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Susceptibility to Severe Acute Respiratory Syndrome Coronavirus 2 Infection Among Children and Adults: A Seroprevalence Study of Family Households in the Barcelona Metropolitan Region, Spain

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Background. Susceptibility of children and adults to severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) infection and persistence of antibody response to the virus after infection resolution remain poorly understood, despite their significant public health implications.

Methods. A prospective cross-sectional seroprevalence study with volunteer families that included at least 1 first-reported adult case positive by SARS-CoV-2 by polymerase chain reaction (PCR) and at least 1 child aged <15 years living in the same household under strict home confinement was conducted in the metropolitan Barcelona Health Region, Spain, during the pandemic period 28 April 2020–3 June 2020. All household members were tested at home using a rapid SARS-CoV-2 antibody assay with finger prick–obtained capillary blood.

Results. A total of 381 family households including 381 first-reported PCR-positive adult cases and 1084 contacts (672 children, 412 adults) were enrolled. SARS-CoV-2 seroprevalence rates were 17.6% (118 of 672) in children and 18.7% (77 of 335) in adult contacts ($P = .64$). Among first-reported cases, seropositivity rates varied from 84.0% in adults previously hospitalized and tested within 6 weeks since the first positive PCR result to 31.5% in those not hospitalized and tested after that lag time ($P < .001$). Nearly all (99.9%) positive children were asymptomatic or had mild symptoms.

Conclusions. Children appear to have similar probability as adults to become infected by SARS-CoV-2 in quarantined family households but remain largely asymptomatic. Adult antibody protection against SARS-CoV-2 seems to be weak beyond 6 weeks post-infection confirmation, especially in cases that have experienced mild disease.

Keywords. SARS-CoV-2; COVID-19; prevalence; household; antibody.

Coronavirus disease 2019 (COVID-19) has become a global public health problem since it emerged at the end of 2019 [1]. One of the countries most affected by the COVID-19 pandemic has been Spain, with more than 778 000 cases and 31 900 deaths confirmed as of 1 October 2020 [2]. The national government declared a state of emergency on 14 March 2020, imposing strict confinement for the population and the closure of all educational, cultural, and leisure places across the country. Although children were initially subject to the same stringent quarantine measures as adults, daily outdoor strolls for those aged <14 years were allowed for no more than 1 hour on 26 April, in parallel with the progressive containment of the disease. The population-enforced lockdown concluded on 21 June.

The extent to which children may be less susceptible than adults to infection caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), the etiological agent of COVID-19, remains unclear [3]. A number of population-based studies [4–7] and clinical case series [8–10] have suggested that pediatric populations have comparatively lower probability of being infected by the virus. Contact-tracing studies show mixed evidence, with either reduced [11–13] or similar [14] infection

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rates in children compared with adults. Duration of antibody protection against the virus is unknown, and some early findings have suggested that it might not persist long once the infection has been resolved [15, 16].

SARS-CoV-2 may be identified by serological detection of antibodies in blood or serum samples once seroconversion has been completed after the first week of symptom onset [17] or by viral RNA detection in upper respiratory or other samples using real-time reverse-transcription polymerase chain reaction (rRT-PCR) during the days immediately after symptom onset [18]. Household serological studies are suitably designed to provide strong evidence of susceptibility to SARS-CoV-2 infection, disease spectrum, and antibody protection in defined, stable, easy-to-follow clusters of confirmed primary cases and their close contacts [19]. Ultimately, such evidence proves essential to inform age-selective or indiscriminate home quarantine measures and for the reopening of schools.

Our primary objectives in this study were to assess seroprevalence of SARS-CoV-2 infection in children and adult contacts living with first-reported PCR-positive adult cases in quarantined family households and to determine persistence of antibody response in cases while identifying associated factors.

METHODS

Study Design

A cross-sectional seroprevalence study with recruitment of volunteer families that included at least 1 first-reported parent positive by SARS-CoV-2 RT-PCR and at least 1 child living in the same household was conducted by researchers at the University Hospital Sant Joan de Deu Barcelona. Family households were identified within the Health Region of metropolitan Barcelona, a densely populated geographical area that became one of the main focuses of the pandemic in Spain. The study period spanned from 28 April 2020 to 3 June 2020.

Definitions

A family household was defined as a household where at least 1 parent aged ≥18 years and 1 child aged <15 years lived together. A COVID-19 first-reported adult case was defined as the parent in the household who had a first confirmed positive result for SARS-CoV-2 RNA detection in a nasopharyngeal swab. An infected contact was defined as a household child or adult, other than the first-reported case, who was found positive for SARS-CoV-2 using a rapid immunochromatographic lateral flow assay (LFA) that detected immunoglobulin G (IgG), IgM, or both in finger prick–obtained capillary blood at the household visit. LFA was selected as an appropriate test for the study for ethical considerations, avoiding extraction of venous blood from healthy or asymptomatic children, and enabled simple and rapid testing at homes. The SARS-CoV-2 household seroprevalence rate was calculated as the proportion of family contacts who were confirmed to be infected using the rapid LFA. Lag time elapsed between the first positive RT-PCR and the rapid LFA was considered as a proxy measure of SARS-CoV-2 antibody response persistence in first-reported cases.

Family Household Identification

The study setting, a tertiary-level university children's hospital located in metropolitan Barcelona, deployed an open web platform named Kids Corona through which families were invited to participate in the study. A team of epidemiological researchers screened eligible families according to their demographic characteristics, residence location, and documented validity of the first-reported RT-PCR–positive result.

Data and Sample Collection

Home testing teams, each composed of 2 research nurses, visited every selected household, collected finger-prick capillary blood from all family members, and performed rapid LFAs at homes. Additionally, venous blood was extracted from all first-reported cases who agreed to donate their blood to the study site's biobank. Blood extraction was carried out in parallel with rapid LFA testing during household visits. Serum samples obtained from blood were biobanked at −80ºC at the study site. The epidemiological researchers interviewed every first-reported case by telephone 24 hours after sample collection. Interviews followed a structured questionnaire to obtain relevant epidemiological and clinical data of family members. Families with any invalid test result or that were not able to answer the questionnaire were excluded from the study.

Microbiological Methods for SARS-CoV-2 Antibody Detection

Rapid IgG/IgM COVID-19 tests (2019-n-CoV Ab Test, Innovita Tangshan Biological Technology Co, China) were performed according to the manufacturer's instructions. A minimum lag time of 14 days between the first positive RT-PCR and the LFA was established to maximize detection of seroconversion in first-reported cases. Since sensitivity of the rapid LFA that we used has been reported to vary from 29.5% in the first 1–5 days after symptom onset to 83.3% after 20 days [20], a performance comparison was undertaken with paired finger-prick capillary blood specimens already tested using rapid LFA and biobanked serum samples tested using an enzyme-linked immunosorbent assay (ELISA) (Abbott SARS-CoV-2 IgG).

Statistical Analyses

SARS-CoV-2 household seroprevalence and seropositivity rates were compared using the χ^2 test or Fisher exact test. Univariate logistic regression analyses were performed to study the associations of clinical and epidemiological variables with SARS-CoV-2 seroprevalence and antibody response, considering those variables that showed a relationship with these outcomes at a P value ≤ .10 for multivariate analysis. Statistical significance was

set at $P < .05$ and confidence intervals (CIs) at 95%. All statistical analyses were performed using Stata v.15 software (StataCorp, College Station, TX).

Ethics Statement

Every adult household member gave an informed consent to participate. Informed consents were obtained from parents/guardians of children who participated in the study, as well as assents from every child aged ≥12 years. The Ethics Committee of Hospital Sant Joan de Deu approved the study prior to start.

RESULTS

Selection of Family Households

A total of 2412 families showed interest in participating in the study, of which 1359 met inclusion criteria. A total of 410 families documented a first RT-PCR–positive result for a household adult case, signed informed consents for participation, and were visited and tested using rapid LFA. Of them, 26 were excluded due to invalid LFA results in any family member, and 3 declined to answer the questionnaire and were also excluded. A final number of 381 family households were selected.

Demographic Characteristics of Family Households

A total of 1465 family members were identified in the selected households, including 381 (26.0%) first-reported adult cases, 672 (45.9%) child contacts (aged <15 years), and 412 (28.1%) adult contacts (aged ≥15 years). Family households ranged from 2 to 7 cohabitants. Women predominated among first-reported cases (n = 237, 62.2%), whereas the majority of contacts (children: n = 357, 53.1%; adults: n = 235, 57.0%) were male. Mean age of adult cases was 41.0 years (standard deviation [SD], 5.9). Children and adult contacts had a mean age of 5.9 years (SD, 3.7) and 40.0 years (SD, 10.2), respectively. Of note, 68.9% of cases were healthcare workers (Table 1).

Clinical Characteristics of First-Reported Cases and Child Contacts

Overall, 87 (22.8%) first-reported cases were hospitalized due to SARS-CoV-2 infection before being confined at home. Mean length of hospital stay was 8.1 days (SD, 6.4). Comorbidities were self-reported by 20.2% of cases, and obesity (12.1%) was the most common comorbid condition (Table 2). In a multiple logistic regression, obesity (adjusted odds ratio [aOR], 4.07; 95% CI, 1.76–9.39), male sex (aOR, 3.13; 95% CI, 1.73–5.65), and age ≥40 years (aOR, 2.28; 95% CI, 1.25–4.16) were identified as risk factors for case hospitalization, whereas being a healthcare worker was a protective factor (aOR, 0.19; 95% CI, .11–.34; Table 3). Nearly all child contacts (99.9%) were paucisymptomatic or asymptomatic, except for a positive female who was hospitalized due to multisystemic inflammatory

Table 1. Demographic Characteristics of the Study Population

Variable	No. (%)
Total family households	381 (100.0)
Household mean surface area (SD), m^2	102.3 (43.0)
Total family members	1465 (100.0)
2	9 (2.4)
3	114 (29.9)
4	197 (51.7)
≥5	61(16.0)
Primary cases	381 (26.0)
Mean age (SD), years	41.0 (5.9)
15–24	1 (0.3)
25–34	47 (12.3)
35–44	246 (64.6)
45–55	82 (21.5)
≥55	5 (1.3)
Sex, female	237 (62.2)
Healthcare worker	261 (68.9)
Child contacts	672 (45.9)
Mean age (SD), years	5.9 (3.7)
<1	35 (5.2)
1–4	297 (44.2)
5–14	340 (50.6)
Sex, male	357 (53.1)
Adult contacts	412 (28.1)
Mean age (SD), years	40.0 (10.2)
15–24	32 (7.8)
25–34	48 (11.7)
35–44	230 (55.8)
45–55	87 (21.1)
≥55	15 (3.6)
Sex, male	235 (57.0)

Values expressed as number (%), unless otherwise stated
Abbreviation: SD, standard deviation.

Table 2. Clinical Characteristics of First-Reported Cases

Variable	No. (%)
Hospitalization due to severe acute respiratory syndrome coronavirus 2 infection	87 (22.8)
Mean length of hospital stay (standard deviation), days	8.1 (6.4)
Main comorbidities	77 (20.2)
Obesity	46 (12.1)
Hypertension	14 (3.7)
Immunocompromised	10 (2.6)
Diabetes	7 (1.8)
Autoimmune disease	27 (7.1)
Asthma	19 (5.0)
Past medical history	
Recent respiratory infection[a]	35 (9.2)
Recent gastrointestinal infection[a]	51 (13.4)
Previous invasive disease infection	25 (6.6)

Values expressed as number (%), unless otherwise stated.
[a]Since January 2020.

Table 3. Factors for Hospitalization of First-Reported Cases With Severe Acute Respiratory Syndrome Coronavirus 2 Infection

	Group 1[a,b]	Group 2[a,b]	Univariate Analysis		Multivariate Analysis	
Variable	% Hospitalized	% Hospitalized	OR (95% CI)	*P* Value	aOR (95% CI)	*P* Value
Healthcare worker vs other professions	11.9	47.5	**0.15 (.09–.25)**	**<.001**	**0.19 (.11–.34)**	**<.001**
Sex, male vs female	39.6	12.7	**4.52 (2.72–7.51)**	**<.001**	**3.13 (1.73–5.65)**	**<.001**
Age, ≥40 vs <40 years	31.5	13.6	**2.92 (1.74–4.90)**	**<.001**	**2.28 (1.25–4.16)**	**.01**
Hypertension, yes vs no	57.1	21.5	**4.86 (1.64–14.42)**	**.01**	2.28 (.62–8.39)	.21
Obesity, yes vs no	37.0	20.9	**2.22 (1.15–4.27)**	**.02**	**4.07 (1.76–9.39)**	**.001**
Previous invasive disease infection, yes vs no	40.0	21.7	**2.41 (1.04–5.58)**	**.04**	1.71 (.64–4.55)	.28
Immunocompromised, yes vs no	20.0	23.0	0.84 (.17–4.02)	.83		
Autoimmune diseases, yes vs no	22.2	22.9	0.96 (.38–2.47)	.94		
Asthma, yes vs no	31.6	22.4	1.60 (.59–4.35)	.36		
Recent respiratory infection,[c] yes vs no	25.7	22.9	1.17 (.52–2.60)	.71		
Recent gastrointestinal infection,[c] yes vs no	29.4	22.1	1.47 (.76–2.83)	.25		

Statistically significant OR, aOR, and *P* values < .05 are marked in bold. Abbreviations: CI, confidence interval; OR, odds ratio; aOR, adjusted odds ratio.

[a]Group 1 refers to the category mentioned in the first place for any variable included in the Variable column (ie, healthcare worker) and Group 2 refers to the category mentioned in the second place (ie, other professions).

[b]Groups ≥10 observations.

[c]Since January 2020.

syndrome (Kawasaki-like) and evolved positively during and after her stay at the study site.

Verification of SARS-CoV-2 Rapid LFA Sensitivity

A total of 250 biobanked serum samples were tested using ELISA, and results were compared with those of finger-prick capillary blood specimens processed using rapid LFA. Mean time elapsed between first positive RT-PCR and rapid LFA for the overall collection of 1465 specimens was 51.2 days (interquartile range [IQR], 42–61); for the 250 paired samples additionally tested using ELISA, it was 49.8 mean days (IQR, 40–60). Seropositivity rates for rapid LFA were low at weeks 3–4 (46.2%), increased up to a peak at week 6 (70.6%), and then dropped markedly to a plateau (range, 35.0%–37.2%) within weeks 8–12. ELISA seropositivity rates showed a similar pattern: detection yield was moderate at weeks 3–4 (61.5%), peaked at week 6 (94.1%), and slowly stabilized in weeks 8–12 (range, 77.5%–87.2%). Overall, ELISA detection yield was 1.3 times higher than that of rapid LFA in the first 6 weeks after infection confirmation and doubled rapid LFA detection yield beyond that time threshold (Figure 1).

SARS-CoV-2 Seropositivity in First-Reported Cases and Associated Factors

A positive result of SARS-CoV-2 using rapid LFA (IgM, IgG, or both targets) was found in 175 (45.9%) of first-reported cases, including 32.3% IgG-positive, 11.0% IgG- and IgM-positive,

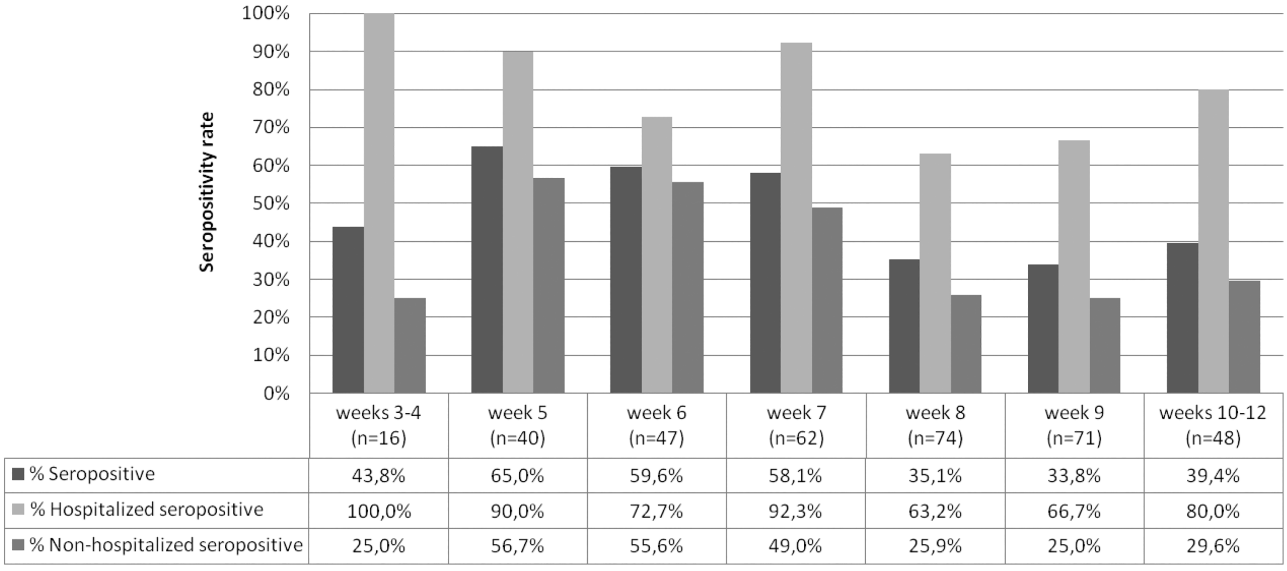
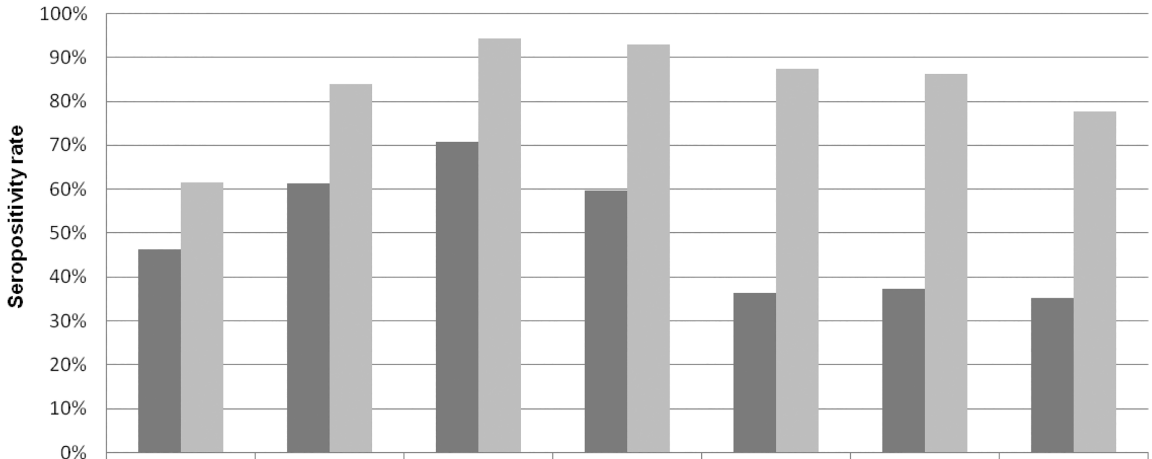


Figure 1. Seropositivity of severe acute respiratory syndrome coronavirus 2 antibodies detected by rapid antibody assay in first-reported cases according to time of convalescence (total samples, N = 381).



	weeks 3-4 (n=13)	week 5 (n=31)	week 6 (n=34)	week 7 (n=42)	week 8 (n=47)	week 9 (n=43)	weeks 10-12 (n=40)
% Seropositive by rapid LFA	46,2%	61,3%	70,6%	59,5%	36,2%	37,2%	35,0%
% Seropositive by ELISA	61,5%	83,9%	94,1%	92,9%	87,2%	86,0%	77,5%

Figure 2. Seropositivity of severe acute respiratory syndrome coronavirus 2 antibodies detected by rapid antibody assay and ELISA in first-reported cases according to time of convalescence (total paired samples, N = 250). Abbreviations: ELISA, enzyme-linked immunosorbent assay; LFA, lateral flow assay.

and 2.6% IgM-positive. SARS-CoV-2 seropositivity rates in the collection of 381 samples showed the same inverted U-shaped pattern observed for the 250 paired specimens (Figure 2). In multiple logistic regression, hospitalization (aOR, 5.59; 95% CI, 2.99–10.46) and time of convalescence ≤6 weeks (aOR, 2.15; 95% CI, 1.30–3.56) were significantly associated with SARS-CoV-2 seropositivity (Table 4). In particular, marked differences between seropositivity rates before and after the convalescence time threshold of 6 weeks were observed among healthcare workers (aOR, 2.40; 95% CI, 1.31–4.38), women (aOR, 2.39; 95% CI, 1.24–4.62), and cases not hospitalized (aOR, 2.35; 95% CI, 1.36–4.08). Conversely, differences in SARS-CoV-2 antibody detection before and after this time threshold were not significant in cases other than healthcare workers, males, and inpatients.

Seroprevalence of SARS-CoV-2 Infection in Household Contacts and Associated Factors

Among the 1084 household contacts, 195 (18.1%) were SARS-CoV-2–positive by rapid LFA, including 118 of 672 children (17.6%; 95% CI, 14.8%–20.7%) and 77 of 412 adults (18.7%; 95% CI, 15.0%–22.8%). The difference in SARS-CoV-2 seroprevalence rates between children and adult contacts was not statistically significant ($P = .64$). Contact age group, contact sex, smoking

Table 4. Severe Acute Respiratory Syndrome Coronavirus 2 Seropositivity in First-Reported Cases and Associated Factors

	Group 1[a,b]	Group 2[a,b]	Univariate Analysis		Multivariate Analysis	
Variable	% Positive	% Positive	OR (95% CI)	*P* Value	aOR (95% CI)	*P* Value
Infection severity, patient not hospitalized vs hospitalized	76.7	37.1	**5.68 (3.26–9.87)**	**<.001**	**5.59 (2.99–10.46)**	**<.001**
Time of convalescence, ≤6 vs >6 weeks	58.8	41.0	**2.06 (1.30–3.26)**	**.002**	**2.15 (1.30–3.56)**	**.003**
Profession, healthcare worker vs others	40.2	59.0	**0.46 (.30–.72)**	**.001**	0.76 (.46–1.28)	.31
Age, ≥40 vs <40 years	52.3	39.1	**1.70 (1.13–2.56)**	**.01**	1.11 (.70–1.75)	.66
Sex, male vs female	52.8	41.8	**1.56 (1.03–2.36)**	**.04**	0.85 (.52–1.39)	.52
Recent respiratory infection,[c] yes vs no	31.4	47.9	0.49 (.23–1.04)	.06	0.43 (.19–.98)	.05
Asthma, yes vs no	63.2	44.9	2.09 (.80–5.44)	.13		
Previous invasive disease infection, yes vs no	60.0	45.1	1.81 (.79–4.14)	.16		
Obesity, yes vs no	53.3	44.8	1.47 (.79–2.73)	.22		
Hypertension, yes vs no	50.0	45.6	1.18 (.41–3.44)	.76		
Autoimmune disease, yes vs no	48.2	45.6	1.10 (.50–2.40)	.81		
Recent gastrointestinal infection,[c] yes vs no	47.1	46.2	1.03 (.57–1.86)	.92		

Statistically significant OR, aOR, and *P* values <.05 are marked in bold. Abbreviations: CI, confidence interval; OR, odds ratio; aOR, adjusted odds ratio.

[a]Group 1 refers to the category mentioned in the first place for any variable included in the Variable column (ie, healthcare worker) and Group 2 refers to the category mentioned in the second place (ie, other professions).

[b]≥10 observations per group.

[c]Since January 2020.

Table 5. Severe Acute Respiratory Syndrome Coronavirus 2 Household Seroprevalence

Variable	Total No.	No. Positive	Prevalence Rate (95% Confidence Interval)	*P* Value
Family households	381	127	33.3 (28.6–38.3)	
Contact groups				.64
Children contacts (aged <15 years)	672	118	17.6 (14.8–20.7)	
Adult contacts (aged ≥18 years)	412	77	18.7 (15.0–22.8)	
Contact age groups, years				.50
<1	35	6	17.1 (6.6–33.6)	
1–4	297	57	19.2 (14.9–24.1)	
5–14	340	55	16.2 (12.4–20.5)	
15–24	32	5	15.6 (5.3–32.8)	
25–34	48	13	27.1 (15.3–41.8)	
35–44	230	36	15.7 (11.2–21.0)	
45–54	87	19	21.8 (13.7–32.0)	
≥55	15	4	26.7 (7.8–55.1)	
Contact sex				.47
Female	492	93	18.9 (15.5–22.6)	
Male	592	102	17.2 (14.3–20.5)	
Smoking habits of family members				.81
Yes	232	43	18.5 (13.8–24.1)	
No	852	152	17.8 (15.3–20.6)	
Household occupancy rate				.13
<20 m^2 per person	374	77	20.6 (.17–.25)	
≥20 m^2 per person	702	118	16.8 (.14–.20)	

Values expressed as number (%), unless otherwise stated.

habits of family members, and household occupancy rate were not found to be significantly associated with SARS-CoV-2 seroprevalence (Table 5). A subanalysis of seroprevalence rates in children did not show any significant differences by the presence or absence of respiratory (19.2% vs 17.5%, $P = .82$) or gastrointestinal symptoms (21.1% vs 17.0%, $P = .31$) or of cutaneous lesions (19.8% vs 17.2%, $P = .48$), as reported by their parents in the previous 4 months. In contrast, the use of public instead of private transportation to go to school before home confinement was enforced was strongly associated with children being seropositive (33.3% vs 14.9%, $P < .001$; Supplementary Table 1).

DISCUSSION

Here, we report similar SARS-CoV-2 seroprevalence rates in children and adult contacts who live with first-reported adult cases in family households under stringent home quarantine conditions. We also note the predominance of asymptomatic presentations among infected child contacts and identify an inverted U-shaped pattern of weak antibody response against SARS-CoV-2 among adult cases in the early convalescence stage and beyond a post-infection time threshold of 6 weeks, particularly in those with mild disease who were not hospitalized. Interestingly, this pattern was not observed only in capillary blood samples tested using rapid LFA but also and more subtly in serum samples tested using ELISA.

Our observation of similar rates of SARS-CoV-2 infection in children and adult contacts is in agreement with results from a study of 391 COVID-19 cases and close family and nonfamily contacts conducted in Shenzhen, China [14]. In that study, minor differences in infection rates were reported in children (7.4% in those aged <10 years, 7.1% in those aged 10–19 years) compared with adults (in the range of 6.1%–9.1% for those aged between 20 and 59 years). Notably, seroprevalence rates determined in our study exceed those values by more than 2 times. This difference could be related to the fact that identification of secondary cases in the referred study was done using RT-PCR in a single determination in a very acute scenario, whereas we used serology assays at 3–12 weeks after first-reported case confirmation. In turn, a study with 105 cases and their household contacts in Hubei Province, China, identified a lower infection rate of 4% in children aged <18 years in comparison with 17.1% in adults [21]. Similarly, age-gradient household prevalence rates that ranged from 20.0% among child contacts aged <5 years to 55.2% among adults aged ≥65 years were reported in a household prevalence study conducted in New York State [22]. Of note, these 2 studies used RT-PCR to identify cases, as opposed to our seroprevalence study. We speculate that age-related prevalence differences between serological and RT-PCR–based household studies could be originated by faster clearance of the virus in children than in adults, regardless of their similar susceptibility to infection, resulting in fewer children being identified as positive using RT-PCR compared with serology. On the other hand, sex of household contacts, smoking habits of family members, and household occupancy rate were not

associated with SARS-CoV-2 susceptibility to infection, as reported in other household studies [12, 13, 23, 24].

Seropositivity rates against SARS-CoV-2 were markedly lower in first-reported adult cases who were tested in an early convalescence stage (≤4 weeks) and at a later post-infection stage (>6 weeks). This finding was observed in both the overall collection of 381 samples tested using rapid LFA and in the representative set of 250 paired samples also tested using ELISA. It raises concerns about reliability of results by rapid LFAs performed in the first weeks after infection and about long-term persistence of antibody response to the virus, since noticeable proportions from 12.8% to 22.5% of convalescent adults had negative results by ELISA 8–12 weeks after infection confirmation. Also of note, antibody protection was weaker in cases who were not hospitalized, suggesting that infection severity may provoke a comparatively stronger response. The time-dependent SARS-CoV-2 antibody response pattern described in this study is in contrast with the observed persistence of antibodies in SARS-CoV-1, its closest-related human coronavirus, from 1 to 2 years [24]. However, it aligns with results recently reported on SARS-CoV-2 antibody decay during convalescence. A preprint study describes loss of IgM antibodies in 31.4% of 1470 adult patients hospitalized with COVID-19 after a median time of 41 days since symptoms onset, as well as loss of IgG antibodies in more than 10% of them after 21 days post-symptom onset [15]. Another study with 37 asymptomatic but SARS-CoV-2–positive patients of all ages and equal number with severe symptoms found that 40% of asymptomatic individuals had undetectable levels of antibodies 2 months after infection compared with 13% of those who were symptomatic [16].

While adults infected with SARS-CoV-2 and particularly the elderly are likely to experience serious disease and require clinical attention, children frequently present no or mild symptoms that resolve without medical intervention [25]. In agreement with previous literature, almost all infected children in our study were asymptomatic or had mild presentations. Interestingly, we did not find any significant difference in SARS-CoV-2 seroprevalence between children with or without respiratory or gastrointestinal symptoms or with cutaneous lesions, which confirms the unprecedent challenge of early diagnosis and transmission control of the virus in pediatric populations. SARS-CoV-2 infection in child contacts was positively correlated with the use of public transportation to go to school, a risk factor presumably related to overcrowding. Similar risk factors of traveling together and of sharing a vehicle have also been described in other studies [14, 23]. Moreover, indoor air quality has previously been associated with transmission risk of the virus in closed settings [26], and the World Health Organization guidelines have recently considered that airborne transmission may occur in crowded, poorly ventilated indoor environments [27]. However, we did not find any significant relationships between high household occupancy, a proxy for overcrowding, or smoking habits of family members, indicative of suboptimal indoor air quality, with SARS-CoV-2 household seroprevalence. A possible explanation for this could be that other behavior factors such as adherence of family members to hygiene measures, face mask use at home, and effective self-isolation of cases initially reported may have been more influential in minimizing household virus transmission [23, 28].

The main strength of our study is that we analyzed information on SARS-CoV-2 prevalence and antibody response using a large number of family households located in a geographical area of high COVID-19 incidence during the study period. Additionally, the study was conducted under strict home quarantine that ensured similar exposure of all family contacts to infection irrespective of their age, thus avoiding biased assessment according to their different social interactions out of the home. A limitation of the study was the imperfect sensitivity of the rapid LFA as well as the reduced number of antibody classes targeted by the test. Nevertheless, we consider that any potential bias derived from suboptimal test sensitivity would comparatively affect identification of infected child and adult contacts to the same extent. A second limitation that derived from the cross-sectional design was the impossibility to discern whether the cases initially identified were the first family members to become infected or not. The time elapsed between positive RT-PCR and rapid LFA (range, 17–82 days) and evidence of the mean incubation period for SARS-CoV-2 (about 4–6 days with 95% of individuals presenting with symptoms within 12 days) [29–31] point toward the plausibility that those first-reported cases were the primary vectors of infection in their homes. Indeed, a recent nationwide study undertaken in South Korea reported that only 46 of 1248 (3.7%) household contacts were infected by children aged 0–18 years [32]. Likewise, a systemic review available in preprint notes that children are likely to be the source of infection in only 10% of households [33].

In conclusion, children appear to be as susceptible to SARS-CoV-2 infection as adults in family households under strict in-home quarantine but remain mostly asymptomatic once infected. Antibody response to infection of adults seems to be weak at an early convalescence stage and beyond 6 weeks post-infection confirmation, particularly among those who have experienced milder infection. Further household studies are needed to determine temporal patterns of antibody response against the virus in children and adults.

Supplementary Data

Supplementary materials are available at *Clinical Infectious Diseases* online. Consisting of data provided by the authors to benefit the reader, the posted materials are not copyedited and are the sole responsibility of the authors, so questions or comments should be addressed to the corresponding author.

Notes

Author contributions. P. B. designed the study, analyzed data, and wrote the manuscript. C. L. collected data, analyzed data, and wrote the manuscript. E. B. collected data and performed experiments. V. F. collected data.

D. H. collected data and performed experiments. M. F. de S. collected data. A. R. collected data and performed experiments. L. F.-S. collected data. D. C. collected data. M. M. collected data. C. J. collected data. P. M. collected data. I. J. collected data. J. J. G.-G. collected data. Q. B. designed the study and collected data. C. M.-A. designed the study, analyzed data, wrote the manuscript, and supervised the study. All authors and the Kids Corona Study Group discussed the results and critically reviewed, discussed, and accepted the final version of the manuscript.

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