by the Department of Welfare and Health of the City of Florence, involved every primary and middle school in the city. It commenced on 16 November 2020 and was completed on 12 February 2021. Participation in screening was not mandatory for students or school personnel; only those who had previously presented a signed informed consent form were allowed to participate in the screening and be tested. Informed consent forms for the students had to be signed by a parent or a legal guardian because they were minors.

During the screening period, some school classes were under quarantine after a previous finding of a case of SARS-CoV-2 infection and, as a consequence, those classes with a higher probability of having cases of infection were not subjected to the screening process.

Screening was first conducted on first-year students at middle schools, and then continued with primary school students. Second- and third-year students at middle schools were involved in screening after they returned to school on 11 January 2021. Therefore, in summary, first-year students at middle schools were screened between 16 November 2020 and 3 December 2020, primary school students were screened between 4 December 2020 and 12th February 2021, and second- and third-year students at middle schools were screened between 11 January 2021 and 9 February 2021. Each time the students at a school were tested, the school personnel (teachers and all other workers) who were working that day were also tested. Consequently, as some teachers/other workers work

in more than one school, and as middle schools were involved in screening on at least two different dates (first-year students at middle schools were tested in November and December 2020, second- and third-year students at middle schools were tested in January and February 2021), some school personnel were tested twice.

Rapid antigen tests for SARS-CoV-2 were performed by teams composed of medical doctors and nurses. The organization and implementation of screening at the schools were managed by medical doctor residents in hygiene and preventive medicine at the University of Florence, and by members of the Department of Welfare and Health of the City of Florence. All members of the team worked together to draft the protocol in advance, before beginning the screening campaign, in order to have a standardized process for testing and isolation that had been shared and approved by all the subjects who were to take part of the project. The protocol and date of testing were communicated to the director of each school well in advance in order to give enough time to prepare the school personnel, and collect the signed informed consent forms that had been provided to families previously.

Each school director decided the location within the school for performing the tests, and this was approved by the public health physicians present at the time. Often, the school gym was chosen for performing the tests as this was the most spacious area available. Classes were tested one at a time, and all students from each class were asked to wait for 15 min after the last student of the class had been tested before returning to their classroom. The waiting period took place in spacious selected areas or rooms where the students and school personnel could keep a suitable distance from each other. School personnel were tested after screening of the students had been concluded. The name of each student tested was written on their test, and a selected member of school personnel took a photograph of each test 15 min after it had been carried out using a smart device provided by the school director. In this way, photographs of each test were saved and stored by the school directors.

Students and school personnel were tested with the Coronavirus Ag Rapid Test Cassette (Swab). This is an in-vitro immunochromatographic assay for the qualitative detection of nucleocapsid protein antigen from SARS-CoV-2 in nasopharyngeal swab specimens directly or after the swabs have been added to viral transport media from individuals who are suspected to have COVID-19 (Menarini Diagnostics, n.d.). In all cases, it was ascertained that the test was valid (according to the package insert of the swab), and invalid tests were repeated.

Each time a test gave a positive result in 15 min, it was checked by the other public health physicians present at the time; if the positive result was confirmed, the person was immediately isolated in a previously selected room called the 'COVID room'. If the person with a positive result was a student, the school director contacted their parents, and asked them to take the student to a selected local health unit where the student was tested with a polymerase chain reaction (PCR) test for SARS-CoV-2 to confirm the result of the rapid antigen test. If the parents were not available to come to the school immediately, the student was isolated, tested with a PCR test in the COVID room by the healthcare workers present at the time, and the test was taken to the laboratory to be examined. The student was asked to wait in the COVID room until their parents could come to take them home. When the person who tested positive during screening was an adult, he or she was asked to use a KN95, FFP2 or FFP3 mask, and to go, using his/her own means, to the selected local health unit for PCR testing. Each time an individual had a positive result on a PCR test, he/she was taken over by the authority of the local prevention unit in the same way as any other citizen who had tested positive for SARS-CoV-2.

Table 1
Distribution of subjects by comprehensive institution.

Comprehensive district	No. of schools	n (% of total) Students	School personnel
1	3	581 (3.8%)	142 (4.5%)
2	3	800 (5.3%)	156 (4.9%)
3	1	324 (2.1%)	64 (2.0%)
4	3	464 (3.0%)	150 (4.7%)
5	1	820 (5.4%)	168 (5.3%)
6	2	875 (5.7%)	138 (4.3%)
7	4	781 (5.1%)	115 (3.6%)
8	4	720 (4.7%)	100 (3.1%)
9	5	564 (3.7%)	104 (3.3%)
10	2	442 (2.9%)	114 (3.6%)
11	3	818 (5.4%)	190 (6.0%)
12	3	544 (3.6%)	136 (4.3%)
13	4	688 (4.5%)	185 (5.8%)
14	4	807 (5.3%)	121 (3.8%)
15	3	545 (3.6%)	124 (3.9%)
16	4	594 (3.9%)	118 (3.7%)
17	4	675 (4.4%)	158 (5.0%)
18	4	601 (3.9%)	130 (4.1%)
19	3	515 (3.4%)	123 (3.9%)
20	4	509 (3.3%)	138 (4.3%)
21	2	682 (4.5%)	140 (4.4%)
22	3	641 (4.2%)	88 (2.8%)
23	2	742 (4.9%)	153 (4.8%)
24	4	501 (3.3%)	126 (4.0%)
Total	75	15,233 (100%)	3181 (100%)

Analysis

For the subjects who participated in screening, in addition to personal data, information about the school, class (in case of students), date of the test, and test result were collected. These data were entered into a Microsoft Excel database and made anonymous. After that, a descriptive analysis of the data was carried out. Data are presented as mean [standard deviation (SD)] or percentage, as appropriate. The analysis was conducted using Microsoft Excel Version 16.46 and Jamovi Version 1.6.15.0 (Jamovi Project, 2021).

Results

The screening involved 75 schools from 24 comprehensive institutions. In total, 18,414 subjects were tested: 15,233 students (82.7%) and 3181 school personnel (17.3%) (Table 1). The screening test was offered to 21,515 students; therefore, 6282 (29.2%) students either were not at school on the day of screening or refused to participate in the study.

For some subjects, it was not possible to collect data such as sex, age or class attended.

Specifically, information regarding age was available for 13,469 students (1764 missing values, 11.6%) and 2101 school personnel (1080 missing values, 34%).

Regarding sex, data were missing for 2140 (14.0%) students and 558 (17.5%) school personnel. Class attended was not available for a very small number of students (1.2%).

Of the 13,093 students for whom information about sex was available, 52% (6802) were male and 48% (6291) were female. For school personnel, 14% were male (368) and 86% were female (2255) (Figure 1).

Data relating to both sex and age were available for 85.9% of students (13,092/15,233) and 65.3% of school personnel (2077/3181).

Almost all students were aged between 6 and 14 years, and the average age was 10.0 years (SD 2.3). The mean age of school personnel was 47.4 years (SD 10.5).

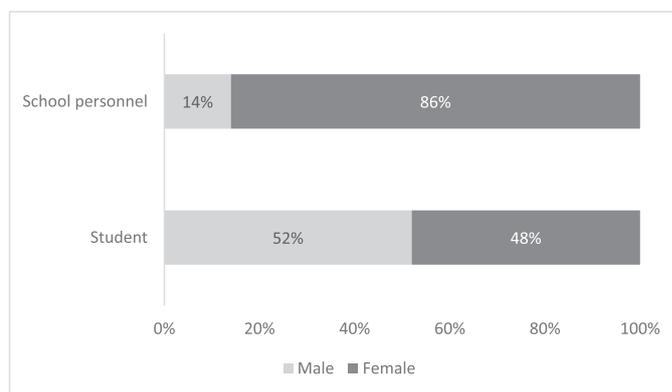
**Figure 1.** Percentage of male and female subjects.

Table 2 shows all the descriptors of the age variable, including the group of subjects with information about age and sex.

Figures 2 and 3 illustrate the distributions of the two samples by sex and age.

Fifty-six percent (8444/15,052) of tested students attended primary school, while 43.8% (6590/15,052) attended middle school. Table 3 shows a distribution of the number of students by class.

Screening tests were performed between November 2020 and February 2021. The two months of greatest activity were December 2020 and January 2021, when most of the students (76.3%) and school personnel (75.9%) were tested (Table 4).

Almost all screening tests were negative. In 27 cases (0.15% of people tested), the swab gave a positive result. Of these, 14 (48.1%) positive rapid antigen tests were confirmed as positive by molecular testing. Figure 4 shows the results for students and school personnel. Six confirmed cases were identified in December 2020, with four, three and one confirmed cases identified in November 2020, January 2021 and February 2021, respectively.

Discussion

Debate around the COVID-19 pandemic is still intense. Re-opening restaurants and shops (Zhong, 2021), finding the balance between the economy and safety (Adolph et al., 2021), the spread of fake news (Moscadelli et al., 2020), and the safe re-opening of schools are some of the greatest challenges that governments are facing. This study found that, at least in the considered period, the circulation of SARS-CoV-2 among pupils at primary and secondary schools in Florence was fairly low: 15,233 students (mainly aged 6–14 years) and 3181 school personnel were tested through a rapid-antigen-test-based screening campaign, and a very small number of SARS-CoV-2 cases were identified (0.08%).

These findings suggest a relatively low risk of being infected at school: in the local health unit in Tuscany, the mean daily number of new cases of SARS-CoV-2 infection was 19.7 per 100,000 during the period of interest (16 November 2020 to 12 February 2021) (ARS TOSCANA Local Health Agency, n.d.). Despite some evidence of outbreaks arising after the re-opening of schools, such as in Israel 10 days after the re-opening of a high school (Stein-Zamir et al., 2020), the present results agree with several studies that have shown lower risk of infection at school. Other evidence from Italy shows that, despite few cases of secondary infection occurring in school, the incidence of SARS-CoV-2 infection among students was lower than in the general population (Gandini et al., 2021). According to a systematic review conducted in the UK, children and adolescents aged <20 years have 44% lower odds of secondary infection, and this relationship is stronger in children aged 10–14 years (Viner et al., 2021). Another US study found that children are rarely an index case within family clusters of infec-

Table 2

Descriptors of the age variable relative to total subjects with information about age and the group of subjects with information about age and sex.

	Total subjects with information about age		Subjects with information about age and sex			
	Student	School personnel	Student Male	Female	School personnel Male	Female
<i>n</i>	13,469	2101	6802	6290	287	1790
Mean	10	47.4	9.9	9.9	44.3	47.9
Median	10	48	10	10	44	49
Standard deviation	2.3	10.5	2.3	2.3	10.1	10.5
Interquartile range	4	16	4	4	14	15
Range	11	53	9	11	43	53
Minimum	5	22	6	5	24	22
Maximum	16	75	15	16	67	75

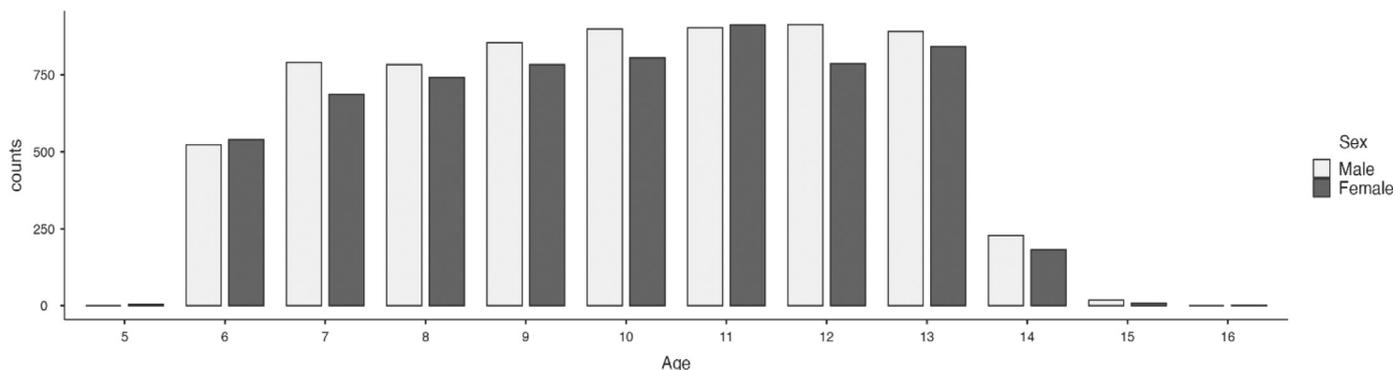


Figure 2. Distribution of students by age and gender (n=13,092).

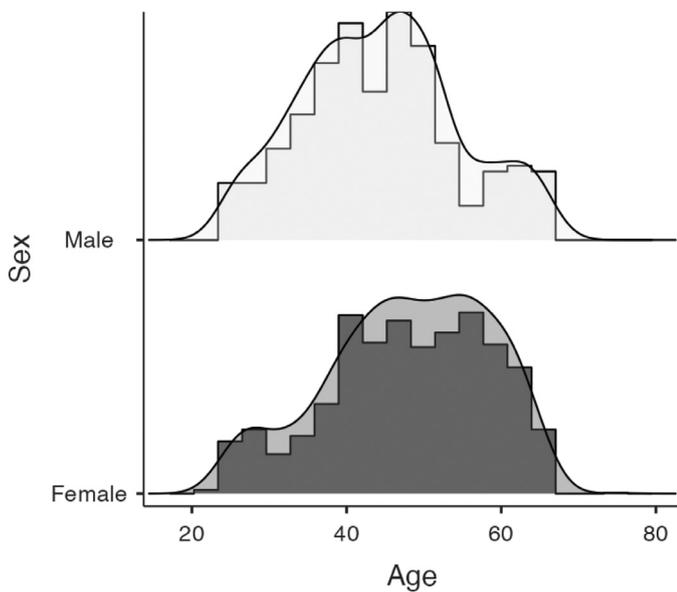


Figure 3. Distribution of school personnel by age and gender (n=2077).

Table 3

Number and percentage of students by class.

School	Class	<i>n</i>	% of total	Cumulative %
Primary school	1	1498	10.0	10.0
	2	1604	10.7	20.6
	3	1744	11.6	32.2
	4	1752	11.6	43.8
	5	1846	12.3	56.1
Middle school	1	2192	14.6	70.7
	2	2223	14.7	85.4
	3	2193	14.5	100.0

Table 4

Number of monthly tests performed during the screening period in school personnel and students.

Month	<i>n</i> (% of total) Students	School personnel	Total subjects
November 2020	900 (5.9%)	335 (10.5%)	1235 (6.7%)
December 2020	5834 (38.3%)	1201 (37.8%)	7035 (38.2%)
January 2021	5784 (38.0%)	1213 (38.1%)	6997 (38.0%)
February 2021	2715 (17.8%)	432 (13.6%)	3147 (17.1%)
Total	15,233 (100.0%)	3181 (100.0%)	18,414 (100.0%)

tion, although they certainly play a role in the transmission of the virus and have high viral loads even though they are often asymptomatic (Ludvigsson and Jonas, 2020). Contact tracing data in China appears to show that children become infected at a similar rate as adults within households, but are less likely to become symptomatic (Bi et al., 2020). However, subsequent data seem to demonstrate that children are less susceptible than adults to SARS-CoV-2 infection. Other data from China (Jing et al., 2020) demonstrate significantly lower odds ratios (ORs) of infection in children within households, confirmed by subsequent data from the Netherlands (including testing with serology) (Van Der Hoek et al., 2020).

In the screening campaign presented in this study, cases of infection were rare and never represented a cluster distribution. The students who tested positive for SARS-CoV-2 may have been infected outside or within the family. Among school personnel, there were very few cases, and this may be a sign that the likelihood of contracting the infection at school is low when the necessary hygiene rules (handwashing, social distancing, use of facemasks) and preventive strategies (not allowing symptomatic people to enter the school, quarantining whole classes after identification of a case of infection) are respected. A study undertaken in France shows that even among symptomatic children, the transmission of the virus is low (Fontanet et al., 2020), and a similar study in Ireland undertaken before the closure of primary schools (before

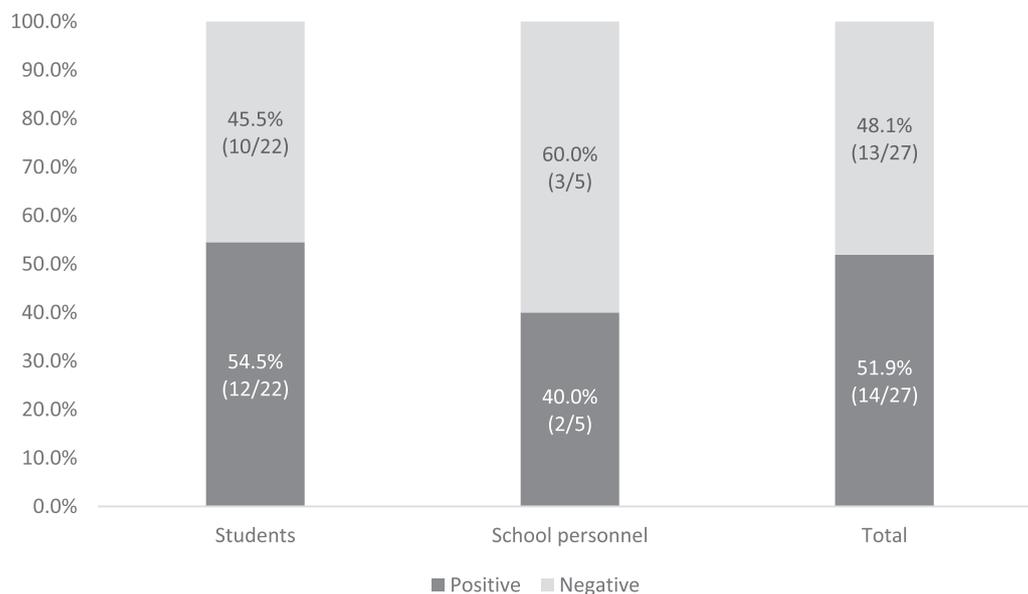


Figure 4. Molecular test results (positive/negative) of the subjects who had a positive result on rapid antigen testing. Percentages and ratios (n/N) are shown in the columns.

12 March 2020) showed no evidence of infection among school children (Heavey et al., 2020). A German study reported similar findings, and stated that the closure of schools for long periods can have detrimental effects on the psychological well-being of the pupils. These similar results suggest that school closures do not lead to effective control of viral transmission, avoiding 2–4% of deaths, which is a much lower percentage than that for the implementation of social distancing and hygiene strategies (handwashing) (Viner et al., 2020). Moreover, school closures in Japan did not show any mitigating effect on the transmission of SARS-CoV-2 infection (Iwata et al., 2020).

This study has some important strengths. Recruitment of a large sample of pupils and school personnel allows generalization of the results. The test used in the screening campaign – a rapid antigen test using nasopharyngeal swabs – is fast, low cost and easy to execute. In addition, in the event of a positive or doubtful test result, a molecular PCR swab test was performed to confirm the test result.

This study also has some limitations. First, no data are available for the subjects who did not take part in the screening campaign; therefore, selection bias cannot be excluded. Second, inter-operator variability could have affected the results as test reading is user dependent and several different operators performed this task, although all operators who participated in the study had been trained in reading the test results. Finally, there was no way of determining if there were false-negative results.

In conclusion, this study adds to the ongoing debate on SARS-CoV-2 and school re-opening and closures, which remains a matter of discussion. It is hoped that the findings will be useful when making decisions in the upcoming school year.

Acknowledgements

The authors wish to thank Sara Funaro, Beatrice Benedetti and Michele Minicucci from the Department of Welfare and Health of the City of Florence for support.

Funding

None.

Conflict of interest statement

None declared.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.ijid.2021.09.027.

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