Public Health England

Prospective active national surveillance of preschools and primary schools for SARS-CoV-2 infection and transmission in England, June 2020 (sKIDs COVID-19 surveillance in school KIDs)

Phase 1 Report (01 September 2020)

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1. We found very few infections and transmission events in 131 educational settings during the 4-6 week summer half-term from 1 June to mid-July 2020
2. Where a SARS-CoV-2 positive case was identified, we did not find any additional cases within the household, class bubble or wider education setting when tested
3. 12,047 participants in 131 schools had 43,039 swabs taken. SARS-CoV-2 infection rate was:
    a. 3.9 /100,000/week (1 per 25,674; 95% CI, 0.10 to 21.7) in students
    b. 11.3/100,000/week (2 per 17,695; 95% CI, 1.40-40.8) in staff
4. SARS-CoV-2 antibody positivity

   a. 10.6% (86/814; 95%CI, 8.5-12.9%) in students
   b. 12.7% (167/1316; 95%CI, 10.9-14.6%) in staff (p=0.14).
5. Non-white ethnicity and having a history of COVID-19 like symptoms were significantly associated with seropositivity in both students and staff, but not school attendance or time spent in school during lockdown.

Abstract

Background

Many countries have started to re-open schools as part of the easing of COVID-19 lockdown measures but staff, students and their families remain concerned about the risk of infection and transmission of SARS-CoV-2 in educational settings. Public Health England (PHE), therefore, initiated a prospective national study in preschools and primary schools during the summer half-term.

Methods

The COVID-19 Surveillance in School KIDs (sKIDs) study included two arms: weekly nasal swabs for at least 4 weeks and blood sampling with nasal and throat swabs at the beginning (early June) and end of half-term (mid-July).

Results

A total of 12,026 participants in 131 schools had 43,039 swabs taken. SARS-CoV-2 infection rate of 3.9 /100,000/week (1/25,674; 95% CI, 0.10 to 21.7) in students and 11.3/100,000/week (2/17,695; 95% CI, 1.4-40.8) in staff. Where a SARS-CoV-2 positive case was identified, there were no additional cases in the household, class bubble or wider education setting when tested. SARS-CoV-2 seropositivity was 10.6% (86/814; 95%CI, 8.5-12.9%) in students and 12.7% (167/1316; 95%CI, 10.9-14.6%) in staff (p=0.14). Non-white ethnicity, a history of COVID-19 like symptoms and having a healthcare worker in the household were significantly associated with seropositivity in both students and staff, but not school attendance, time spent in school or level of contact between staff and students.

Conclusions

SARS-CoV-2 infection and transmission rates were low in preschool and primary schools under surveillance. Seropositivity rates in students and staff were similar and not associated with school attendance during the lockdown. Similar studies are needed in secondary schools and higher educational settings.

Introduction

The declaration of COVID-19 as a global pandemic led most countries to close their schools as part of their national lockdown measures,[1-3] with more than 1 billion children and young people – equivalent to two-thirds of enrolled learners worldwide – affected so far.[4] Although children were recognised to contribute to only a small proportion of confirmed COVID-19 cases and rarely developed severe or fatal disease,[5,6] their role in asymptomatic infection and transmission, which is well-described for other respiratory viral infections such as influenza, was uncertain. The close proximity of children –especially young children – in educational settings could lead to rapid transmission not only between the children and staff but also to their household contacts and potentially the wider community. This is well-described for other viral infections, including influenza, where children are known to be the main drivers of infection and transmission.[7,8] Experience from previous coronavirus outbreaks, including middle east respiratory syndrome (MERS) and severe acute respiratory syndrome (SARS), suggest that school closures did not contribute to the control of these epidemics.[3] School closures not only affects education but can also have a negative impact on the physical and mental wellbeing of children,[3] especially those from vulnerable and disadvantaged backgrounds.[9]

In England, a rapid increase in SARS-CoV-2 since early March 2020 led to school closures on 20 March and wider lockdown on 23 March.[10] Children of key workers including healthcare workers and vulnerable children, however, had the option to attend school throughout the lockdown.[11] Nationally, COVID-19 cases plateaued in mid-April 2020 and then declined, allowing gradual easing of lockdown measures.[12] Preschool and some primary school years (nursery [3-4 year-olds], reception [4-5 year-olds], years 1 [5-6 year-olds] and 6 [10-11 year-olds]) were allowed to open from 01 June and some secondary school years (years 10 [14-15 year-olds] and 12 [16-17 year-olds]) reopened from 15 June 2020 until the end of the summer half-term (4-6 weeks).[13] Strict social distancing and infection control measures were implemented for staff and students, including smaller class sizes and clustering staff and students into self-contained bubbles.[13]

The decision to re-open schools has been divisive in England and worldwide. Whilst the benefits of children returning to school cannot be denied, parents and school staff remain concerned about the risk of infection and transmission within

educational settings, potentially putting the students, staff and their household members at risk of infection. To address this question, Public Health England (PHE) initiated a prospective national study monitoring SARS-CoV-2 infection and transmission in students and staff attending preschools and primary schools during the summer half-term in England.

Methods

The COVID-19 Surveillance in School KIDs (sKIDs) study involved two arms (https://www.gov.uk/guidance/covid-19-paediatric-surveillance).[14] In the swabs arm, schools across England with least 30 students attending for at least 4 weeks during the summer half-term were approached to take part in the study. The investigators worked with the department of education, local healthcare Trusts, health protection teams and the Local Authority to identify a local experienced person to take nasal swabs from students, such as a local nurse or first aider. Staff members self-swabbed under supervision. For the serology arm, schools that were not participating in weekly swabbing were approached in five regions where a paediatric investigation team could be assembled: North London, East London, Oxford, Derby and Manchester.

For all schools, the headteacher sent the study information pack to staff and parents and asked them to return a signed consent form and completed questionnaire before the sampling day. Written informed consent was obtained from staff and parents/guardians of participating students and a questionnaire completed at the beginning and end of the summer half-term. In the swabbing schools, a nasal swab was taken on the same day every week and couriered to the PHE national reference centre for testing. The investigators worked closely with schools to test unwell staff and students for SARS-CoV-2 either through local testing or by posting swabs to their homes. Headteachers, staff and parents were asked to notify PHE if any participant tested positive for COVID-19 or was a contact of positive case. At the end of the summer half-term, participants were also asked whether they had taken any time off school because they or someone in their school bubble had confirmed SARS-CoV-2 infection. SARS-CoV-2 positive participants were invited to enrol in a household transmission study, where all household members were swabbed and then had blood samples take for antibody testing 4-6 weeks later.

In serology schools, a team of clinicians, nurses, phlebotomists and administrative staff attended the school within two weeks of school opening. Local anaesthetic cream was offered to all students before blood sampling. A class teacher was present with each student; in some schools, some parents were allowed to attend the session with their child at the beginning or end of the school day. A nose and throat swab were obtained from the students at the same time. Participating staff also had a blood sample and throat swab taken by the investigation team; the staff took their own nose swab at some sites.

Laboratory testing

Swabs were tested and results reported typically within 48 hours. Nucleic acid was extracted from samples and analysed by a real-time reverse transcription polymerase chain reaction RT-PCR assay on an Applied Biosystems 7500 FAST system targeting a conserved region of the open reading frame (ORF1ab) gene of SARS CoV-2.[15] A positive RT-PCR result was reported to the participant, local investigator, head teacher and local PHE health protection team. The participant and household members self-isolated as per national guidance. Public health risk assessment was undertaken with the school to decide additional measures, including isolation of the participant's school bubble. Serology was performed using a chemiluminescent microparticle immunoglobulin G (IgG) immunoassay targeting the nucleoprotein (SARS-CoV-2 IgG, Abbott Commerce Chicago, USA).[16]

Data management and investigations

Questionnaire data were entered into Microsoft Access and analysed using Stata v.15.0. continuous data with a normal distribution are described as mean with standard deviation or as median with interquartile range in they did not have a normal distribution. Categorical data are described as proportions and compared with the χ^2-test of Fisher's exact. To account for missing data on student/staff status, we assumed that the student:staff ratio in participants with missing information was the same as the proportion with available information. Tests for association with SARS-CoV-2 antibody positivity were performed using logistic regression. A multivariable regression model was built using likelihood ratio tests and included factors that were statistically significant in the univariable analysis, or that did not have large amounts of missing data. School attendance was not statistically

significant in the model for student and not included in the multivariable analysis. Being unwell with COVID-19 like illness or having confirmed COVID-19 were not included in the multivariable analyses because of their strong correlation with seropositivity. Univariable analysis including only participants in the complete case multivariable analysis was performed in addition to the final multivariable analysis to ensure that the results were consistent. Differences between schools were tested for using clustering on the final multivariable models.

Results

In total, there were 12,026 participants in 131 schools with a median of 93 (IQR, 62-155) participants in the 86 schools taking part in weekly swabbing and 43 (30-69) in the 45 schools participating in serology testing (**Figure 1**). Overall, 59.1% (6,441/10,890) of those with available data were students and 40.9% (4,449/10,890) were staff (**Table 1**). Of the 43,039 swabs taken, 23,358 (59.3%) with available information were from students and 16,052 (40.7%) were from staff. The number of swabs taken increased from the beginning of June 2020 and peaked in the last week of June before declining. One student and five staff had detectable SARS-CoV-2 on their nose or throat swabs. Three (two previously symptomatic, one asymptomatic) staff had very high RT-PCR cycle threshold values (>39) consistent with very low viral load, and, when the sample was concentrated and re-analysed, tested negative; all three were also antibody negative 4-6 weeks later. Of the remaining confirmed infections, the single asymptomatic student was a child of a healthcare worker who had been symptomatic and tested RT-PCR positive on nasopharyngeal swabbing four weeks previously (**Table 1**). After adjusting for missing staff/student status, we estimated a swab positivity rate of 3.9 (1/25,537; 95% CI, 0.10 to 21.8) per 100,000 students and 11.3 (2/17,554; 95% CI, 1.4-41.2) per 100,000 staff per week of testing.

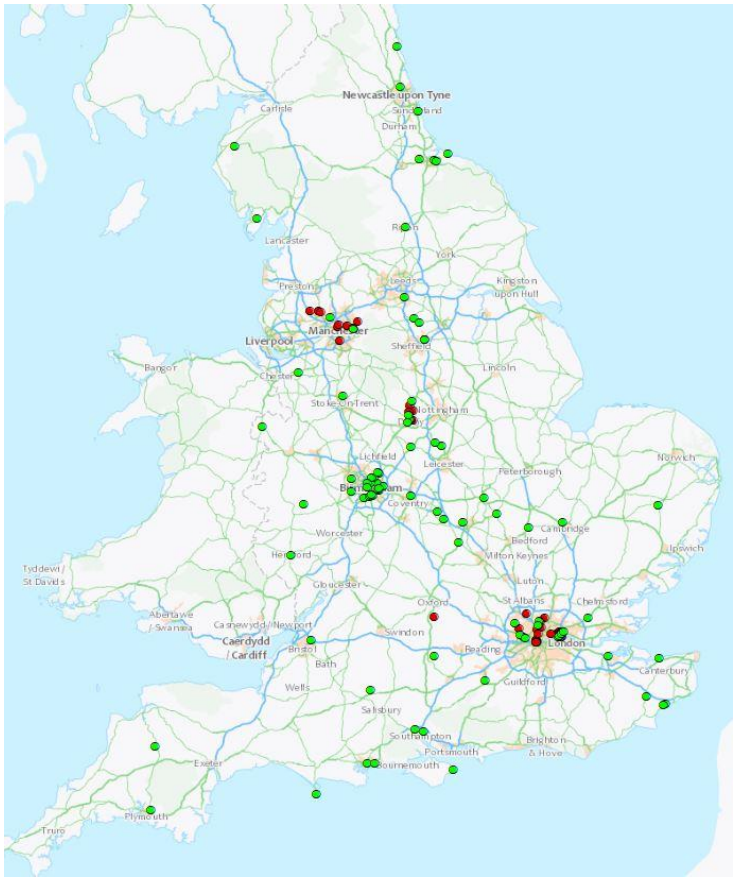

Figure 1. sKIDs participating sites in England. The red dots indicate schools taking part in the blood sampling arm and the green dots indicate in the weekly swabbing arm

Testing of household and school contacts

As a precaution, all six participants with detectable SARS-CoV-2 on their swabs along with their household contacts and school class bubbles were asked to self-isolate for 14 days. Their household contacts were offered a nasal swab; all those tested were negative and none became symptomatic during follow-up (**Table 2**). Additionally, Teacher E's school bubble was offered nasal swab testing for SARS-CoV-2 and all were negative. Teacher F worked in a special education needs school and was part of an outbreak involving two teachers. This teacher became symptomatic and tested positive for SARS-CoV-2 48 hours after the third negative weekly swab. Another staff member working in different bubble also became symptomatic and tested positive for SARS-CoV-2, leading the school to close for the remaining two weeks. Local public health teams tested every student and staff member but did not identify any additional cases in the school.

	Students	Staff	Total
Participants	6441 (59.1%)	4449 (40.9%)	12026
Missing status			1116
Sex			
Female	3252 (50.9%)	3743 (84.9%)	6995 (64.8%)
Male	3135 (49.1%)	666 (15.1%)	3801 (35.2%)
Missing sex			1,230
Ethnicity			
White	3763 (73.4%)	3238 (84.1%)	7001 (69.6%)
Mixed / Multiple ethnic groups	405 (6.3%)	90 (2.0%)	495 (4.1%)
Black African / Caribbean / British	213 (4.2%)	124 (3.0%)	337 (3.0%)
Asian / Asian British	574 (8.9%)	334 (7.5%)	908 (7.6%)
Other ethnic group	173 (2.7%)	49 (1.1%)	222 (1.9%)
Missing ethnicity			3063
Total Number of Swabs taken	23358	16052	43091
Median (IQR) participant numbers in swabs schools	53 (25-96)	35 (20-46)	93 (62-155)
Median (IQR) participant numbers in serology schools	13 (8-36)	28 (17-36)	43 (30-69)
Median Number of Swabs per school	53 (25-96)	35 (20-46)	93 (62-155)
Median (IQR) swabs in swab schools	4 (3-5)	4 (4-5)	4 (3-5)
Median (IQR) swabs in serology schools	3 (2-4)	3 (2-4)	3 (2-4)
Age (years)			
<5	480 (8.4%)		
5	1002 (17.6%)		
6	996 (17.4%)		
7	372 (6.5%)		
8	450 (7.9%)		
9	484 (8.5%)		
10	578 (10.1%)		
11	1273 (22.3%)		
>11	73 (1.3%)		
Missing age	733		
Region in England			
East Midlands	1080 (16.8%)	561 (12.6%)	1860 (15.5%)
East of England	259 (4.0%)	140 (3.1%)	429 (3.6%)
London	971 (15.1%)	1266 (28.5%)	2320 (19.3%)
North East	418 (6.5%)	202 (4.5%)	946 (7.9%)
North West	409 (6.3%)	375 (8.4%)	785 (6.5%)
South East	512 (7.9%)	283 (6.4%)	858 (7.1%)
South West	485 (7.5%)	308 (6.9%)	899 (7.5%)
West Midlands	1989 (30.9%)	1154 (25.9%)	3172 (26.4%)
Yorkshire and The Humber	318 (4.9%)	160 (3.6%)	757 (6.3%)

Table 1. Characteristics of staff and students participating in school surveillance for SARS-CoV-2

*Total numbers include data on participants with missing student/staff status

	Region	Participant	Symptomatic?	Infection Source	RT-PCR testing*	Retested RT-PCR	Antibody 4-6 weeks later	Household contacts	Outcome	School action
A	London	Teacher	Symptomatic a few weeks previously	Not identified	Throat swab (Ct 35.27)	Positive	Positive (2.96)	All negative	Likely recovering from past infection	Bubble isolated
B	London	Teaching assistant	Symptomatic a few weeks previously	Not identified	Throat swab (Ct 39.97)	Negative	Negative (0.02)	All negative	SARS-CoV-2 infection unlikely	Bubble isolated
C	London	Primary school student	Asymptomatic	Healthcare worker parent	Throat swab (Ct 31.74)	Positive	Positive (6.20)	All negative	Asymptomatic infection	Bubble isolated
D	South East	Teacher	Asymptomatic	Not identified	Nose swab (Ct 40.05)	Negative	Negative (0.01)	Lived alone	SARS-CoV-2 infection unlikely	Bubble isolated
E	Midlands	Teacher	Symptomatic	Household member	Nose swab (Ct 40.03)	Negative	Negative (0.01)	Lived alone	SARS-CoV-2 infection unlikely; School bubble tested – all negative	Bubble isolated
F	Midlands	Teacher	Symptomatic	Not identified	Nose swab (Ct 37.53)	Positive	Declined testing	Declined testing	Another staff member also tested positive; whole school tested – all negative	School closed

Table 2. Summary of participants with detectable SARS-CoV-2 RNA on nasal/throat swab.

* RT-PCR Cycle threshold (Ct)

Serology

SARS-CoV-2 antibody positivity was 11.9% (253/2,163; 95%CI, 10.5-13.3%) overall, including 10.6% (86/814; 95%CI, 8.5-12.9%) in students and 12.7% (167/1316; 95%CI, 10.9-14.6%) in staff (p=0.14). Antibody positivity varied across the different English regions, but within regions was similar between staff, students and community based seroprevalence during the same week (**Figure 2)**. In two regions, antibody positivity was higher in students than staff but this was not statistically significant. For both students (**Table 3**) and staff (**Table 4**), after adjusting for other variables included in the final model (and differences between schools for staff; p=0.0026 for clustering), antibody positivity was associated with non-white ethnicity and having a history of COVID-19 like symptoms, but not with school attendance or with frequency of school attendance during the lockdown. Students who were children of healthcare workers, but not other keyworkers, were also significantly more likely to be antibody positive. In staff members, too, antibody positivity was associated with having a healthcare worker in the household. Only 20.9% (18/86) of seropositive students reported COVID-19 like illness compared to 60.1% (101/168) of staff (p<0.001).

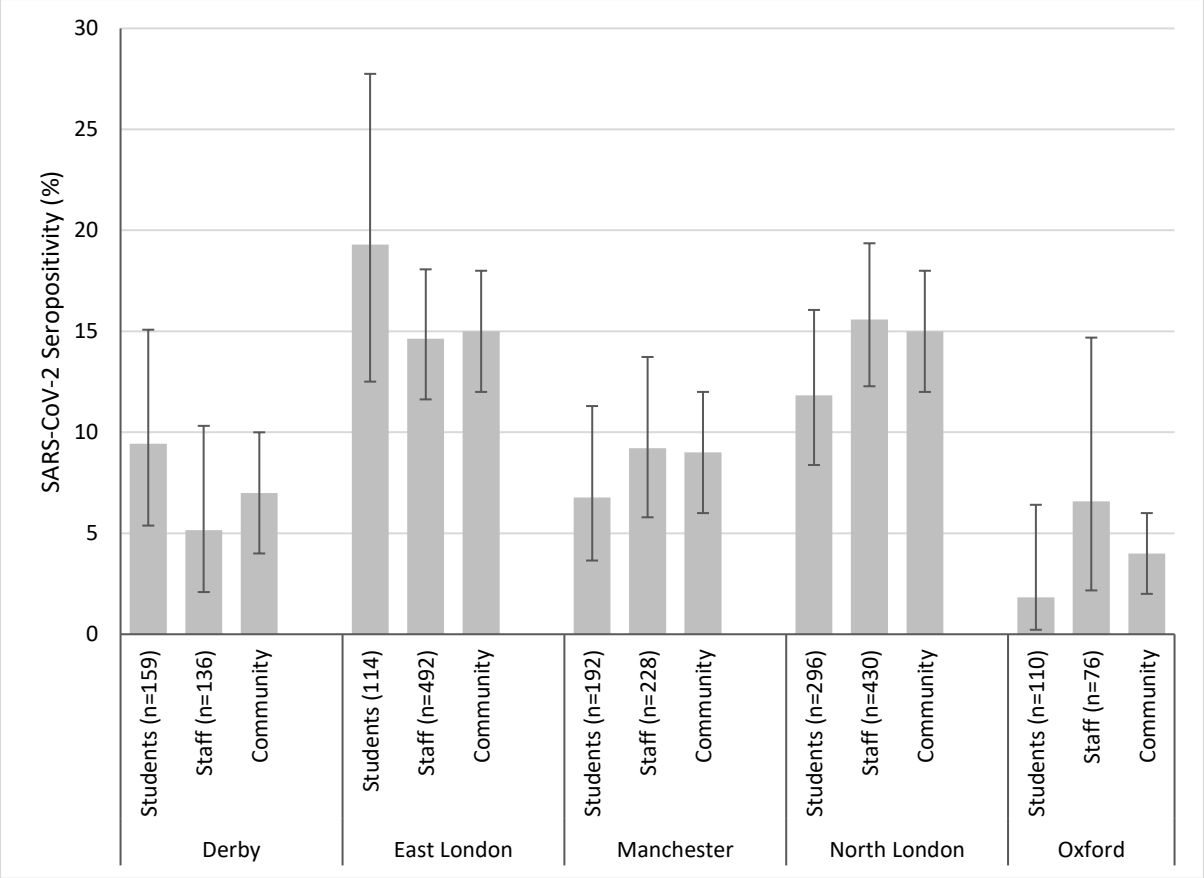

Figure. Seropositivity in staff and students attending preschool and primary school in five English regions compared to regional seroprevalence during the first two weeks of June 2020. *Community seroprevalence are published weekly by Public Health England*.[17]

	Antibody positive	Univariate analysis		Complete case univariate analysis		Multivariable analysis		Multivariable analysis adjusted for clustering by school (p=1.0)	
	n/N (%)	OR (95% CI)	P value	OR (95% CI)	P value	OR (95% CI)	P value	OR (95% CI)	P value
Factor		N=814		N=665		N=665		N=665	
Sex									
Female	36/413 (8.7)	Ref	0.081		0.34	Ref	0.36	Ref	0.36
Male	50/400 (12.5)	1.50 (0.95, 2.35)		1.26 (0.78, 2.04)		1.26 (0.77, 2.09)		1.26 (0.77, 2.09)	
Missing sex	0/1 (-)								
Age in years									
3-6	22/306 (7.2)	-	0.036	Ref	0.16	Ref	0.37	Ref	0.37
7-10	41/305 (13.4)	2.00 (1.16, 3.46)		1.71 (0.97, 3.01)		1.45 (0.8, 2.63)		1.45 (0.8, 2.63)	
11+	20/181 (11.2)	1.60 (0.85, 3.03)		1.49 (0.78, 2.88)		1.55 (0.77, 3.11)		1.55 (0.77, 3.11)	
Missing age	3/22 (13.6)								
Ethnicity									
White	34/449 (7.6)	Ref	0.0002	Ref	0.0015	Ref	0.011	Ref	0.011
Mixed / Multiple ethnic groups	9/75 (12.0)	1.66 (0.76, 3.63)		1.74 (0.79, 3.84)		1.20 (0.52, 2.80)		1.2 (0.52, 2.8)	
Black African / Caribbean / British	9/52 (17.3)	2.55 (1.15, 5.68)		2.95 (1.3, 6.68)		2.35 (0.97, 5.71)		2.35 (0.97, 5.71)	
Asian / Asian British	12/92 (13.0)	1.83 (0.91, 3.69)		1.83 (0.88, 3.81)		1.18 (0.53, 2.65)		1.18 (0.53, 2.65)	
Other ethnic group	20/77 (26.0)	4.28 (2.31, 7.94)		3.72 (1.93, 7.17)		3.48 (1.73, 7.03)		**3.48 (1.73, 7.03)**	
Missing ethnicity	2/69 (2.9)								
Region									
Derby	15/158 (9.5)	0.70 (0.37, 1.32)	0.0001	0.77 (0.4, 1.49)	0.022	0.59 (0.29, 1.21)	0.22	0.59 (0.29, 1.21)	0.24
East London	22/114 (19.3)	1.59 (0.88, 2.85)		1.65 (0.88, 3.08)		1.31 (0.65, 2.62)		1.31 (0.65, 2.62)	
Manchester	12/168 (7.1)	0.51 (0.26, 1.01)		0.68 (0.33, 1.41)		0.73 (0.33, 1.59)		0.73 (0.33, 1.59)	
North London	35/267 (13.1)	Ref		Ref		Ref		Ref	
Oxford	2/107 (1.9)	0.13 (0.03, 0.53)		0.25 (0.06, 1.07)		0.40 (0.09, 1.79)		0.40 (0.09, 1.79)	
Been unwell with COVID-19 symptoms *									
No	68/712 (9.6)	Ref	0.014						
Yes	18/102 (17.7)	**2.03 (1.15, 3.58)**		NA					

Attended school during lockdown **									
No	17/119 (14.3)	Ref	0.32						
Yes	63/571 (11.0)	0.74 (0.42, 1.32)		NA					
Missing attendance	6/124 (4.8)								
Frequency of school attendance during lockdown **									
Did not attend	17/119 (14.3)	Ref	0.54						
One day or less per week	17/181 (9.4)	0.62 (0.3, 1.27)							
Less than half the week	9/91 (9.9)	0.66 (0.28, 1.55)		NA					
More than half the week	13/127 (10.2)	0.68 (0.32, 1.48)							
Everyday	24/172 (14.0)	0.97 (0.50, 1.90)							
Missing frequency	6/124 (4.8)								
Previous confirmed COVID in household									
No	81/791 (10.2)	Ref	0.086	NA					
Yes	5/23 (21.7)	2.43 (0.88, 6.73)							
Mean (s.d.) no. children at home									
Seronegative student	2.29 (0.90)	Ref	0.031	Ref		Ref	0.065	Ref	0.065
Seropositive student	2.53 (1.15)	1.28 (1.02, 1.61)		1.3 (1.03, 1.63)	0.027	1.26 (0.99, 1.61)		1.26 (0.99, 1.61)	
Missing number of children	77 (9.5%)								
Parental occupation									
Neither healthcare or key worker	50/551 (9.1)	Ref	0.024	Ref		Ref	0.017	Ref	0.017
Healthcare worker	21/115 (18.3)	2.24 (1.28, 3.9)		2.23 (1.23, 4.02)	0.035	2.54 (1.33, 4.88)		**2.54 (1.33, 4.88)**	
Keyworker (excluding healthcare workers)	15/148 (10.1)	1.13 (0.62, 2.08)		1.04 (0.55, 1.96)		0.99 (0.5, 1.95)		0.99 (0.5, 1.95)	

Table 3. Risk factors for antibody positivity in students participating in school surveillance for SARS-CoV-2

*only 12 children were tested for SARS-CoV-2, 4 were negative and 8 did not report their results

** including these factors in the multivariable model would did not affect the odds ratio

OR = odds ratio; CI = confidence interval; s.d. = standard deviation

	Antibody positive	Univariate analysis		Complete case univariate analysis		Multivariable analysis		Multivariable analysis adjusted for clustering by school (p=0.0026)	
	n/N (%)	OR (95% CI)	P value	OR (95% CI)	P value	OR (95% CI)	P value	OR (95% CI)	P value
Factor		N=1,316		N=1,150		N=1,150		N=1,150	
Sex									
Female	129/1044 (12.4)	Ref	0.23	Ref	0.071	Ref	0.10	Ref	0.14
Male	39/257 (15.2)	1.27 (0.86, 1.87)		1.45 (0.97, 2.16)		1.43 (0.94, 2.18)		1.4 (0.91, 2.16)	
Missing	0/15 (-)								
Ethnicity									
White	100/950 (10.5)	Ref	0.0012	Ref	0.0019	Ref	0.011	Ref	0.012
Mixed / multiple ethnic groups	8/46 (17.4)	1.79 (0.81, 3.94)		1.47 (0.64, 3.39)		1.28 (0.54, 2.99)		1.31 (0.54, 3.15)	
Black African / Caribbean / British	19/67 (28.4)	3.36 (1.9, 5.95)		3.38 (1.9, 6.01)		3.13 (1.7, 5.75)		**3.19 (1.69, 6.02)**	
Asian / Asian British	25/157 (15.9)	1.61 (1, 2.59)		1.6 (0.99, 2.58)		1.58 (0.94, 2.67)		1.68 (0.97, 2.93)	
Other ethnic group	3/29 (10.3)	0.98 (0.29, 3.3)		1 (0.3, 3.38)		1.04 (0.3, 3.66)		1.18 (0.32, 4.31)	
Missing	13/67 (19.4)								
Region									
Derby	7/134 (5.22)	0.3 (0.14, 0.68)	0.001	0.35 (0.15, 0.78)	0.019	0.38 (0.16, 0.86)	0.070	0.35 (0.13, 0.99)	0.23
East London	72/491 (14.7)	0.94 (0.66, 1.35)		1.02 (0.7, 1.49)		0.80 (0.52, 1.23)		0.74 (0.4, 1.38)	
Manchester	19/189 (10.1)	0.61 (0.36, 1.05)		0.75 (0.42, 1.33)		0.68 (0.38, 1.24)		0.71 (0.32, 1.59)	
North London	66/428 (15.4)	Ref		Ref		Ref		Ref	
Oxford	4/74 (5.4)	0.31 (0.11, 0.89)		Omitted		Omitted		Omitted	
Been unwell with COVID-19 symptoms									
No	67/938 (7.1)	Ref	<0.001						
Yes	101/378 (26.7)	4.74 (3.38, 6.64)							
Attended school during lockdown									
No	34/196 (17.4)	Ref	0.073	Ref	0.042	Ref	0.048	Ref	0.099
Yes	130/1034 (12.6)	0.69 (0.45, 1.04)		0.65 (0.42, 0.98)		0.52 (0.27, 1)		0.58 (0.3, 1.12)	
Missing	4/86 (4.7)								

Frequency of school attendance during lockdown									
Only Home	34/196 (17.4)	Ref	0.19						
Mainly Home	52/467 (11.1)	0.6 (0.37, 0.95)							
Equal School and Home	42/296 (14.2)	0.79 (0.48, 1.29)							
Mainly school	26/173 (15.0)	0.84 (0.48, 1.47)							
Full time	10/98 (10.2)	0.54 (0.26, 1.15)							
Missing	4/86 (4.7)								
Student contact during lockdown									
None	53/353 (15.0)	Ref	0.58	Ref		Ref		Ref	
Occasional	84/663 (12.7)	0.82 (0.57, 1.19)		0.76 (0.52, 1.11)	0.376	1.13 (0.64, 2)	0.74	1.13 (0.63, 2.03)	0.71
Regular	23/173 (13.9)	0.87 (0.51, 1.47)		0.85 (0.49, 1.45)		1.31 (0.66, 2.63)		1.35 (0.65, 2.77)	
Missing	8/127 (6.3)								
Other household occupation									
Neither health or key worker	123/1073 (11.5)	Ref	0.0036		0.0064	Ref	0.012	Ref	0.010
Healthcare worker	12/42 (28.6)	3.09 (1.54, 6.19)		3.02 (1.5, 6.09)		2.87 (1.36, 6.06)		**3.10 (1.43, 6.75)**	
Keyworker not including healthcare workers	33/201 (16.4)	1.52 (1.00, 2.30)		1.46 (0.94, 2.25)		1.52 (0.96, 2.38)		1.52 (0.95, 2.42)	

Table 4. Risk factors for antibody positivity in school staff participating in SARS-CoV-2 surveillance

OR = odds ratio; CI = confidence interval

Discussion

Active prospective surveillance identified very low rates of SARS-CoV-2 infection or transmission in schools during the summer half-term in England. Only 3/43,039 swabs from 12,026 participants had SARS-CoV-2 infection. SARS-CoV-2 seropositivity was 10.6% in students and 12.7% in staff at the start of the summer half-term. We found no association between antibody positivity and either school attendance or exposure to educational settings during the lockdown period. The level of staff exposure to students was also not associated with antibody positivity. Instead, non-white ethnicity, being symptomatic with COVID-19 like symptoms and having a healthcare worker in the household were major determinants of seropositivity in both students and staff.

In England, school re-opening involved a phased, partial opening of preschool and some primary and secondary school years during the short 4-6 week half-term, with strict physical distancing and infection control precautions. We implemented a two-arm surveillance programme to assess SARS-CoV-2 infection risk in anticipation of all schools reopening fully in September. We successfully recruited large numbers of students and staff across a wide range of educational settings and found very low swab positivity rates. Three participants with an initial positive swab subsequently tested negative with no evidence of antibody development 4-6 weeks later, highlighting the risk of false positivity associated with mass testing during periods of low community prevalence, even with the most specific assays.[18] Additionally, while weekly testing was reassuring for the participating schools, both the child of a healthcare worker and the two symptomatic teachers could potentially have been picked up through effective contact tracing and community testing, respectively. Reassuringly, we found no evidence of secondary transmission to household or schools contacts of the three index cases.

Serology

The similar contemporaneous seropositivity rates in staff and students indicates that children are as likely to be infected with SARS-CoV-2 as adults and, since they represent only 1-3% of confirmed COVID-19 cases,[14,19] suggests that they are more likely than adults to have asymptomatic or mild disease. This contrasts with recent

reports suggesting that children have a lower susceptibility to SARS-CoV-2 infection.[6,20] The few published population-based seroprevalence studies have included very few or no children.[1] Others have utilised residual sera from children presenting to healthcare, random household sampling which is influenced by parental risk factors, or been undertaken during outbreak investigations, making age comparisons and interpretations difficult.[1] This study is unique in that it allows comparison of independent groups of children (students) and adults (staff) from the same community. One explanation for the reported lower seroprevalence in children compared to adults may be a lower risk of virus exposure during the lockdown.

The lack of association between seropositivity and school attendance during the lockdown is an important finding, especially given that only children of keyworkers and vulnerable children attended schools during the lockdown. Since keyworkers, especially frontline healthcare workers, were more likely to be infected with SARS-CoV-2,[21] and develop COVID-19,[22] particularly at the start of the UK epidemic when universal testing and personal protective equipment in healthcare settings was limited, their children would have been at increased risk of household exposure to the virus. Children of healthcare workers were significantly more likely to be seropositive than other children in our cohort. At the same time, children remaining at home were as likely to be seropositive as those attending school during the lockdown. Household secondary attack rates are 10-fold higher than any other setting.[23] This, together with our findings supports the return of children back to school. There are few other similar studies for comparison, but in Sweden, which kept preschools and primary schools open with social distancing and infection prevention measures, repeated serosurveys among non-COVID-19 primary care patients in nine counties during weeks 18–21 showed similar seropositivity rates in <20 year-olds and working-age adults.[1,24]

Seropositivity among staff (and students) was similar to community seroprevalence at the time, providing additional reassurance that they are at similar risk of infection compared to other professions.[21] We also found higher seropositivity in staff who did not attend school during lockdown. This could be due to the increased risk of exposure to high-risk household members, such as healthcare workers and

keyworkers, or more opportunities for acquiring the infection in the community, or both. For both staff and students, the significant association between antibody positivity and a history of COVID-19 like symptoms is an important validation finding. The higher seropositivity in black and minority ethnic groups is also consistent with the published literature,[25] although to our knowledge this the first report in children.

Strengths and Limitations

The strength of this surveillance is the large numbers of schools and participants recruited within two weeks of schools re-opening and highlight the willingness of parents to allow their children to take part in school surveillance. An important limitation is that the surveillance was conducted after easing of lockdown when SAR-CoV-2 infection rates were at their lowest. Also, only a few school years were open and extensive social distancing and infection control measures were in place, with small class sizes clustered into defined bubbles and many children attending school for only some days every week. Moreover, the study was open to all staff and students but the characteristics of those who took part – and, therefore, risk factors such as household contacts – may be different to those who did not consent. Additionally, we did not collect samples at the start of the lockdown and, therefore, cannot comment on whether seropositive participants might have been exposed to SARs-Cov-2 in school prior to lockdown. Finally, our findings cannot be extrapolated to senior schools,[2] because the risk of SARS-CoV-2 exposure, asymptomatic infection and symptomatic disease in teenagers is likely to be different to younger children,[26,27] with a potentially higher propensity for SARS-CoV-2 transmission and outbreaks in senior schools,[28,29] compared to primary schools.[28]

Conclusions

We found no evidence of an increased risk of SARS-CoV-2 infection in students or staff attending school during the summer half-term in England. SARS-CoV-2 infection rates were very low, with no secondary cases identified among household or school contacts. SARS-CoV-2 seropositivity rates were similar in students and staff indicating that children do get infected but may be more likely to have asymptomatic or mild illness. Similar studies are needed in secondary schools and higher education settings where the risk of infection, transmission and disease are likely to be different.

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