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The Role of Children and Young People in the Transmission of SARS-CoV-2

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The authors have no funding or conflicts of interest to disclose. The emergence of the novel severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) in late December 2019, causing a disease later termed COVID-19, marked the beginning of an unprecedented pandemic. By early 2022, the number of confirmed cases exceeded 265 million globally, with >5 million deaths.¹ The emergence of more transmissible SARS-CoV-2 variants of concern (VOCs), such as alpha, delta and omicron, poses additional risks to global public health.² The vast majority of severe cases and deaths occur in older adults and high-risk groups with underlying health conditions, while children and young people (CYP) predominantly have a mild disease course, with approximately one-third of cases being asymptomatic.^{3,4} Data from 10 European Union countries from

August 2020 to October 2021, a time when the alpha variant was dominant in most European countries, revealed that in the age group 1–18 years hospitalization was required in <1.2% of all reported cases. Fewer than 0.04% of CYP developed severe disease and the overall case fatality rate was equal to or below 0.01%.³ Conversely, CYP suffered widely from mitigation measures during the pandemic such as social distancing and school or day-care closures.

Children and adolescents are at increased risk of developing a rare but severe condition called multisystem inflammatory syndrome in children (MIS-C), typically within 6 weeks after SARS-CoV-2 infection.⁵ Similar to adults, although seemingly at lower rates, children can develop long-term sequelae, often summarized under the term “long COVID,” a poorly-defined condition, which does not appear to correlate with the initial disease severity, and can lead to significant morbidity.

Even 2 years into the pandemic the extent to which CYP are infected with and able to transmit SARS-CoV-2 remains uncertain. Yet, it appears that the probability of transmitting SARS-CoV-2 may at least in part be related to reduced susceptibility of this specific age group.

CHILDREN'S SUSCEPTIBILITY TO SARS-COV-2 INFECTION

Before the circulation of VOCs a meta-analysis including 77,758 individuals with reported household transmission found that only 17% of exposed CYP below 18 years became infected compared with 28% of exposed adults.⁶

A more recent study from Israel looking at 15 family clusters during dominance of the more virulent alpha strain found secondary household transmission in exposed children and adolescents to be around 70% compared with 90% in adults.⁷ A meta-analysis comparing a total of 40,000 children with 250,000 adults suggests that individuals younger than 14 years have an approximately 50–60% lower risk of infection than older age groups. Interestingly, the same analysis found that above the age of 14 years the risk of infection was similar to older age groups.⁸ Still, much of those data were collected at a time when many countries implemented mitigation measures such as distancing and school and day-care closures. Underreporting of mild or asymptomatic pediatric cases and the circulation of less transmissible virus variants at the time some of those studies were conducted may partly explain those findings.

In contrast to those previous studies done early in the pandemic, more recent data suggest that the probability of children to become infected is similar to that of adults, especially since the occurrence of the more virulent VOCs.⁹

However, children seem to be less prone to developing symptomatic COVID-19. To explain this finding, several potential factors have been hypothesized in the literature. Among others, age-specific differences in the immune response, divergent expression of the angiotensin-converting enzyme 2 receptor (ACE-2 receptor), lower prevalence of comorbidities predisposing to severe COVID-19, and differences in social behavior have been proposed.⁵

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INFECTIVITY OF CHILDREN

Compared with the lower risk of developing severe disease or symptoms at all, the question whether CYP are naturally less infective than older age groups and their potential to drive SARS-CoV-2 transmission, is discussed with much more controversy since the beginning of this pandemic.

Although PCR-based studies comparing nasopharyngeal viral loads of CYP and adults reveal conflicting results, some authors have emphasized that even with comparable viral loads, asymptomatic individuals may be less likely to transmit SARS-CoV-2 as a result of both early virus clearance and less production and emission of infective aerosols.¹⁰ A recent meta-analysis including results of 3385 individuals showed that compared with symptomatic COVID-19 patients, asymptomatic individuals experience a 55% shorter viral RNA shedding time. Furthermore, subgroup analysis of the same review revealed a significantly shorter shedding time in individuals under the age of 18 years compared with adults.¹¹ In addition, there is evidence that asymptomatic individuals may neutralize the virus more rapidly, and are up to 42% less likely to spread SARS-CoV-2.^{6,11}

Since the beginning of the pandemic, findings of studies focusing on transmission have varied widely, especially when they focused on CYP. Given the generally less severe course of COVID-19 in children and a large proportion of asymptomatic cases, SARS-CoV-2 is likely to be substantially underreported in this age group.² Nonetheless, high-quality evidence is difficult to generate as PCR-based studies are unable to make firm assumptions about whether the detected RNA fragments in a sample reflect replication-competent particles. Additionally, viral loads in nasopharyngeal specimens seem to fluctuate during the course of infection and are not necessarily reflecting infectiousness. Poor understanding of antibody response to SARS-CoV-2 infection, especially in oligo- or asymptomatic patients, complicate the interpretation of seroprevalence studies.¹¹

CYP represent a very heterogeneous group regarding basic physiology and functioning of the immune system.² So far, published data on the role of children in transmitting SARS-CoV-2 show highly variable transmission rates, potentially due to variations in SARS-CoV-2 prevalence in the community and implemented mitigation measures at the time of the study, differing strategies for detecting secondary cases and variable adherence to infection control measures in households and child-care facilities.² In addition, the predominance of different VOCs and their impact on transmission also have to be taken into account.¹²

HOUSEHOLD TRANSMISSION

A Canadian study investigating 6280 pediatric index cases in households between June and December 2020 found that children under 3 years of age were least likely to be an index case, whereas siblings and caregivers for the same group showed the highest risk for secondary infection. In contrast, the risk of being the household's SARS-CoV-2 index case increased with age.¹³ Compared with the time of alpha dominance, household secondary attack rate with the delta VOC increased throughout all age groups by 70%. Even then, individuals below 30 years of age infected fewer household members than all the other age groups.¹²

From studying other respiratory viruses such as respiratory syncytial virus (RSV), it is widely accepted that proximity and time of exposure have a positive relation with the probability of infection.¹⁴ Although toddlers and young children have a smaller volume of expired air, parents and other household members will likely stay close to young children to provide care and comfort. Successful implementation of mitigation measures such as mask wearing or adequate hand hygiene might be challenging for parents when looking after a sick child, especially toward the younger age spectrum.^{13,14} In older children and adolescents, it is easier to implement mitigation measures. However, from adolescence onward individuals develop lung capacities similar to adults and importantly, have a greater range of social interaction outside the household they live in, potentially resulting in a more prominent role in propagating transmission.¹⁴

SCHOOL OR CHILD-CARE TRANSMISSION

Existing data on transmission in educational settings are highly inconsistent. Those data are likely influenced by differences in implemented public health measures at the time of data collection, rates of community transmission, availability of vaccines and vaccination rates, and circulating virus strains.² Although SARS-CoV-2 transmission in schools and nurseries has been extensively documented, the risk of transmission to and from children in those settings appears to be low, especially before adolescence. In particular, at times of low transmission rates in the community and—more importantly—when public health measures are implemented at schools, such as improved ventilation, mask wearing and physical distancing.¹⁵ Based on first principles, it is likely that once viral activity in the community increases, transmission in schools also increases. However, a large UK study found that the majority of school outbreaks were caused by members of staff, rather than school pupils.¹⁶

Extracurricular activities such as overnight camps seem to pose an increased risk for transmission, especially when compliance with physical distancing and mask wearing is low.¹⁵

With the emergence of the highly transmissible delta variant schools again became a focus of public and expert discussions regarding their role in driving the pandemic. Notably, a data analysis of 783 schools in the United States done at a time when the delta strain was dominant that included data of 59,561 students and 11,854 teaching personnel from kindergarten to grade 12 found that the risk of within-school transmission was lower than the risk of transmission in the community. The US counties included in this study had an average rate of 47% fully vaccinated citizens during the study period. At schools distancing of at least 3 feet was recommended, mask wearing was obligatory and quarantine was enforced for close contacts of cases. Importantly, institutions where the suggested public health measures were implemented stringently experienced very low rates of in-school transmission, even with cases rising exponentially in the community. Nonetheless, it has to be noted that the secondary attack rate during the period of delta predominance was estimated to be 2.6% compared with 1% when the α strain was dominant.¹⁷

CONCLUSIONS

Children and young people have received far less attention than adults since the start of the pandemic. While CYP show the lowest burden of disease with regards to severity and long-time sequelae, the physical, mental and economical damage to this age group, mainly caused by public health mitigation measures, should not be underestimated. Although the available data regarding the role of CYP in SARS-CoV-2 transmission are inconsistent, there is no convincing evidence to date, 2 years into the pandemic, that children are key drivers of the pandemic.

The existing data support that even with the occurrence of highly transmissible VOCs educational and child-care settings are relatively safe spaces if prevention strategies are adhered to. This should be taken into account by public health experts and health authorities, especially in the light of a worldwide omicron VOC wave, when making decisions about mitigation strategies.

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