Analysis of a direct access testing system for the detection of SARS-CoV-2 in the paediatric population attending school

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April 16, 2024

Abstract

Abstract Rationale, aims and objectives During the COVID-19 pandemic, in order to keep schools open and reduce SARS-CoV spreading, it is necessary to identify and isolate early SARS-CoV-2 positive paediatric patients (PP). The aim of this study was to describe the appropriateness of school hot spot (HS) setting for SARS-CoV 2 testing based on open access of PP. Method A cross-sectional study was performed between September 2020 and March 2021 among a sample of 13,283 PP in four different hospital settings. We collected: date of swab execution, type of swab, execution setting of the swab, result of the swab, information about community spread of the virus in the 14 days prior to the swab execution, sex and age. Results In Our sample, females were 45.8%. The swabs executed in all the hospital settings had a lower likelihood of resulting positive compared with the school HS setting. New-borns below 3 months and patients aged between 11 and 13 years old reported a higher probability of a swab tested positive compared to adolescents. Instead, children aged between 3 months and 2 years and aged between 3 years and 5 years were less likely to result positive. Conclusion We found a high prevalence of PP positive to the test for the detection of SARS-CoV-2 at the school hot spot compared with other settings. The open access modality to the nasopharyngeal swab was effective in identifying PP with COVID-19. Public health authorities should implement these testing modality in order to reduce SARS-CoV-2 infections in school settings.

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Analysis of a direct access testing system for the detection of SARS-CoV-2 in the paediatric population attending school

Short title

Direct testing system for paediatric patients

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Abstract

Rationale, aims and objectives

During the COVID-19 pandemic, in order to keep schools open and reduce SARS-CoV spreading, it is necessary to identify and isolate early SARS-CoV-2 positive paediatric patients (PP). The aim of this study was to describe the appropriateness of school hot spot (HS) setting for SARS-CoV 2 testing based on open access of PP.

Method

A cross-sectional study was performed between September 2020 and March 2021 among a sample of 13,283 PP in four different hospital settings. We collected: date of swab execution, type of swab, execution setting of the swab, result of the swab, information about community spread of the virus in the 14 days prior to the swab execution, sex and age.

Results

In Our sample, females were 45.8%. The swabs executed in all the hospital settings had a lower likelihood of resulting positive compared with the school HS setting. New-borns below 3 months and patients aged between 11 and 13 years old reported a higher probability of a swab tested positive compared to adolescents. Instead, children aged between 3 months and 2 years and aged between 3 years and 5 years were less likely to result positive.

Conclusion

We found a high prevalence of PP positive to the test for the detection of SARS-CoV-2 at the school hot spot compared with other settings. The open access modality to the nasopharyngeal swab was effective in identifying PP with COVID-19. Public health authorities should implement these testing modality in order to reduce SARS-CoV-2 infections in school settings.

Keywords

COVID-19; SARS-CoV-2; school health; paediatric; nasopharyngeal swab

Introduction

COVID-19 epidemic spread out rapidly since its initial outbreak in China, forcing the World Health Organization (WHO) to declare the state of global pandemic on March 2020[1]. Children and adolescents represented less than 13% of the COVID-19 cases confirmed in Europe between August and November 2020[2]. Children tend to have a mild infection and 15-35% can be asymptomatic[3] reaching out to a lower number of hospitalizations or fatal outcomes than adults[4]. In Italy, on August 2021, the 15.8% of total COVID-19 cases diagnosed involved children aged 0-19 years old[5]. In particular, all case patients aged <18 years since the loosening of the first lockdown (4th May 2020), the majority of diagnosed cases occurred in adolescents aged 13-17 years (41.3%), followed by children aged 7-12 years (28.0%), 2-6 years (21.0%) and 0-1 year (7%). The hospitalisation rate was 4.8%, with the highest percentage of hospital admissions in infants aged [?]1 year (16.2%)[6].

Moreover, many studies suggest that the paediatric population is a minor contributor to the spread of the virus, but it remains open to debate what proportion of this population may contribute to silent contamination[7]. However, it is possible that these data are affected by an underestimation due to the higher rate of asymptomaticity and milder symptoms in children which makes the manifestation of the infection difficult to recognise[8]. Indeed, from the above-mentioned surveillance data[6], it is difficult to tell whether children under 12 years of age are less likely to be infected or whether it is simply more complicated to identify positive cases due to a mostly asymptomatic presentation. In addition, the possible underestimation in the identification of paediatric SARS-CoV2 positive patients may also have been influenced by inadequate testing capacity or a lack of effort to recruit this population group, justified by a lower frequency of adverse consequences compared with adults and the elderly.[2] In particular, the lack of efficiency in tracking systems and the possible limited availability of diagnostic tests are likely to reduce the contact notification rate in the school context, in which, following the identification of SARS-CoV-2 positive individuals, an effective contact tracing strategy should be applied together with the administration of appropriate diagnostic tests to identify possible transmission.[2] Indeed, the European Centre for Disease Prevention and Control (ECDC) recommends that in the general population a major effort should be made to offer diagnostic tests to the majority of asymptomatic cases to ensure timely isolation and adequate contact tracing.[9]

Last, to explore the characteristics of the SARS-CoV-2 infection among the paediatric population and the issue of asymptomaticity, studies about the seroprevalence[10] reported respectively that only 47% and 60% of the paediatric population tested positive for the presence of SARS-CoV2 antibodies complained of symptoms in accordance with the development of infection.

Thus, in the school context, in line with the above-described data, the preventive measures implemented by most of countries in case of a suspected case agree that the student should self-isolate until a healthcare provider prescribes a test or decides that the student is not a suspected case[11]. Focusing on Italy, the various scenarios in which paediatric patients need to undergo one of the diagnostic procedures to detect SARS-CoV2 positivity always require the intermediation of a general practitioner (GP) or a paediatrician[12]. As far as we know, no one tried to investigate a different kind of setting as a valid alternative of testing in the paediatric population. The aim of this study was to describe a setting for SARS-CoV 2 testing based on the spontaneous presentation of paediatric patients without a medical prescription and explore its appropriateness.

Methods

Context and setting

The *Azienda Ospedaliero-Universitaria (AOU) "Citta della Salute e della Scienza"* in Turin (Piedmont region, Italy) constitutes one of the largest health care centres in Europe[13]. Inside the AOU, the "Ospedale Infantile Regina Margherita" (OIRM) is a paediatric Hospital that seeks to prevent, diagnose and treat children's diseases. The hospital has surgical and medical specialties for the treatment of infants, children and adolescents in the Piedmont region[14]. On 14th September 2020, a nasopharyngeal molecular swab[3,15] execution centre for SARS-CoV-2 detection was opened at OIRM. This centre, called school hot spot (HS), was designed with the aim of quickly providing SARS-CoV-2 tests to school-age children. Patients accessed to the service sent by their GP or spontaneously if they referred to having symptoms of COVID-19[16] or reported close contact with a positive patient according to ECDC guidelines[17]. The HS was open from Monday to Saturday from 10.30 am to 3.00 pm and on Sunday 10.30 am to 01.00 pm.

Children entered the HS accompanied by a parent or a legal guardian and a paediatric nurse performed nasopharyngeal swabs. Access to the HS was free for all and no medical prescriptions were required.

In addition, at the OIRM, in the emergency room, SARS-CoV-2 nasopharyngeal swabs are performed on all paediatric patients who reported COVID-19 symptoms[16] or contact with COVID-19 positive patients in the previous 14 days in agreement with ECDC general guidance for management of persons who have had contact with COVID-19 cases[17,18]. Furthermore, patients admitted to the hospital wards, even in day hospital (DH), are subjected to a swab for the detection of SARS-CoV-2 before hospital admission.

To understand and comment the different risk of exposure to SARS-CoV-2, the percentage of distance learning activities in the various age groups appears to be an important information. Thus, to give context, Table 1 describes the percentages of distance learning activities in schools divided by date and age group.

Data collection

The present paper describes a cross-sectional study performed between 14th September 2020 and 18th March 2021 among a sample of 13,283 paediatric patients (aged 0-19 years) who underwent a swab at OIRM in four different hospital settings (HS, Emergency department, DH setting and hospital wards). The data collection ended on 18th March because the number of daily swabs had been significantly reduced due to the improvement of the epidemiological situation of SARS-CoV-2 infections. Hospital wards include COVID-19 ward where positive COVID-19 paediatric patients were hospitalized. Each record represented a unique patient as we considered only the first swab performed at the OIRM for each patient.

Two types of test on nasopharyngeal swabs were analysed: nucleic acid amplification test (NAAT), also called molecular test, and detection of virus-specific antigens by rapid antigen detection tests (RADTs), also called rapid test[19].

The data collected included: date of swab execution, type of swab (NAAT or RADTs), execution setting of the swab (HS, emergency department, DH setting and hospital wards, result of the swab (positive, negative or indeterminate), sex and age of the paediatric patients.

Last, since the effective reproductive number (Rt), defined as averages of the number of people infected by a typical case at any given moment, play a central role in tracking infectious disease outbreaks, we recorded, for each swab performed, the mean value of the Rt in the Piedmont region calculated in the 14 days prior to the date of execution of the swab[20]. The Rt values were collected from the weekly reports of the Italian ministry of health[21–23].

Statistical analysis

Descriptive analyses were performed for all variables. Age was categorized in 6 age groups according to the degree of school. In Italy, children less than three months old do not attend any type of school, children from 3 months to 2 years old attend the day nursery school, children from 3 to 5 years old attend kindergarten school, children between 6 and 10 years old attend primary school, children from 11 to 13 years old attend junior secondary school and children from 14 to 19 years old attend secondary school.

To further describe the activity of the HS, descriptive statistics of the variables were stratified by setting and chi-squared tests and adjusted residuals (Kruskall Wallis test where appropriate) were calculated.

Multivariable logistic regression models were carried out to understand if children accessing the HS were more likely to be positive compared with children accessing the other settings.

SPSS statistics (v27) was used and a two-tailed p-value < 0.05 was considered significant. Missing values were excluded.

Results

A total of 13,283 paediatric patients were included in our analysis. Females accounted for 45.8%. The median age was 6.8 years (IQR 3.0-11.2) and the most frequent age category was between 6 and 10 years (27.9%). The HS was the most frequent setting (66.9%), followed by the emergency department (20.9%). The overwhelming majority of the swabs were executed as NAAT (96.3%). Overall, 1,422 tested positive (10.7%), 11,771 tested negative (88.6%), 90 were indeterminate or missing (0.7%). The mean of pooled Rt in the 14 days preceding the swab had a median of 1.18 (IQR=0.90-1.37), with a minimum of 0.68 in December 2020 and a maximum of 2.16 in October 2020.

According to the chi-square tests, the swabs tested positive more frequently among children above 6 years of age. The HS was the setting that presented the higher percentage of positive swabs (Table 2). In addition, the mean of pooled Rt in the 14 days preceding the swab had a different distribution across the swabs' results

(Mann Whitney U test: <0.001), with a median of 1.31 (IQR=0.98-1.83) for children with a positive swab and a median of 1.18 (IQR=0.90-1.37) for those with a negative swab.

Focusing on the HS, females accounted for 53.6% and the most frequent age category was between 6 and 10 years old (31.6%). Compared with the other settings, the children and adolescents who accessed the HS were more frequently male and aged between 3 years and 13 years (Table 3). In addition, the mean of pooled Rt in the 14 days preceding the swab had a different distribution across the settings (Kruskall Wallis test p<0.001). Indeed, pairwise comparisons showed a different distribution of the Rt in the 14 days preceding the swab for the swab executed in the school hotspot setting (median 1.22, IQR 0.96-1.39) compared with the other settings (emergency department: median 1.05, IQR 0.89-1.31; DH: median 1.05, IQR 0.89-1.31; hospital wards: median 1.05, IQR 0.89-1.31). Last, Table 4 shows the multivariable models with a swab tested positive as outcome. The swabs executed in all the settings had a lower likelihood of resulting positive compared with the HS setting. Compared with adolescents aged between 14 and 19 years old, new-borns below 3 months and patients aged between 11 and 13 years old reported a higher probability of a swab tested positive. Instead, children aged between 3 months and 2 years and children aged between 3 and 5 years were less likely to result positive. The higher was the mean of pooled Rt in the 14 days preceding the swab, the higher was the likelihood of resulting positive. Compared with children who received the NAAT, those who received the RADT were less likely to test positive. Figure 1 shows the total number of swabs per week and number of swabs that tested positive per week (only school hotspot setting).

Discussion

The aim of this study was to explore an organisational mode (the "school hot spot") for SARS-CoV-2 testing based on the spontaneous presentation of paediatric patients by analysing the results of tests for SARS-CoV-2 carried out in the HS and comparing these results with SARS-CoV-2 tests performed in other paediatric hospital settings.

We found that the age group from 6 to 10 years attended school more in presence than older children (Ordinance n. 112, 20/10/2020)[24] and, therefore, may have more chances of contagion and consequently may be more likely to be tested[25]. In addition, we found that sex was not associated with a higher probability of being tested in paediatric population, as reported in the literature[25]. In our sample, the swabs tested positive more frequently among children in the age group between 11 and 13 years. This might be partially explained by the fact that, in Italy, these group of children attended face to face school more than older children[24] and are more likely to be swabbed[26,27].

Compared with other settings, the HS was probably frequented more by children attending face-to-face learning compared with older ones. This could be due to the fact that face-to-face learning requires more frequent testing because the probability of having contact with positive people is higher. In literature, it is known that face-to-face learning increases the risk of contagion in children[27].

We found a greater likelihood of testing positive in patients who swabbed at the HS compared with other settings. Indeed, the HS was aimed at patients with COVID-19 symptoms or with a history of close contact with a positive COVID-19 case, while the other settings had a different target population. In the emergency department, the only patients who were not tested were those who had a short outpatient visit and had no history of close contact with COVID-19 patients. In DH service, only patients who had a negative history for COVID-19 symptoms or contact with COVID-19 patients were tested, while, if the medical service was deferrable, patients with a history of COVID-19 were postponed. For this reason, in emergency department and DH, the prevalence of positive swabs was lower. Last, swabs performed in the hospital wards reported a greater probability of being positive than the DH service because they also include swabs performed in the COVID-19 ward of the paediatric hospital. Thus, we can hypothesize that the HS organizational model has been used in an appropriate manner because the probability that a COVID-19 positive patient was swabbed at the HS was higher compared with other examined settings, suggesting that patients and their families are able to understand when the swab is needed without asking a doctor or they are properly addressed by their GP or paediatrician.

Moreover, the multivariable models revealed other remarkable associations. First, in agreement with the literature[28], our study found that new-borns are more likely to become infected than other paediatric patients. Then, we found that adolescents in the 11 to 13 age group had higher probability to test positive than patients in the 14 to 19 age group. A possible explanation for this could be that this age group attended face-to-face school more frequently and, consequently, was more exposed to the infection and was tested more[27,29,30]. Surprisingly, children aged between 3 months and 2 years and children aged between 3 years and 5 years had lower probability to test positive than adolescents (14-19 years age group). Although this age group went to school for more time in presence than adolescents, COVID-19 cases are less easily identifiable because young children tend to have milder symptoms as reported in literature[11].

Understandably, children who received RADT were less likely to test positive. Indeed, this test was performed to patients only in the emergency department in case of a large influx of patients or when there was no time to wait for the result of the NAAT swab for the patient's emergency conditions.

Finally, a higher mean of pooled Rt in the 14 days preceding the swab was associated with higher probability of being positive to the swab. In line with this, as shown in Figure 1, also the proportion of swabs that tested positive and the number of total swabs performed in the HS followed the trend of the SARS-CoV-2 pandemic. As it is easy to understand, when the viral circulation is greater the probability of being symptomatic or having had contacts may also increase.

The present paper had some strengths and limitations that should be acknowledged. To the best of our knowledge, this was the first study that described a direct access testing modality for paediatric patients attending school. Furthermore, we analysed a large sample of paediatric patients spread over two waves of pandemics. However, the limitations were mainly related to the impossibility of correlating the patients' history and symptoms with the result of the tests obtained. Moreover, we do not know how many patients contacted a doctor before presenting to the school hotspot and consequently we do not know the percentage of patients who presented spontaneously.

Nevertheless, the proposal of a new strategy of testing is urgent, especially among children and adolescents. As reported in the literature, there is limited evidence of the effectiveness of school closures in containing the pandemic and, given the important health implications of school closures on young people's lives, it is important to implement preventive measures in order to reduce COVID-19 transmission and keep schools open[11]. Indeed, it is essential to test symptomatic cases and contact tracing should be initiated promptly following identification of a confirmed case in order to isolate positive patients[31]. This is even more important with the spread of the Delta variant (declared a Variant of Concern in May 2021).[32] The Delta variant is the dominant strain, characterized by a higher transmission rate.[33] Children are not vaccinated or are under-vaccinated and therefore there is an increasing number of SARS-CoV-2 cases reported.[34] Moreover, with the increasing number of infections, also cases of hospitalization among children and adolescents can increase.[34] Thus, increasing testing capacity appears necessary and the possibility of undergoing a swab for SARS-CoV-2 in direct access mode, as in our HS, could be implemented to carry out as many tests as possible[35]. Indeed, exploring this testing modality, we found a high rate of paediatric patients positive at the HS compared with other hospital testing settings (emergency department, DH and Hospital wards).

The free presentation mode can be effective in identifying a high number of positive patients but also to be able to exclude the diagnosis of COVID-19 in many paediatric patients in order to allow a quick return to school[36]. Particularly, this testing system should be aimed at older children because they are more likely to be infected in school settings[36,37]. In a context of pandemic emergency and limited medical personnel, this testing modality saves doctors who, instead of carrying out the patient history before deciding whether to carry out the nasopharyngeal swab, can devote themselves to other clinical activities. In view of the restart of face-to-face learning activities, public health authorities should implement this testing modality in order to help reduce the spread of SARS-CoV-2 in school settings.

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Acknowledgements

The authors would like to thank the Public Health residents of the University of Turin, the operators of the "school hot spot" service of the OIRM Hospital.

Conflict of interest

There are no external funding sources. All authors declare that they have no conflict of interest.

Ethical approval

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Tables

Date	**Type of learning activities**
14/09/2020	Start of the school year (face-to-face teaching activity)
27/10/2020	Start of distance learning activities in the 14-19 age group (75% of total school time)
02/11/2020	Start of total distance learning activities in the 14-19 age group (100% of total school time)
29/11/2020	Start of total distance learning activities in the 12-19 age group (100% of total school time)
23/12/2020	Start of Holidays (closed school)
07/01/2021	Opening of schools in the 6-14 age group. Beginning of total distance learning activities in the 14-19 age grou
16/01/2021	Start of partial distance learning activities in the 14-19 age group (50% of total school time)
08/03/2021	Start of total distance learning activities in the 12-19 age group (100% of total school time)
15/03/2021	Start of total distance learning activities in all age groups (100% of total school time)

Table 1. Description of learning activities in the period under examination.

Characteristic	**Overall (n=13,283) N (%)**	**Swabs' results**	**Swabs' results**	**p-value**
		Tested negative (n=11,771) N (%)	**Tested positive (n=1,422) N (%)**	
Gender				
Female	6,069 (45.8)	5,365 (89.0)	663 (11.0)	0.462
Male	7,191 (54.1)	6,385 (89.4)	757 (10.6)	
Age category				
0 to 2 months	278 (2.1)	248 (91.2)	24 (8.8)	**<0.001**
3 months to 2 years	3,031 (22.8)	2,782 (92.3)[a]	231 (7.7)[b]	
3 to 5 years	2,754 (20.7)	2519 (92.3)[a]	211 (7.7)[b]	
6 to 10 years	3,710 (27.9)	3,228 (87.3)[b]	470 (12.7)[a]	
11 to 13 years	2,206 (16.6)	1,868 (85.3)[b]	323 (14.7)[a]	
14 to 19 years	1,304 (9.8)	1,126 (87.4)[b]	163 (12.6)[a]	
Setting				

School hot spot (HS)	8,888 (66.9)	7,611 (85.9)[b]	1,245 (14.1)[a]	**<0.001**
Emergency department	2,771 (20.9)	2,609 (95.3)[a]	130 (4.7)[b]	
Day Hospital	1,248 (9.4)	1,204 (97.9)[a]	26 (2.1)[b]	
Hospital wards	376 (2.8)	347 (94.3)[a]	21 (5.7)[b]	
Type of swab				
Nucleic acid amplification test	12,787 (96.3)	11,291 (88.9)	1,412 (11.1)	**<0.001**
Rapid antigen detection test	496 (3.7)	480 (98.0)	10 (2.0)	

n=sample size

Figures are expressed as number (N) and percentages (%). Overall: column percentages. Swabs' results: row percentages.

p-value obtained via Chi-squared test.

[a] adjusted residual >1.96

[b] adjusted residual <-1.96

Table 2. Characteristics of the sample: overall and stratified by swabs' results

Characteristic	**School hot spot (HS)**				
(n=8,888)	**Emergency department**				
(n=2,771)	**Day Hospital**				
(n=1,248)	**Hospital wards**				
(n=376)	**p-value**				
	N (%)	**N (%)**	**N (%)**	**N (%)**	
Gender					
Male	4,126 (46.4)[a]	1,294 (47.0)	480 (38.5)[b]	169 (45.1)	**<0.001**
Female	4,757 (53.6)[b]	1,460 (53.0)	768 (61.5)[a]	206 (54.9)	
Age category					
0 to 2 months	13 (0.1)[b]	197 (7.1)[a]	29 (2.3)	39 (10.4)[a]	**<0.001**
3 months to 2 years	1,638 (18.4)[b]	1,087 (39.2)[a]	235 (18.8)[b]	71 (18.9)	
3 to 5 years	1,981 (22.3)[a]	448 (16.2)[b]	263 (21.1)	62 (16.5)[b]	
6 to 10 years	2,805 (31.6)[a]	513 (18.5)[b]	323 (25.9)	69 (18.4)[b]	
11 to 13 years	1,555 (17.5)[a]	384 (13.9)[b]	213 (17.1)	54 (14.4)	
14 to 19 years	896 (10.1)	142 (5.1)[b]	185 (14.8)[a]	81 (21.5)[a]	
Type of swab					
Nucleic acid amplification test	8,888 (100.0)[a]	2,297 (82.9)[b]	1,248 (100.0)[a]	3,54 (94.1)[b]	**<0.001**
Rapid antigen detection test	0 (0.0)[b]	474 (17.1)[a]	0 (0.0)[b]	22 (5.9)[a]	

n=sample size

Figures are expressed as number (N) and column percentages (%).

p-value obtained via Chi-squared test.

[a] adjusted residual >1.96

[b] adjusted residual <-1.96

Table 3. Characteristics of the sample stratified by setting

	Swab tested positive adjOR	Swab tested positive 95% CI	Swab p-valu
Gender			
Female	Ref.		
Male	0.97	0.86-1.08	0.535
Age category			
14 to 19 years	Ref.		
0 to 2 months	1.85	1.14-3	**0.012**
3 months to 2 years	0.77	0.61-0.96	**0.020**
3 to 5 years	0.66	0.53-0.83	**<0.00**
6 to 10 years	1.1	0.9-1.34	0.343
11 to 13 years	1.32	1.07-1.63	**0.009**
Setting			
School hot spot (HS)	Ref.		
Emergency department	0.37	0.3-0.45	**<0.00**
Day Hospital	0.14	0.1-0.21	**<0.00**
Hospital wards	0.39	0.25-0.62	**<0.00**
Mean of pooled Rt in the 14 days preceding the swab	1.75	1.53-1.99	**<0.00**
Type of swab			
Nucleic acid amplification test	Ref.		
Rapid antigen detection test	0.33	0.17-0.63	**0.001**

Abbreviations: adjOR adjusted Odds Ratio, CI Confidence Interval, Rt effective reproductive number.

Table 4. Multivariable logistic regression model: swab tested positive as outcome.

Figure legend

The Figure shows the trend of total number of swabs per week and number of swabs that tested positive per week from 14th September 2020 to 18th March 2021 (only school hotspot setting). Only the date of the first day of the week is shown. Above the number of swabs that tested positive, the percentage of positive swabs (out of the total number of swabs) is shown for each week. The week starting from 15th March 2021 consists of only 4 days as the data collection ended on 18th March 2021.

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`Figures.docx` available at https://authorea.com/users/739108/articles/712936-analysis-of-a-direct-access-testing-system-for-the-detection-of-sars-cov-2-in-the-paediatric-population-attending-school