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COVID-19 in children: analysis of the first pandemic peak in England

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ABSTRACT

Objectives To assess disease trends, testing practices, community surveillance, case-fatality and excess deaths in children as compared with adults during the first pandemic peak in England.

Setting England.

Participants Children with COVID-19 between January and May 2020.

Main outcome measures Trends in confirmed COVID-19 cases, severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) positivity rates in children compared with adults; community prevalence of SARS-CoV-2 in children with acute respiratory infection (ARI) compared with adults, case-fatality rate in children with confirmed COVID-19 and excess childhood deaths compared with the previous 5 years.

Results Children represented 1.1% (1,408/129,704) of SARS-CoV-2 positive cases between 16 January 2020 and 3 May 2020. In total, 540 305 people were tested for SARS-COV-2 and 129,704 (24.0%) were positive. In children aged <16 years, 35,200 tests were performed and 1408 (4.0%) were positive for SARS-CoV-2, compared to 19.1%–34.9% adults. Childhood cases increased from mid-March and peaked on 11 April before declining. Among 2,961 individuals presenting with ARI in primary care, 351 were children and 10 (2.8%) were positive compared with 9.3%–45.5% in adults. Eight children died and four (case-fatality rate, 0.3%; 95% CI 0.07% to 0.7%) were due to COVID-19. We found no evidence of excess mortality in children.

Conclusions Children accounted for a very small proportion of confirmed cases despite the large numbers of children tested. SARS-CoV-2 positivity was low even in children with ARI. Our findings provide further evidence against the role of children in infection and transmission of SARS-CoV-2.

What is already known on this topic?

- Children account for only a small proportion of confirmed cases of COVID-19.
- Most childhood cases of COVID-19 are mild and self-limiting.
- Whether this is due to limited testing for severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) in children is not known.

What this study adds?

- Despite widespread testing, SARS-CoV-2 positivity rates throughout the pandemic peak were low in children compared with adults, including those presenting with acute respiratory infection in the community.
- Case-fatality rate in children with COVID-19 was <0.5% and there was no evidence of excess childhood mortality in children during the first wave of the COVID-19 pandemic in England.

INTRODUCTION

Experience from countries recovering from large outbreaks of COVID-19 shows that children rarely develop severe or critical illness,[1] or die from the infection as compared with adults.[2 3] It is still unclear why the epidemiology, clinical features and outcomes of COVID-19 are so different in children compared with adults. COVID-19, caused by the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), typically presents as an acute respiratory illness. Common symptoms include fever and cough, as well as fatigue, chest tightness and dyspnoea, although individual symptoms or clusters of symptoms have moderate to low sensitivity and specificity for the infection.[4] While most individuals recover without specific treatment or hospitalisation, some, especially older adults, may progress to acute respiratory distress syndrome and multiorgan failure, which is associated with high case-fatality rates despite early and aggressive management in intensive care settings.[5 6]

In England, with a population of 55 million individuals, the first imported cases of COVID-19 were identified at the end of January 2020. Initially, case numbers increased slowly and were related to imported cases. However, despite contact tracing and testing individuals who met a geographic and symptom-based case definition, cases with no clear transmission chains or overseas travel started to emerge at the end of February. These cases were detected through community sentinel surveillance schemes, and cases without overseas travel were diagnosed in intensive care units (ICUs), through ICU sentinel surveillance, on the first week of March. Cases increased rapidly during the subsequent 2 weeks with evidence of community transmission across the country.

On 12 March, the UK moved from a containment to a delay phase of the government response to the pandemic, with emphasis placed on slowing the spread of the virus, lowering the peak impact on hospital and ICU services and pushing it away from the winter season; this included the recommendation for anyone with fever or cough to stay at home. Available testing capacity from individuals with mild symptoms in the community was also shifted to those who required hospitalisation and for outbreak investigations in closed institutional settings (such as care homes and prisons). On 23 March, the UK government closed all but essential shops and services and recommended that the entire population stayed at home unless they provided an essential service or were a key worker.

In England, Public Health England (PHE) has been conducting enhanced national surveillance of COVID-19 since the first cases were reported in Wuhan, China, in December 2019.[7] While adults rightly remained the primary focus of national surveillance, an extensive surveillance strategy was also established to contemporaneously monitor childhood COVID-19 in England.[7]

Currently, COVID-19 cases have peaked and hospital admissions are the lowest since 23 March in England.[8] Here, we describe the surveillance, epidemiology and outcomes of childhood COVID-19 during the first peak. In addition to disease trends, we assessed SARS-CoV-2 positivity rates in different childhood age groups compared with adults, community surveillance of SARS-CoV-2 in children and adults presenting with acute respiratory infection in primary care, cause of death in SARS-CoV-2-positive children and monitoring excess deaths in children compared with the previous 5 years.

METHODS

PHE initiated COVID-19 surveillance in England after the first cluster of cases was reported in Wuhan, Hubei Province, China in December 2019. In early January, an RT-PCR diagnostic test for SARS-CoV-2 was developed and validated by PHE. By early March 2020, the tests were also delivered by PHE regional laboratories and National Health Service (NHS) laboratories across England. Case definitions for SARS-CoV-2 testing varied over the course of the first peak of the pandemic (table 1).[9] Throughout this period, confirmed cases and their close contacts were isolated to prevent transmission into the community. During the delayed phase of outbreak control, emphasis was shifted to testing those presenting to hospital with suspected COVID-19 with the aim of rapidly diagnosing cases and protecting those who were SARS-CoV-2 negative. Clinical follow-up of confirmed cases in children aged <16 years began at the start of the pandemic and is ongoing.[7] Fatal cases were identified through regular linkage with the Patient Demographic Service, an electronic database of all NHS patients, as well as direct reporting of deaths by paediatricians and local Health Protection Teams.

SARS-COV-2 POSITIVITY

The respiratory DataMart system and Second Generation Surveillance System (SGSS) were used to assess SARS-CoV-2 testing in different age groups.[10] SGSS receives reports of all positive SARS-CoV-2 tests, as part of its laboratory data capture. In addition, the previous DataMart system and SGSS were modified to include negative results from NHS and Public Health laboratories, which were then consolidated in a unified database which used a probabilistic algorithm to remove duplicates and results from patients that had tested positive. Positive results from one laboratory that only reported positives and results from patients outside England were excluded.

Table 1 Summary of case definitions for population testing for SARS-CoV-2 in England

Time period	Case definition
Before 7 February 2020	**Epidemiological criteria** In the 14 days before the onset of illness: ► travel to China OR contact with a confirmed case of COVID-19; **and Clinical criteria** ► severe acute respiratory infection requiring admission to hospital with clinical or radiological evidence of pneumonia or acute respiratory distress syndrome; OR ► acute respiratory infection of any degree of severity, including at least one of shortness of breath (difficult breathing in children) or cough (with or without fever); OR ► fever with no other symptoms.
From 7 February 2020	**Epidemiological criteria** In the 14 days before the onset of illness: ► travel to affected countries, including transit, for any length of time, in these countries OR contact with a confirmed case of COVID-19; **and Clinical criteria** ► severe acute respiratory infection requiring admission to hospital with clinical or radiological evidence of pneumonia or acute respiratory distress syndrome; OR ► acute respiratory infection of any degree of severity, including at least one of shortness of breath (difficult breathing in children) or cough (with or without fever); OR ► fever with no other symptoms.
From 13 March 2020	**Inpatient definition** ► requiring admission to hospital; and ► have either clinical or radiological evidence of pneumonia; OR ► acute respiratory distress syndrome; OR ► influenza-like illness (fever ≥37.8°C and at least one of the following respiratory symptoms, which must be of acute onset: persistent cough (with or without sputum), hoarseness, nasal discharge or congestion, shortness of breath, sore throat, wheezing or sneezing.

**Imported cases* were defined as cases with travel to countries with known COVID-19 circulation at the time or with contact with a confirmed case while abroad within a maximum incubation period of their onset of symptoms.
†*Secondary cases* were defined as cases that had contact with a confirmed or probable/suspected case in the UK and did not fit the definition of an imported case.
‡*Sporadic cases* were defined as cases with no travel history to countries with known COVID-19 circulation, and no known contact with a confirmed case.
SARS-CoV-2, severe acute respiratory syndrome coronavirus 2.

COMMUNITY SWABBING

Community-based surveillance for influenza-like illness was established by the Royal College of General Practitioners Research and Surveillance Centre creating a network of general practices across England and Wales >50 years ago.[11 12] Adults and children presenting to around 100 participating general practices with an influenza-like illness (defined as fever with one systemic and one respiratory symptom) had a nasopharyngeal swab taken for testing. Clinicians were instructed to sample one or two patients a week. Details of the swabbing scheme are detailed elsewhere.[11] In March 2020, this surveillance was extended for SARS-CoV-2 testing in the community, including expanding the number of virology sampling practices to 300.[11]

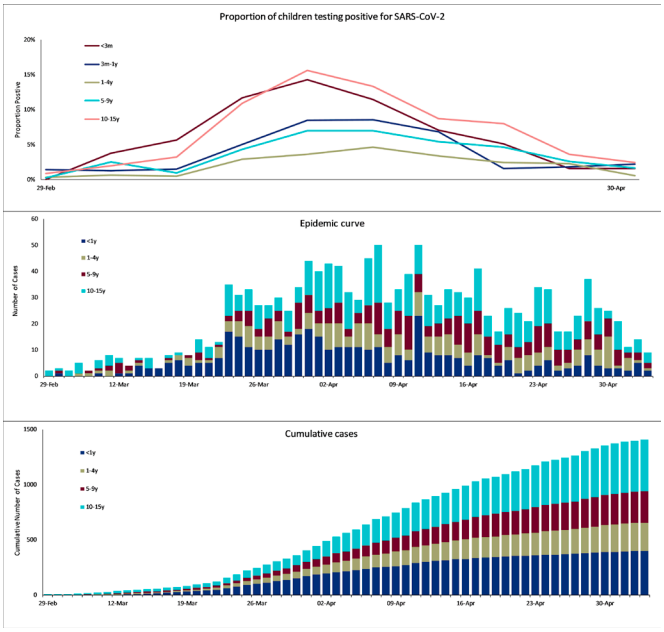

Figure 1 Epidemic curve (A), cumulative number of confirmed cases (B) and proportion of test positives (C) by age group for COVID-19 in children during the first pandemic peak (February to May 2020) in England.

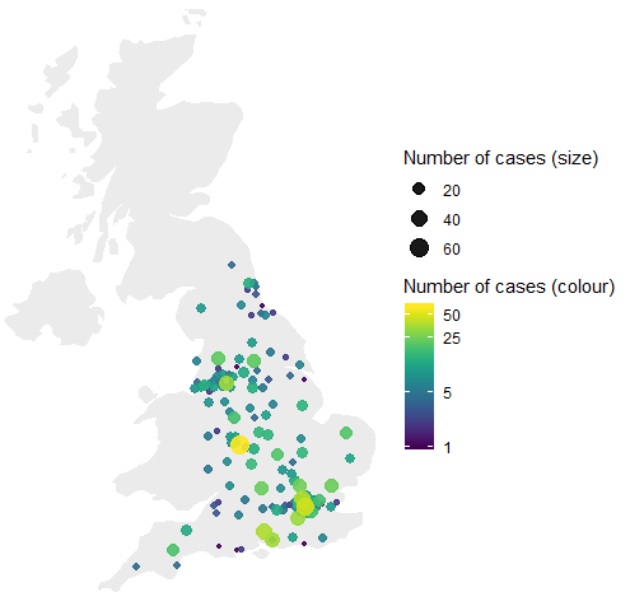

Figure 2 Distribution of confirmed COVID-19 cases in children during the first pandemic peak (February to May 2020) in England.

MORTALITY TRENDS

Data on death registrations until midnight on each day are sent the next day to PHE by the General Registry Office. Death registrations since 1 January 2015 were aggregated by age in years, date of death, date of registration, gender and region. To model weekly all-cause deaths by week of death in children, the Euromomo algorithm was used to fit a trend to deaths in the past 5 years using only spring and autumn data (to avoid potential spikes from influenza and cold weather). The data were modelled using a Poisson distribution with rescaling based on overdispersion and an expected number calculated along with predictions limits (+2 Z-scores). To account for delays from death to registration, which could be long if reported to a coroner, an adjustment to data from the previous 50 weeks was applied using a model of the proportion of deaths registered with each time lag from 0 to 50 weeks. The same model is used to estimate excess mortality in older age groups with the exception that a cosine wave is used to capture the usual pattern of higher deaths in the winter compared with summer. Results of excess mortality trends are reported to Euromomo each week and presented as a Z-score analysis (https://www.euromomo.eu/).[13]

RESULTS

EPIDEMIOLOGY

Between 1 January and 3 May 2020, 129 704 (24.0%) out of 540 305 people tested positive for SARS-CoV-2 in England. In children, the first confirmed cases were reported on 29 February 2020. Cases started to increase during the second week of March and peaked on 11 April 2020 before declining gradually, corresponding to the trends observed in adults (figure 1). COVID-19 cases were confirmed across the country, with greater numbers diagnosed in large cities (figure 2). Children accounted for 1408 (1.1%) confirmed cases across all age groups and 742 (52.7%) were male. The median age of childhood cases was 5.9 years, with higher number of cases in infants and older adults (figure 3).

Test positivity rates by age

Children represented 6.6% (n=35 200) of 536 278 people with reported age who were tested for SARS-CoV2 and 1408/35 200 (4.0%) children tested were positive, compared with 19.1%–34.9% of adults (figure 4). Infants aged <3 months (272/4072), followed by older infants (128/3358) and children aged 1 year (107/4280) had the most tests performed and the highest number of positive tests among children aged <16 years (figure 1). Test-positivity rates varied over the course of the pandemic, peaking around the same time as the peak in COVID-19 cases (figure 1).

Community surveillance of acute respiratory infection

Overall, 2968 individuals with influenza-like illness presenting to any of the participating general practices had nasopharyngeal swabs taken and 10 (2.8%) of 351 children were positive compared with 9.3% (88/946) in those aged 15–44 years, 18.6%

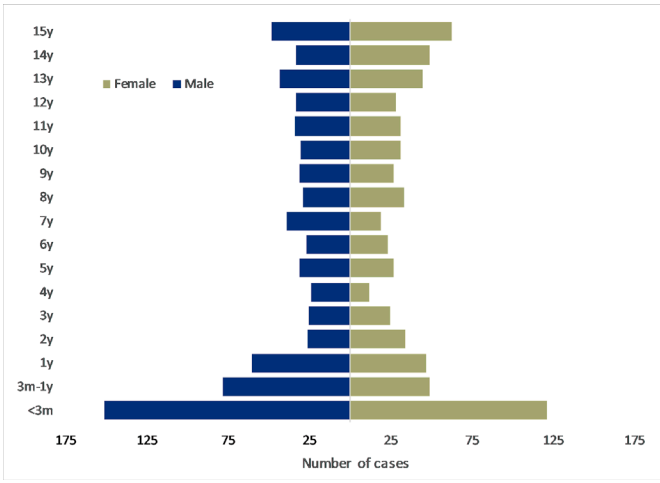

Figure 3 Age distribution of children with confirmed COVID-19 by sex in children during the first pandemic peak (February to May 2020) in England.

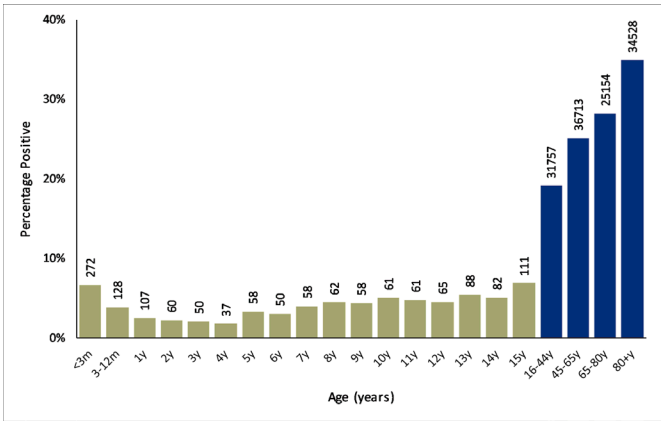

Figure 4 Percentage of test positivity by age group in children (green bar) compared with adults (blue bars) tested for severe acute respiratory syndrome coronavirus 2 during the first pandemic peak (February to May 2020) in England.

(178/959) in those aged 45–64 years, 20.6% (74/359) in those aged 65–79 years and 45.5% (150/330) in adults aged ≥80 years (figure 5). Samples were taken throughout the surveillance period and children rarely tested positive at any time, especially those aged 3–9 years, where only 1 of 168 (0.6%) was positive.

Deaths

There were eight deaths in children with confirmed COVID-19. Four children aged 10–15 years, three of whom had multiple comorbidities, died (CFR, 0.3%; 95% CI 0.07% to 0.7%) of the infection. In the remaining cases, another cause was identified and SARS-CoV-2 was reported to be incidental or an indirect contributor to death.

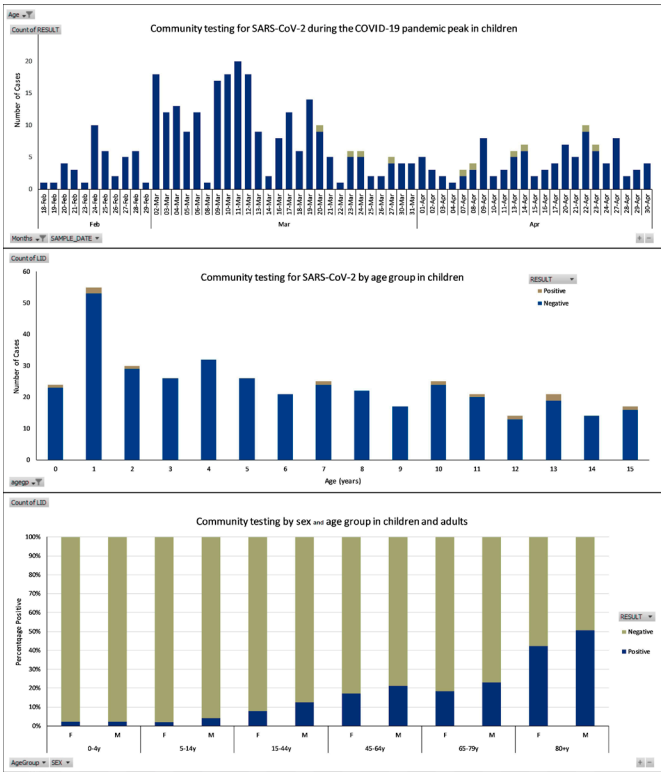

Figure 5 Number of children with acute respiratory infection who were tested for severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) in general practices across England over the course of the pandemic (A) and by age (B). Figure 3C depicts the proportion of individuals with acute respiratory infection who tested positive by age and sex in England.

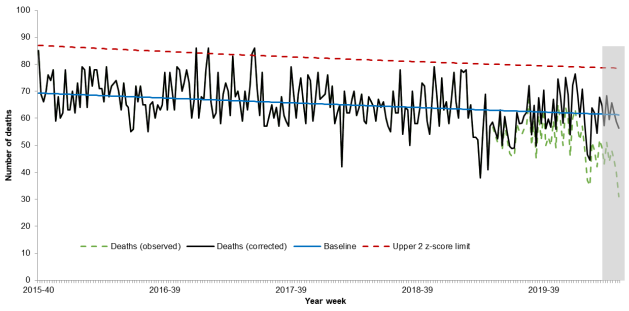

Figure 6 Observed, delay-corrected and expected all-cause deaths in children aged 0–15 years in England from 2015 (week 40) to 2020 (week 18). Data are shown by week of death.

Mortality surveillance

There has been no increase in excess deaths in children aged 0–15 years until 3 May 2020 (figure 6). Between weeks 12 and 18 of 2020, where excess deaths have been reported in other age groups, the cumulative number of corrected daily deaths in children was one fewer than the expected number for this period when compared to the same period in the pre-COVID-19 era.

DISCUSSION

The experience in England adds to the growing body of evidence on the limited role of children in the COVID-19 pandemic, with just over 1% of confirmed cases occurring in children. Infants, especially those children aged <3 months and those aged 1 year were the most tested age groups and had the highest number of positive cases. With nearly half a million SARS-CoV-2 tests performed during the first 4 months of 2020, the positivity rate among 35 200 children tested was only 4.0% compared with 19.1%–34.9% in adults and older adults. Community testing of children presenting in primary care with acute respiratory infection identified very low rates of SARS-CoV-2 positivity (2.8%) even at the peak of the pandemic, especially among preschool and primary school-aged children. This contrasts with the higher positivity rates with increasing age in adults, reaching nearly 50% in those aged ≥80 years. Currently, SARS-CoV-2 positivity rates in the community are low across all age groups.[14] Reassuringly, the case-fatality rate in children was below 0.5% with no evidence of excess mortality during the first peak of the COVID-19 pandemic in England.

Other countries with widespread SARS-CoV-2 testing practices have all reported low COVID-19 rates in children, who accounted for only 1%–3% of total confirmed cases.[3] Inclusion of negative test results provides further reassurance of the large numbers of tests performed across all age groups, including children. The lower risk of COVID-19 may be due to lower expression of the cell surface enzyme ACE2 in the nasal epithelium of children compared with adults.[15] This binds to the SARS-CoV-2 spike protein and promotes internalisation of the virus into human cells. Although clinical follow-up of childhood cases is ongoing, our initial assessment based on the source of paediatric testing suggests that around half the confirmed cases were hospitalised, which compares with 33% in the USA and 67% in Italy.[16 17] Those that were not hospitalised were mainly during the containment phase when close contacts of confirmed cases,

specifically children of key workers, were screened for the virus, along with children attending the emergency department with acute respiratory infections.

A key unanswered question remains whether asymptomatic children might be contributing to community transmission of SARS-CoV-2. Reports of asymptomatic carriage in children are mainly from active follow-up of contacts of confirmed cases or screening children without adequate follow-up to determine whether they were presymptomatic or truly asymptomatic,[18] as has been reported in adults.[19] Although community testing of SARS-CoV-2 in England was not as widespread as some other countries, especially during the peak of the pandemic, our data found that only 4.0% of children nationally and only 2.8% of symptomatic children with acute respiratory infection in the community tested positive for SARS-CoV-2.

In Iceland, only 38/564 (6.7%) children aged <10 years who were symptomatic, had recently travelled to high-risk countries or had contact with infected persons, were positive compared with 1183/8635 (13.7%) individuals aged ≥10 years.[20] The difference was more marked in population screening during lockdown when daycare and elementary schools remained open, yet none of 848 children aged <10 years were positive compared with 100/12 232 (0.8%) in children aged ≥10 years.[21] In the Netherlands, community testing of patients presenting with acute respiratory infection in primary care also did not identify SARS-CoV-2-positive children.[22] Additionally, children were never the first to be infected or to be the source of infection in the household.[22] This is supported by other household transmission studies where children of confirmed cases, especially those aged <10 years, were significantly less likely to be SARS-CoV-2 positive or becoming symptomatic when compared with adults in the same household.[23 24] This also applies in educational settings. In New South Wales, Australia, 9 students and 9 staff from 15 schools had confirmed COVID-19 and 735 students and 128 staff were identified as close contacts.[25] No teacher or staff member, and only one child from a primary school and one child from a high school, may have contracted COVID-19 from the initial school cases.[25]

An unintended consequence of the COVID-19 lockdown on children has been that the national 'Stay at Home' message, along with concerns about acquiring COVID-19 in hospital, discouraged parents from seeking medical help, resulting in large reductions in emergency department attendances and hospitalisation than in previous years.[26 27] This has led to significant concerns about delayed presentations and potentially avoidable fatalities.[17] Reassuringly however, we were unable to identify any overall excess childhood mortality in England. This contrasts with adult data using the same methodology where high levels of excess mortality were observed in all but the age group of 0–14 years, and especially among those aged ≥85 years. In England alone, there were an estimated 56 456 all-cause excess deaths during the 2 months since 16 March 2020.[28]

Finally, the very low childhood case-fatality rate is reassuring and consistent with the global literature.[1] In England, regular prospective data linkage using multiple sources allowed rapid capture and follow-up of fatal cases. Recently, however, a small number of children in England presented with hyperinflammatory shock and mixed features of atypical Kawasaki disease and toxic shock syndrome; these children progressed to warm, vasoplegic shock, requiring volume resuscitation and inotropic support.[29] Since then, similar cases with varying presentations and severities have been reported in other countries that have experienced the COVID-19 pandemic.[30] Investigations are ongoing to assess the temporal association with SARS-CoV-2.

Strengths and limitations

The strength of this study is the establishment of a single national surveillance hub with access to multiple local and national data sources in near real-time. The availability of total tests performed was critical to assess any effects of test shortages and changes in testing recommendations. The data also provided insight into the age distribution of confirmed COVID-19 cases; the large numbers of tests performed in infants aged <3 months suggested wider testing, potentially including those born to SARS-CoV-2-positive pregnant women. The outcomes of SARS-COV-2-positive neonates and of infants born to SARS-CoV-2 mothers are being assessed in a national prospective study currently underway in the UK and Ireland.[7] Similarly, the large number of tests and positive results in older infants and children aged 1 year is likely to reflect wider testing for SARS-CoV-2 in these age group because of frequent presentations with non-specific febrile illnesses. Collecting data across the age groups allowed comparison of children with adults for test positivity overall and in community surveillance of acute respiratory infections in primary care. Limitations include the suboptimal sensitivity of nasopharyngeal and oropharyngeal swabs for SARS-CoV-2.[31] The lack of reliable serology during the pandemic also meant that cases could not be confirmed retrospectively. Important questions still remain unanswered. We need more information on asymptomatic childhood SARS-CoV-2 infection and transmission as well as seroincidence studies in community and educational settings. Such studies are underway (https://www.gov.uk/guidance/covid-19-paediatric-surveillance) and will become particularly important to ease the lockdown and allow children and teachers safely back to school, and to understand transmission patterns should a second peak emerge.

CONCLUSIONS

England is currently nearing the end of the first peak of the COVID-19 pandemic. Consistent with other countries, children account for a very small proportion of confirmed cases and have very low case-fatality rates. Despite the large number of children tested, only 4% were positive for SARS-CoV-2. In the community, SARS-CoV-2 positivity was low even in children presenting with acute respiratory infections. Community transmission and serosurveillance will become increasingly important as lockdown measures are gradually eased.

Contributors SNL is responsible for national surveillance of COVID-19 surveillance in children at Public Health England. All contributed to the results, interpretation and discussion.

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Competing interests None declared.

Patient consent for publication Not required.

Ethics approval Public Health England (PHE) has legal permission, provided by Regulation 3 of The Health Service (Control of Patient Information) Regulations 2002, to process patient confidential information for national surveillance of communicable diseases. This includes PHE's responsibility to monitor the safety and effectiveness of vaccines, and as such, individual patient consent is not required. PHE's Caldicott Guardian approved the collection of data by RCGP RSC to support national surveillance.

Provenance and peer review Not commissioned; internally peer reviewed.

Data availability statement All data relevant to the study are included in the article or uploaded as supplementary information. No additional data available.

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