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Prevalence of COVID-19 in children, adolescents and adults in remote education situations in the city of Fortaleza, Brazil

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ABSTRACT

Objectives: A retrospective study was conducted to identify the prevalence of COVID-19 through serology and RT-PCR in children, adolescents and adults. A database of the COVID-19 Tracking Program in school children was used.
Methods: The data comprised sociodemographic and clinical variables, results of serological tests (IgM and IgG), and real-time-polymerase chain reaction (RT-PCR) results of IgM-positive individuals. The statistical analysis was performed with a 5% significance level.
Results: Among 423 children, 107 (25.3%) exhibited seroprevalence with IgG, IgM or IgG/IgM; among 854 adolescents, 250 (29.2%) had positive serology; and among 282 adults, 59 (20.9%) were positive. The frequency of positivity on RT-PCR for SARS-CoV-2 was 3.5%, 3.6% and 6.0% in children, adolescents and adults, respectively. Children had a lower incidence of symptoms than adolescents ($p = 0.001$) and adults ($p = 0.003$); the most frequent were fever, ageusia, anosmia, headache, dry cough, sore throat, muscle pain, runny nose, dyspnoea, and diarrhoea.
Conclusions: The prevalence rate for all groups was 26.7% in serology and 4.04% in RT-PCR. Children had lower rates of IgM and fewer symptoms compared with adolescents and adults. The data suggest the potential for transmissibility in all age groups.

Introduction

In late 2019, the outbreak of an emerging disease (COVID-19) due to a new coronavirus, later called SARS-CoV-2, emerged in Wuhan, China, and rapidly spread worldwide (Lai et al., 2020). Coronaviruses are simple positive-sense RNA viruses that have a large characteristic genome (Wang et al., 2020). In humans, the coronavirus that causes respiratory infection belongs to the genus *Betacoronavirus*, originating in bats. SARS-CoV-2 has approximately 79% sequence similarity to SARS-CoV (Lu et al., 2020). As the number of cases rapidly increased and the disease reached hundreds of countries, the World Health Organization (WHO) declared the COVID-19 epidemic as a pandemic on 12 March 2020 (WHO, 2021a).

Until 20 April 2021, SARS-CoV-2 had infected approximately 141,594,845 people, killing more than 302,139,776 in 223 countries and causing social and economic disruption worldwide. Brazil has been severely affected with a total of 374,682 deaths (WHO, 2021a); of these, 78,118 occurred in the northeast, with 162,357 in the state of Ceará (Brasil, 2021a). In Ceará, almost half the deaths (6303 deaths) were concentrated in Fortaleza, the state capital (Brasil, 2021b).

COVID-19 has impacted many populations, with distinct clinical repercussions correlated with age groups. In comparison with

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adults, the clinical expression of the largest proportion of the paediatric group presents few symptoms. Oligosymptomatic and asymptomatic patients maintain their transmission capacity and are therefore agents of significant epidemiological impact (Dong et al., 2020; Ludvigsson, 2020; Zou et al., 2020). The paediatric group represents about 1% of hospitalised cases and deaths (Castagnoli et al., 2020). The most common symptoms described at the onset of the disease are fever (50%) and mild cough (38%) (Jiehao et al., 2020); other clinical features include sore throat, rhinorrhoea, sneezing, myalgia, fatigue, diarrhoea, and vomiting.

Children may experience more upper airway problems than lower respiratory symptoms (Dong et al., 2020) and appear to recover in 1–2 weeks (Cao et al., 2020). For this reason, school closures have been implemented almost everywhere globally to prevent the potential spread of COVID-19 (Cohen et al., 2020). Educational institutions have had to remain closed due to the COVID-19 pandemic, as part of the effort to ensure social distancing to contain the transmissibility of the disease (Shah et al., 2020). Children are seen as important transmitters of COVID-19 (Macartney et al., 2020). In Brazil, a special regime for remote school activities was adopted as of 19 March 2020, under MEC Ordinances nº 345, which authorised teaching activities using digital educational resources, information and communication technologies, or other conventional means in public and private schools (Brasil, 2020).

Although some teaching and learning activities can be carried out through the remote mode and the closure of schools is a crucial measure of containment, it must be noted that the disruption of regular classroom education has significant social and economic impacts on society at regional, national and global levels (Macartney et al., 2020). Children from disadvantaged backgrounds are more likely to suffer from school closure, not only in terms of academic learning but also due to loss of access to free school meals and social services (Viner et al., 2020).

During the remote learning period, conflicts between educational institutions, public administrators, educators, and parents have been fuelled by the lack of certainty about how safe it is for children to attend school and how long the remote learning period should last; questions that have been very carefully dealt with by other countries (Ismail et al., 2021). To fill these information gaps, epidemiological studies seek to provide data to support the formulation of care strategies at different levels, to mitigate the risk of spreading SARS-CoV-2 and its variants, in addition to helping governments to take informed and safe decisions regarding the ideal time to reopen schools. In this sense, to prevent a further increase in the number of COVID-19 cases, relaxation of physical distancing, including the reopening of schools, must be accompanied by large-scale testing of symptomatic individuals and effective tracking of their contacts, followed by isolation of diagnosed individuals (Panovska-Griffiths et al., 2020).

Thus, the present study aimed to verify the prevalence of COVID-19 in children, adolescents and adults during a period of remote education, combining serological and molecular diagnosis, and correlating with epidemiological and clinical characteristics.

Methods

Study type

This was a transversal retrospective study guided by the STROBE tool. The study was conducted by the Institute of the Heart of Children and Adolescents (InCor Criança) in partnership with the municipality of Fortaleza, a city located in north-eastern Brazil. Incor Criança is a philanthropic health institution with a mission to provide comprehensive and equitable care to the paediatric population. The city of Fortaleza is the capital of the State of Ceará, with a population of 2,686,612, of which 852,195 are children and adolescents: 378,175 between the ages of 0–9 years and 474,020 between 10–19 years (IBGE, 2021). The city is divided into six educational districts geographically distributed to encompass its entire territory. The education network in Fortaleza is made up of municipal and state schools. The study was carried out in municipal schools responsible for early childhood education and elementary education.

This study was conducted in compliance with the Declaration of Helsinki and submitted to the medical ethics review board of the Hospital Universitário Walter Cantídio, which reviewed and approved (approval number: CAAE: 43505120.0.0000.5045) the ethical aspects of the research. All parents/guardians and educators were informed about the study's purpose and consented to the collection of data by signing the informed consent form.

Samples

A multistage sampling procedure was used to recruit children, adolescents and adults. Cluster sampling was used between the schools belonging to each of the city's six educational districts. Children, adolescents and adults were excluded if they had any medical condition that prevented or hindered their school attendance. The study subjects were divided into three age groups: children aged up to 9 years; adolescents aged 10–19 years; and adults aged >19 years (WHO, 2014), who were school employees. The sample size for the groups of children and adolescents was defined based on the total number of students in the municipal education network (229,165 students) for a 95% confidence level and an accuracy level of 2.5%, totalling 1277 students. The sample of the adult group was made up of all the employees (teachers and administrative professionals) who participated in classroom activities in the schools and who had contact with students during the delivery of supplies (food and school supplies), totalling 282 individuals (Table 1).

Data collection

Data collection was carried out in February 2021 through a data search on the online RedCap platform to gather sociodemographic, clinical and laboratory data from the target individuals studied during the COVID-19 screening carried out from 09 November to 09 December 2020. The tracking period coincided with the

Table 1
Sample distribution in each educational district.

District	Total students	Distribution by district	N of students	N of adults
I	32,807	12.61%	161	33
II	35,271	16.84%	215	55
III	31,969	11.20%	143	48
IV	40,230	22.94%	293	57
V	42,612	19.97%	255	61
VI	46,276	16.44%	210	28
Total	229,165	–	1277	282

beginning of the second wave of the pandemic, with a moving average value equal to 451.9 cases, 53.44% less than the time series' peak, which was 970.6 cases in May 2020 (Figure 1).

The screening was conducted by a doctor, nurse and six laboratory technicians trained to conduct interviews and clinical evaluations and collect peripheral blood for serology and nasopharyngeal secretions to detect SARS-CoV-2 with real-time-polymerase chain reaction (RT-PCR). The data for each stage was entered into RedCap, which had three parts: (1) sociodemographic data (name, sex, age, weight, number of inhabitants per household, and family's economic status); (2) clinical screening for COVID-19 (symptoms, comorbidities, sick contacts); and (3) results of serological tests for IgM and IgG and results of RT-PCR for the detection of SARS-CoV-2.

The study participants initially underwent screening and when signs or symptoms suggestive of COVID-19 were detected, they were directed to a private environment for an interview, clinical evaluation and collection of tests. Individuals were considered symptomatic when they presented signs or symptoms such as fever, cough, rhinorrhoea, dyspnoea, chest pain, sore throat, ageusia and anosmia, adynamia, muscle pain, diarrhoea, headache, vomiting, or skin changes (Cao et al., 2020; Dong et al., 2020; Jiehao et al., 2020). They were considered asymptomatic when they had no signs or symptoms of the disease. Those without signs or symptoms went through the same screening process in another environment and all the sanitary measures of hygiene and social distancing were taken, as appropriate to the pandemic moment. Individuals who presented positive serology for IgM or IgM and IgG were submitted to nasopharyngeal and oropharyngeal secretion collection for RT-PCR analysis.

Serological assays

Peripheral blood samples were collected from participants by finger puncture. The presence or absence of IgM and IgG antibodies against SARS-CoV-2 was analysed using the Leccurate SARS-CoV-2 Antibody Test kit (Beijing Lepu Medical Technology Co., Ltd.), which uses a colloidal gold chromatographic immunoassay technique. According to the manufacturer's specifications, the protein used for diagnosis is N (nucleocapsid), with a sensitivity of 98.9% and specificity of 97.6%.

SARS-CoV-2 RT-PCR methods

Soon after collection, nasopharyngeal and oropharyngeal secretions were sent to the Laboratory of Biotechnology and Molecular Biology (LBBM) of the State University of Ceará. Each sample was inactivated by heating at 55 °C for 30 min. Detection of the SARS-CoV-2 virus was performed using a commercial kit [MOLECULAR KIT SARS-CoV-2 (E) Bio-Manguinhos — Berlin Protocol (Corman et al., 2020)] based on PCR in real-time with fluorescent probes. The RNA extraction of 160 μL from the biological sample then started, following the protocol of the MGIEasy Nucleic Acid Extraction kit (item no. 1000020261) and adapting the MGISP-960 equipment program to the protocol. The controls were then aliquoted, and the thermocycler was programmed with an initial cycle of 45 °C for 15 min, then 95 °C for 2 min and 40 cycles of 95 °C for 15 s and 58 °C for 30 s. Sample analysis was verified based on the number of cycle threshold values (CT) obtained, being considered positive when they presented CT $\leq$ 40 for the E gene and CT $\leq$ 35 for the RP. The samples were considered negative if CT > 40 for the E gene and CT > 35 for the RP (Corman et al., 2020).

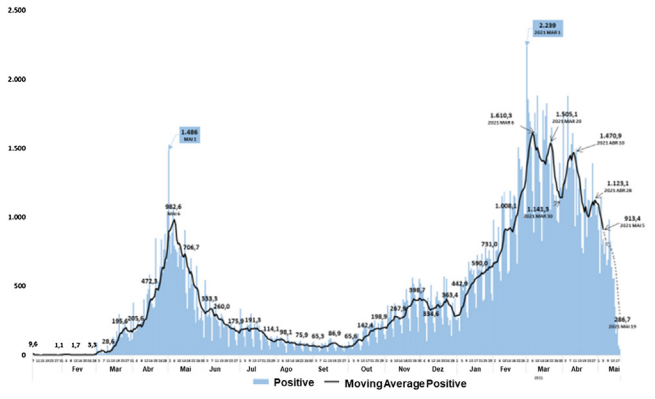

Figure 1. Distribution of confirmed cases of COVID-19 and moving average in Fortaleza-CE, from January 2020 to May 2021.
Source: Integra SUS — Indicators/SESA — COVID-19 — Updated May 25, 2021, at 9:30 am. Labels with seven-day moving average values presented at fifteen-day intervals. The cases are arranged daily according to the date of onset of symptoms.

Statistical analysis

In analysis of the participants' characteristics between serology groups and age groups, the Student's t-test and the Mann–Whitney U test were used, verifying the non-adherence of the data to the Gaussian distribution. When investigating the association between categorical variables, Pearson's Chi-square test and Fisher's exact test were used. A significance level of 5% was adopted. Statistical analyses were performed using the statistical program JAMOVI and Microsoft Excel 2016. The research data were expressed in tables and graphs. The numerical variables were expressed as mean, standard deviation, minimum and maximum. The categorical variables in the data were exposed in frequency and incidence rate.

Results

Children and adolescents

Of the 1277 children and adolescents who were surveyed, 649 (50.8%) were female. Their ages ranged 3.8–18.7 years, with a mean of 11.3 years (SD ± 2.7). When evaluated by age group, there were 423 students aged <9 years (33.1%) and 854 aged 10–19 years (66.9%).

The socioeconomic assessment of the families of children and adolescents showed that 33% of the providers were unemployed, 26.1% were employed and 36.4% were self-employed. A total of 20.8% of families lived on less than US$207 per month, and the income of 75.6% of families was between US$207–621; 74.1% participated in social programs and 41.2% in exceptional social protection measures to face the pandemic (emergency aid).

Children and adolescents expressed 28% seroprevalence; children with a prevalence of 25.3% distributed in IgM + IgG (4.7%), IgG (18%) and IgM (2.6%) and adolescents with a prevalence of 29.2% distributed in IgM + IgG (9.7%), IgG (15.3%) and IgM (4.2%) (Table 2).

The majority (73.7%) were asymptomatic at the time of the evaluation or in the last 21 days. The remaining (26.3%) had

Table 2
Distribution of serological results and RT-PCR in relation to age groups.

Group	Age range		
	≤9 years	10–19 years	Adults
IgM + IgG	20 (4.7%)	83 (9.7%)	24 (8.5%)
IgG	76 (18.0%)	131 (15.3%)	21 (7.4%)
IgM	11 (2.6%)	36 (4.2%)	14 (5.0%)
Negative	316 (74.7%)	604 (70.7%)	223 (79.1%)
Total	423	854	282

symptoms such as fever (16.2%), ageusia (11.5%), anosmia (10.9%), headache (9.5%), dry cough (8.1%), sore throat (7.8%), muscle pain (5%), runny nose (4.8%), dyspnoea (2.8%), diarrhoea (2.8%), adynamia (2.2%), vomiting (1.7%), chest pain (0.6%), hives (0.6%), and pruritus (0.3%). Children and adolescents with positive serology had comorbidities in 32.2%, with those associated with atopy components being more frequent, such as respiratory in 8.4% and cutaneous in 17.4%.

When the contacts of children and adolescents were assessed for serology for IgM with symptomatic family members in the last 21 days before testing, it was found that 6.5% of IgM-positive children and 3.9% of IgM-negative children remained in contact, without statistical significance (p = 0.626). In adolescents, 5.9% of positive IgM and 2.3% of negative IgM maintained contact, with no statistical significance (p = 0.200).

The seropositive prevalence rate was highest in district III (37.8%), followed by districts I, II, IV, V, and VI at 34.2%, 31.6%, 29.7%, 21.6%, and 18.1%, respectively.

RT-PCR tests were performed on 150 children and adolescents who expressed IgM or IgM + IgG, 52% of whom were female. Their ages ranged 6.5–16 years, with a mean of 11.24 years (SD ± 2.41), and in those who tested negative, ages ranged 5.3 to –17.5 years, mean 12.35 SD ± 2.44. Of the 31 children tested, SARS-CoV-2 was detected in 48.4%, which represents 3.5% of the total children analysed. Among adolescents, 26.1% tested positive, which was 3.6% of the total sample. It was observed that children aged <9 years were 2.6 times more likely (95% CI 1.17–6.01) to present positive RT-PCR compared with adolescents (p = 0.018) (Table 3). Of those with positive RT-PCR, 76.1% were asymptomatic at the time of the exam or in the past 21 days. The symptomatic children and adolescent (23.9%) presented fever (20%), ageusia (11%), headache (11%), anosmia (9%), sore throat (9%), muscle pain (7%), dry cough (7%), diarrhoea (4%), vomiting (2%), adynamia (2%), and hives (2%).

Adults

Of the 282 adults who were evaluated, 207 (73.4%) were female. Their ages ranged 19–72 years, with an average of 45.38 years (SD ± 10.17). Of these, 59 (20.9%) were confirmed with positive serology, distributed between IgM (5%), IgG (7.4%) and IgM + IgG (8.5%) (Table 2). Of those who tested with positive serology (IgG, IgM, or IgM + IgG), 45.8% were asymptomatic at the time of the evaluation or in the last 21 days. There were symptoms in 54.2%, such as ageusia (32%), fever (29%), headache (27%), anosmia (24%), muscle pain (20%), dyspnoea (19%), adynamia (19%), sore throat (19%), runny nose (17%), dry cough (12%), chest pain (8%), diarrhoea (7%), vomiting (7%), hives (7%), and others (2%).

Of the 37 adults who expressed IgM or IgM + IgG, 17 (45.9%) tested positive for the detection of SARS-CoV-2 by RT-PCR, which represented 6.0% of the sample. Of these, nine (52.9%) were female. Ages ranged 28–61 years, with a mean of 45.9 years (SD ± 9.9), as shown in Table 3.

In adults with positive RT-PCR, 52.9% were asymptomatic at the time of assessment or in the past 21 days. They were symptoms in 47.1% such as ageusia (35.3%), headache (35.3%), anosmia (29.4%), adynamia (29.4%), sore throat (23.5%), fever (23.5%), muscle pain (17.6%), runny nose (17.6%), and chest pain (11.8%), and dyspnoea, vomiting, dry cough, and allergy with (5.9%) each.

When comorbidities were evaluated for the group of adults with positive RT-PCR, the most frequent were hypertension (23.5%), allergy (11.8%), diabetes mellitus (5.9%), hypercholesterolemia (5.9%), and asthma (5.9%).

Correlation between age groups

When analysing the prevalence of positive serology for COVID-19 among the age groups, a significant association was detected between these variables (p = 0.017), with adults showing the lowest prevalence (20.9%) when compared with adolescents (29.3%; p = 0.018). There was no difference in the prevalence of positive serology for COVID-19 between children and adolescents and between children and adults.

In the analysis of IgM prevalence in the age groups, there was a significant difference in the prevalence rate between children and adolescents (p = 0.003), where children aged <9 years presented 7.3% of IgM positivity against 13.9% of adolescents. Children also had a lower prevalence rate than adults (13.5%; p = 0.021). When comparing adolescents and adults there was no difference between the prevalence rates of IgM positivity (p = 0.846).

In the analysis of the prevalence of IgG in the age groups, making Bonferroni correction in the analysis, there was no significant difference in the prevalence rate between children and adults (p = 0.084), where children aged <9 years showed 22.7%

Table 3
Symptom assessment for individuals who tested positive for serology and RT-PCR.

	N	≤9 years	10–19 years	Adults	p
Positive serology	416 (26.7%)	107 (25.3%)	250 (29.3%)[a]	59 (20.9%)[b]	0.017
PCR +	63 (33.7%)	15 (48.4%)[a,b]	31 (26.1%)[c]	17 (45.9%)[b]	0.014
Symptomatic	367 (23.5%)	71 (16.8%)[a,b]	219 (25.6%)[c]	77 (27.3%)[c]	0.001
Symptoms					
Fever	232 (14.9%)	53 (12.5%)	141 (16.5%)	38 (13.5%)	0.130
Dry cough	142 (9.1%)	42 (9.9%)	74 (8.7%)	26 (9.2%)	0.759
Coryza	93 (6.0%)	26 (6.1%)	44 (5.2%)	23 (8.2%)	0.179
Chest pain	24 (1.5%)	4 (0.9%)[a]	8 (0.9%)[a]	12 (4.3%)[b,c]	<0.001
Sore throat	143 (9.2%)	38 (9.0%)[a]	66 (7.7%)[a]	39 (13.8%)[b,c]	0.009
Headache	164 (10.5%)	44 (10.4%)	80 (9.4%)	40 (14.2%)	0.073
Dyspnoea	78 (5.0%)	8 (1.9%)[a,b]	43 (5.0%)[a,c]	27 (9.6%)[b,c]	<0.001
Fatigue	58 (3.7%)	11 (2.6%)[a]	24 (2.8%)[a]	23 (8.2%)[b,c]	<0.001
Anosmia	121 (7.8%)	10 (2.4%)[a,b]	83 (9.7%)[c]	28 (9.9%)[c]	<0.001
Ageusia	143 (9.2%)	14 (3.3%)[a,b]	93 (10.9%)[c]	36 (12.8%)[c]	<0.001
Vomiting	42 (2.7%)	12 (2.8%)	20 (2.3%)	10 (3.5%)	0.544
Diarrhoea	47 (3.0%)	12 (2.8%)[a]	20 (2.3%)[a]	15 (5.3%)[b,c]	0.039
Muscle pain	102 (6.5%)	12 (2.8%)[a,b]	56 (6.6%)[a,c]	34 (12.1%)[b,c]	<0.001

Data expressed in n (%).
Pearson's Chi-square test.
[a] p < 0.05 vs. adults.
[b] p < 0.05 vs. adolescents.
[c] p < 0.05 vs. children.

IgG positivity versus 16% of adults; adults also had a higher prevalence rate than adolescents (25.1%; p = 0.006). In the comparison between children and adolescents there was no difference between the prevalence rates of IgM positivity (p = 0.354).

In the analysis of the prevalence of PCR+ in the age groups, making Bonferroni correction in the analysis, among those who performed the RT-PCR test, there was a significant difference in the prevalence rate between children and adolescents (p = 0.048), where children aged <9 years presented 48.4% of positive PCR against 26.1% of adolescents; children did not have a different prevalence rate than adults (45.9%; p = 0.841). The same occurred in the comparison between adolescents and adults, in which there was no difference between the prevalence rates of PCR positivity (p = 0.066).

As for the presence of symptoms of COVID-19 on the day or up to 21 days before the exam, there was a significant association of this variable as the age group (p = 0.001), where those aged <9 years had the lowest incidence of symptoms compared with adolescents (p < 0.001) and adults (p = 0.003). Children and adolescents had fewer comorbidities than adults. The most frequent in this last group were hypertension, diabetes mellitus, hypercholesterolemia, and cancer.

In the analysis of the symptoms of the three groups, both serology and positive RT-PCR, there was a significant association with age group: chest pain and fatigue (both p < 0.001); sore throat (p = 0.009) and diarrhoea (p = 0.039), with a higher incidence in adults and no difference between children and adolescents. Muscle pain and dyspnoea (p < 0.001) had a difference in incidence between the three age groups, in which children aged <9 years had the lowest incidence of these symptoms and adults the highest incidence. Anosmia and ageusia (p < 0.001) had a lower incidence among children aged <9 years and no difference between adolescents and adults.

Estimates of children and adolescents with positive serology and RT-PCR in Fortaleza

It was observed that 7.3% of the population of children and 13.9% of adolescents had positive IgM or IgM and IgG; 18% of children and 15.3% of adolescents had positive IgG; and 3.5% of children and 3.6% of adolescents had positive RT-PCR. The prevalence rate of serology and RT-PCR identified in this study applied to the population of children and adolescents allowed it to be inferred that between 09 November–09 December 2020, in Fortaleza, there were 93,194 individuals positive with IgM or IgM + IgG; 140,596 individuals with positive IgG; and 30,300 individuals with SARS-CoV-2 confirmed by RT-PCR (Table 4).

Discussion

This study evaluated the results of RT-PCR for SARS-CoV-2 and serology for IgM and IgG, and their correlations with epidemiological and clinical variables in order to verify the prevalence of COVID-19 in children, adolescents and adults in the municipal health system education in Fortaleza, Brazil, during the remote education period coinciding with the rise of the second infection wave of the COVID-19 pandemic (Figure 1) from 09 November to 09 December 2020. A significant difference in the prevalence of IgM in children and adolescents was noticed, where children presented 7.3% IgM positivity against 13.9% of adolescents; children also had a lower prevalence rate than adults (13.5%). Comparing adolescents and adults, there was no difference between the prevalence rates of IgM positivity. The lower vulnerability in children may result from lower individual organic susceptibility, added to lower contaminating and effective infective exposure. These inferences are supported by authors like Dong et al. (2020), Lee et al. (2020) and Weisberg et al. (2021).

No significant difference was observed between children and adults and between adolescents and adults regarding the prevalence of positive RT-PCR. However, there was a significant difference in the prevalence rate between children and adolescents, where children aged <9 years had a higher positivity rate, with 2.6 times greater positivity in RT-PCR. Of the total number of individuals assessed in the study – 1227 children and adolescents and 282 adults – the estimated rate for positive RT-PCR was 3.5% in children, 3.6% in adolescents and 6% in adults. In a study carried out with 605 children, Cohen et al. (2020) demonstrated that the RT-PCR test and serology were positive for 1.8% and 10.7% of all children, respectively. The frequency of positivity in the RT-PCR for SARS-CoV-2 was significantly higher in children with positive serology than those with negative serology. In a preliminary investigation with adults and symptomatic school students in France, Fontanet et al. (2020) showed that 16.7% of adults and 8.3% of students had an acute infection, as determined by a positive RT-PCR test.

Since antibodies (IgM/IgG) against SARS-Cov-2 are only detectable around day 7 from the onset of symptoms (in approximately 50% of cases), a negative serological result during the first 7 days of the disease cannot be used as criteria to rule out a case (Sethuraman et al., 2020). Sensitivity in the detection of total antibodies increases from the second week after the onset of symptoms and by the 14th day >90% of patients have already developed antibodies (detectable by ELISA). However, the detection of antibodies only indicates previous contact with the virus and does not define the moment at which this contact occurred. Serological tests (ELISA tests and rapid tests) are not considered diagnostic tests. Their results must be carefully evaluated in the light of clinical information, the results of other tests and the epidemiological context. Thus, implementation should be mainly focused on epidemiological research and seroprevalence studies (PAHO/WHO, 2020).

Data found by Yongchen et al. (2020) demonstrated that individuals had specific positive serology for the virus, despite the absence of genetic material in RT-PCR. This fact can be explained by to the period in which the virus can be detected. Some researchers have shown that this occurs from 1 to 2 days before the onset of symptoms in samples of the upper respiratory tract, which can persist for 7–12 days in moderate cases and up to 2 weeks in severe cases (WHO, 2021b), and others point to around 20 days (Chen, 2020; Lippi et al., 2020; To et al., 2020; Xiao et al., 2020). However, this period cannot be taken as the rule, as another screening study that compared RT-PCR and serology showed that whoever presents with positive serology may or may not have circulating viral RNA (Cassaniti et al., 2020).

This study demonstrated that 73.7% of children and adolescents who were seropositive and 76.1% of those virologically confirmed by RT-PCR were asymptomatic at the time of evaluation or in the last 21 days. The most frequent symptoms in children and adolescents were fever, ageusia, anosmia, headache, dry cough, and sore throat. The literature is unclear regarding the percentage and type of symptoms that are more prevalent in this group. Cohen

Table 4
Estimated prevalence for the paediatric population of Fortaleza-CE, distributed in IgM, IgG and RT-PCR.

Population	0–9 years N = 378,175	10–19 years N = 474,020	N 852,195
IgG prevalence rate	(18%) 68,071	(15.3%) 72,525	140,596
IgM prevalence rate	(7.3%) 27,606	(13.9%) 65,588	93,194
RT-PCR prevalence rate	(3.5%) 13,236	(3.6%) 17,064	30,300

et al. (2020) showed that in 605 children tested, 53.2% were asymptomatic. In a review of 2143 paediatric cases, Dong et al. (2020) demonstrated that in virologically confirmed children, 13% were asymptomatic. Jiehao et al. (2020) described the most common symptoms such as fever (50%) and mild cough (38%); other clinical features included sore throat, runny nose, sneezing, myalgia, fatigue, diarrhoea, and vomiting. Dong et al. (2020) highlighted that children might have more problems in the upper airways than lower respiratory symptoms. Thus, epidemiological inferences may not represent the reality, as asymptomatic children are less likely to be tested and still contribute to transmission (Dong et al., 2020). Corroborating this statement, Zou et al. (2020) analysed the relationship between viral load and symptoms of infection in 18 patients with COVID-19 and found that the pattern of viral nucleic acid excretion in those with SARS-CoV-2 infection was similar to influenza and that the viral load determined in asymptomatic patients was similar to patients with symptoms, which indirectly suggested the potential for transmission in asymptomatic or mild cases with COVID-19. Maltezou et al. (2021) suggested that the transmission direction is from adult to child; however, since the study was based on the dates of the PCR test and because adults have symptoms in greater proportions than children, more adults may be identified first, and positive children may be assessed as secondary cases. When comparing the groups regarding the presence of symptoms, children had fewer symptoms than adolescents, and both less than adults. Among the symptoms reported by participants in the three groups, chest pain, sore throat, muscle pain, dyspnoea, fatigue, and diarrhoea were more prevalent in the adult group.

Several reports have shown that children and young adults experience a milder form of the disease than adults. Asymptomatic, mild and moderate infections are present in >90% of all children who have tested positive for COVID-19. Critical cases represent 5.9% in children, which is different from adults, who express rates of 18.5% (Dong et al., 2020). Possible reasons for the lower number and degree of infections in children and young adults include less exposure to the virus due to home isolation and less exposure to pollution and cigarette smoke, contributing to healthier airways. The distribution, maturation and functioning of viral receptors such as ACE2 (Angiotensin Converting Enzyme) may be important in susceptibility to severe, age-dependent COVID-19 (Dong et al., 2020; Lee et al., 2020). Another reason for infections with less impact in the paediatric group is the lower abundance of anti-N-specific antibodies, since the release of N proteins requires the lysis of cells infected by the virus (Weisberg et al., 2021).

Publications highlight the increase in the home infection rate by the proportion of family groups with at least one member presenting COVID-19 infection (Hubiche et al., 2021) or refer that the majority of infected children are likely to be secondary to exposure to a confirmed adult COVID-19 case (Jiehao et al., 2020). The current study found no association between children and adolescents seropositive for IgM and contact with a family member with COVID-19. Hubiche et al. (2021) and Jiehao et al. (2020) agreed that intra-family transmission is not yet fully understood, and requires longitudinal data to confirm these inferences. A French study evaluating the spread of COVID-19 concluded that in the context of increased viral transmission in the population, the spread among children and adolescents remained lower than that observed among adults, despite keeping schools open; however, the impact was age-dependent, with data from high schools close to that of adults (Guen et al., 2021). A study of infection and transmission in England showed a significant correlation between outbreaks in educational settings and the incidence of COVID-19 in the community, even during a period of low incidence in the community (Ismail et al., 2021).

Another characteristic of children and adolescents was the low frequency of associated diseases. Adults had more comorbidities represented by hypertension, diabetes mellitus, hypercholesterolemia, and cancer. It is worth mentioning that the comorbidities preceding COVID-19 – such as cardiovascular disease, chronic kidney disease, chronic lung diseases, diabetes mellitus, hypertension, immunosuppression, obesity, and sickle cell anaemia – predispose to an unfavourable clinical course, with increased risk of intubation and death (Cecconi et al., 2020; Huang et al., 2020; Zhou et al., 2020). Almost 90% of fatal cases have occurred in patients aged ≥65 years (Tehrani et al., 2021). On average, it has been observed that it is rare for infected children to be hospitalised and <1% of paediatric cases can be fatal (Pierce et al., 2020).

Finally, for the population of children and adolescents in the period studied in Fortaleza, Brazil, it was estimated that 93,194 individuals could express IgM (recent contact); 140,596 individuals could express IgG (late contact), and 30,300 individuals would be virologically detectable at RT-PCR. Thus, this study reveals a worrying situation due to the significant number of children and adolescents with the potential to transmit COVID-19.

The study had several limitations: no data were collected in students' homes; instead, children and adolescents were invited to attend school institutions, and sick individuals may not have attended. Further, all participants were not submitted to SARS-CoV-2 verification by RT-PCR, failing to surprise genetic material of the virus in moments before IgM positivity, which may have underestimated the prevalence rates.

Based on the above, it is hoped that this study will support the planning of public policies that recognise the potential for transmissibility of COVID-19 by children and adolescents, even those who are asymptomatic; that this group may maintain contact with vulnerable adults in home environments; that effective sanitary measures should be implemented when returning to normal activities; and that investments in research in the field of diagnosis, treatment and prevention are needed.

Conclusions

In summary, after the peak of the first epidemic wave and during the distance education period, these data identified a prevalence rate, for all groups, of 26.7% in serology (IgM and IgG) and 4.04% in RT-PCR. Children have lower rates of positivity for IgM and fewer symptoms compared with adolescents and adults. The data suggest the potential for transmissibility in all age groups. The return to classroom activities in schools should be considered with continuous monitoring and health strategies to mitigate transmission. This study should be continued after returning to classroom activities to better understand the disease's behaviour.

Conflict of interest

The authors declare that there is no conflict of interest.

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