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COVID-19 in children and adolescents

A knowledge summary – Version 2



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Summary

Knowledge about COVID-19 is constantly increasing. The Public Health Agency is following the national epidemiological development closely and in close cooperation with the country's infectious disease control units. Children continue to make up a small percentage of confirmed COVID-19 cases, even after more extensive testing started.

Number of cases among children and adolescents increases with age

A very small proportion of cases have been diagnosed among children up to 6 years of age both in Sweden and globally, but it should be borne in mind that young children have also not been extensively tested. However, slightly more cases are seen as the children get older. With increasing age, a rising number of cases is seen among teenagers, but not as many as among people over 19 years of age.

Teenagers seem to be more susceptible to becoming infected than younger children, but experience mild symptoms. Teenagers also transmit the infection to a greater extent than younger children, but to a lesser extent than adults. During October, the number of diagnosed cases increased, especially among older teenagers. A contributing reason for greater transmission among teenagers may be that they move around more in society and often have many close contacts. The specific role of teenagers in the spread of infection needs to be investigated further through outbreak investigations and infection tracking.

The infection seems to spread more during leisure time than at school

No studies have indicated widespread contagion in schools or between children. Since the start of the autumn term, some outbreaks have been reported in schools, mainly in relation to adults and older children or teenagers.

In some cases, it is difficult to determine whether the infection spread during leisure time or at school. The knowledge we have today indicates that schools as such do not seem to be a risk environment for children. Rather, the infection seems to spread during leisure time, in close-contact sports and in other social contexts, such as parties or camps. A number of measures have been taken at schools, such as adjusting schedules to avoid congestion, not allowing parents to stay on the premises, holding some of the teaching outdoors and allowing teaching of secondary school students to take place partly remotely. Professionals who meet larger groups of children in schools, primary school teachers, preschool teachers and child minders do not have a higher relative risk of being diagnosed with COVID-19 compared to other professions.

Children are not the driving force of the pandemic

The scientific knowledge gained since June about children and adolescents and COVID-19 largely confirms previous knowledge. Children generally experience milder symptoms than adults, and a large proportion show mild or no symptoms. Fever and a cough are the most commonly reported symptoms. Children are not driving the COVID-19 pandemic. Children are rarely index cases, and scientific studies show that infectivity between children is significantly lower than between adults. No clear risk groups have so far been identified in children, but the Swedish Public Health Agency is continuously monitoring the state of knowledge. Few children have needed intensive care and even fewer have died, both in Sweden and internationally.

School closures might have negative effects

Knowledge of the consequences of school closures has increased. Possible negative effects such as loss of learning and impact on mental and physical health have been highlighted. The negative consequences might have hit hardest against children who are already at risk, such as children with disabilities, children with underlying diseases, children in socio-economically disadvantaged groups and children living in social vulnerability and poverty.

In the light of current knowledge and in a situation where the pandemic is far from over, it is important to take measures that allow children and adolescents to attend preschool, primary and secondary schools as far as possible.

Background

In May 2020, the Public Health Agency published a knowledge summary on COVID-19 among children and adolescents (1). The report showed that children and adolescents accounted for a small proportion of COVID-19 cases, and in most cases the children had mild symptoms and were infected by an adult. Furthermore, it showed that children are infected to a lesser extent than adults, and that the schools have not been a driving force in the spread of infection. Staff working in preschool and school had also not been diagnosed with COVID-19 to a greater extent than other professionals.

This report describes the development of the epidemiological situation in Sweden and summarises the state of knowledge about COVID-19 in children and adolescents based on research published from May to October 2020.

School during the pandemic in Sweden

Starting in March 2020, secondary schools worked mainly with distance learning based on the Public Health Agency's recommendations supported by the Regulation 2020:115 (2). The measure was introduced early in the pandemic to slow down the spread of infection. Upper secondary school pupils were deemed to have greater autonomy and the ability to manage distance learning, and generally have less need of care and supervision than younger pupils. Pre- and primary schools stayed open, but measures were taken to reduce the spread of infection.

Thanks to the epidemiological development and increasing knowledge about COVID-19, the recommendation on distance learning ended on 15 June 2020. As a result, secondary schools and higher education institutions could return to classroom teaching at the start of the autumn semester in 2020.

The government has decided to offer schools more flexible solutions when needed based on the local epidemiological situation. For example, schools can offer distance learning or extend a semester if the local situation regarding the spread of infection so requires. Various measures such as schedule adjustments and a mix of classroom and distance learning have also been introduced in schools to reduce the risk of infection.

Towards a common view of the school during the COVID-19 pandemic

There is now a broad consensus in the world that efforts to reduce the spread of coronavirus infection should be implemented while allowing, to the extent possible, children and adolescents to attend school.

Since the start of the pandemic in 2020, 180 countries have closed their schools, affecting 1.5 billion students. Studies show that children and teenagers have been adversely affected by school closures (3). There has been a learning loss, and

negative effect on mental and physical health. The negative consequences have also hit hardest against children who are already at risk, such as children with disabilities, children with underlying diseases, children in socio-economically disadvantaged groups and children living in social vulnerability and poverty.

In addition to the immediate negative effects, there are long-term, negative effects that need to be taken into account. Education is one of the foremost social determinants of health. Young children carry with them their learning skills, and a poor start can mean greater learning difficulties later in school. For older children and teenagers, a good education is a first step towards a job. Poorer education can affect the chances of finding work and even salaries can be affected in the long term.

Closed schools, mainly preschool and primary schools, also mean more work and responsibility for parents, who may also be affected by changes in their workplaces. Increased responsibility for children in the home mainly affects mothers, which has a negative impact on gender equality and equality in society (4).

The Public Health Agency's work in progress

The Public Health Agency monitors the epidemiological situation and continuously monitors the state of research on COVID-19. Knowledge is updated continuously, and the Agency plans to develop a data base on a number of aspects relevant for children and COVID-19, such as children's immunological response (t-cells), the different COVID-19 risks among occupational groups, the sustainability of the vaccination programme during the pandemic and the mental health of secondary school students after the distance learning in the spring semester.

The Public Health Agency also monitors the impact of the pandemic on public health and future knowledge will describe the impact of the pandemic on public health and public health and infection control efforts.

Testing of children

Since 31 August 2020, the Public Health Agency recommends that preschool children be tested for COVID-19 if they have symptoms. The recommendation is national, and there are regional variations in terms of testing capacity and priorities. Since the national recommendation was issued, testing of children has increased. The number of children tested naturally affects the number of confirmed cases of COVID-19, (5) which means that the numbers of reported cases before and after September 1 are not comparable.

Infection tracking

On 1 October 2020, the Public Health Agency updated a guidance for infection tracking with a recommendation that members of the household of a person who has confirmed COVID-19 should be informed of steps to be taken under the

Communicable Diseases Act. Upper secondary pupils must follow these steps if they share a home with someone who has COVID-19. This means that during such period pupils will be taught remotely and must avoid activities during their leisure time that involve close contact. Children in pre- and primary schools can continue to attend preschool and school even if they live with someone who has COVID-19 (6).

Purpose

The overall aim of this report is to summarise the epidemiological situation and current knowledge about children and adolescents up to 19 years of age, in terms of morbidity, mortality and infectivity in relation to COVID-19 in Sweden. It also summarises the scientific literature on the spread of infection linked to preschools and schools and the morbidity to date among school staff.

Questions:

- How many cases of COVID-19 among children and adolescents have we had so far in Sweden?
- What is the spread of infection like in preschools and schools in Sweden?
- How have staff in preschools and schools been affected by COVID-19 in Sweden?
- What are the symptoms, morbidity and mortality among children and adolescents?
- What does infectivity look like among children and adolescents?
- Are there risk groups among children and adolescents?
- What public health consequences of school closures can be identified?

Method

This report summarises cases to date (to and including 5 November) and the number of patients in intensive care (to and including 5 November) among children and adolescents aged 0-19. Outbreaks in preschools, primary and secondary schools are also presented.

Furthermore, the COVID-19 risk for school staff compared to other profession categories is presented. Personal data from notifications of confirmed COVID-19 have been combined with registers of occupational classification at Statistics Sweden. Those diagnosed between 13 March and 19 October have been included in the analyses.

We have used "generalised linear models" (glm) with poisson link to compare the risk of being diagnosed with COVID-19 among different occupational groups. This analysis method is often used when following people over time with respect to a specific endpoint. The results are presented as relative risks (RR). A relative risk is the probability that a particular event will occur in one group compared to another group, a so-called reference group (comparison group). For example, a relative risk of 1 means that the risk in both groups is the same. A relative risk of 2.0 means that the risk is twice as high compared with the reference group. A relative risk below 1 indicates the risk is lower in the group compared with the reference group. Please note that the relative risk does not say anything about scope, i.e. the proportion of the group that is affected.

Finally, a summary of the state of research on COVID-19 among children and adolescents is presented. Studies published between May 2020 and 15 October 2020 have been reviewed in a quick scoping review. The review is based on the Swedish Public Health Agency's systematic monitoring of COVID-19 research. The studies were selected based on the fact that they are about children aged 0-19 or COVID-19 and school.

Results

Confirmed cases among children and adolescents in Sweden to date

In Sweden as well as in the rest of the world, the proportion of confirmed cases of COVID-19 among persons up to 19 years of age has been significantly lower than among adults. In Sweden, 6.7 per cent of cases are among children aged 0-19 (the same age group make up 23 per cent of the population) see Table 1. [View the latest available statistics see here.](#)

Among children and adolescents, there are very few deaths due to COVID-19.

Table1. Number of diagnosed cases of COVID-19 per age group and proportion of total cases and number of deaths (as of 2020-11-05).

Age group	Cases	Percentage of cases (n=137,730)	Deaths	Proportion of deaths (n=5,997)
0-9	1,107	0.8 %	2	0.0 %
10-19	9,338	6.8 %	0	0
20-29	25,831	18.8 %	11	0.2 %
30-39	22,778	16.5 %	17	0.3 %
40-49	23,110	16.8 %	46	0.8 %
50-59	23,325	16.9 %	166	2.8 %
60-69	12,808	9.3 %	415	6.9 %
70-79	7,682	5.6 %	1,279	21.3 %
80-89	7,655	5.6 %	2,491	41.5 %
90+	4,071	3.0 %	1,570	26.2 %

Table 2 shows smaller age groups. The number of cases among children and adolescents represents a very small part of the total number of diagnosed cases in Sweden. Note that Table 2 is updated slightly earlier than Table 1, hence the difference in numbers.

Table 2. Number of cases of COVID-19 diagnosed by age group, proportion of total cases, number of deaths and proportion of total deaths. NOTE: as per 2020-10-15.

Age group	Cases	Proportion of all cases (108,969)	Deaths	Proportion of total deaths (5,930)
0-5	425	0.4 %	*	*
6-9	394	0.4 %	*	*
10-12	541	0.5 %	0	0 %
13-15	961	0.9 %	0	0 %
16-17	1,388	1.3 %	0	0 %
18-19	3,141	2.9 %	0	0 %

*isolated cases, too few to report

Table 3 shows that very few children and adolescents between 0-19 years of age have needed intensive care for COVID-19 in Sweden.

Table 3. Number of intensive care cases with diagnosed COVID-19, by age group and proportion of total cases of intensive care patients in Sweden. As per 2020-11-05.

Age	Intensive care cases	Of the total number of intensive care cases (2,763)
0-9 years	9	0.3 %
10-19 years	20	0.7 %
20-29 years	99	3.6 %
30-39 years	122	4.4 %
40-49 years old	304	11.0 %
50-59 years	692	25.0 %
60-69 years old	835	30.2 %
70-79 years	549	19.9 %
80-89 years old	127	4.6 %
90+ years	6	0.2 %
All age groups	2,763	100%

Figure 1 shows the number of cases per 100,000 inhabitants. The first peak of the curve, around week 25, is related to increased testing

Figure 1. Number of cases of COVID-19 per 100,000 inhabitants among children and adolescents – preschool, primary and secondary school age, by age group. From the start of the pandemic, week 10 through week 44.

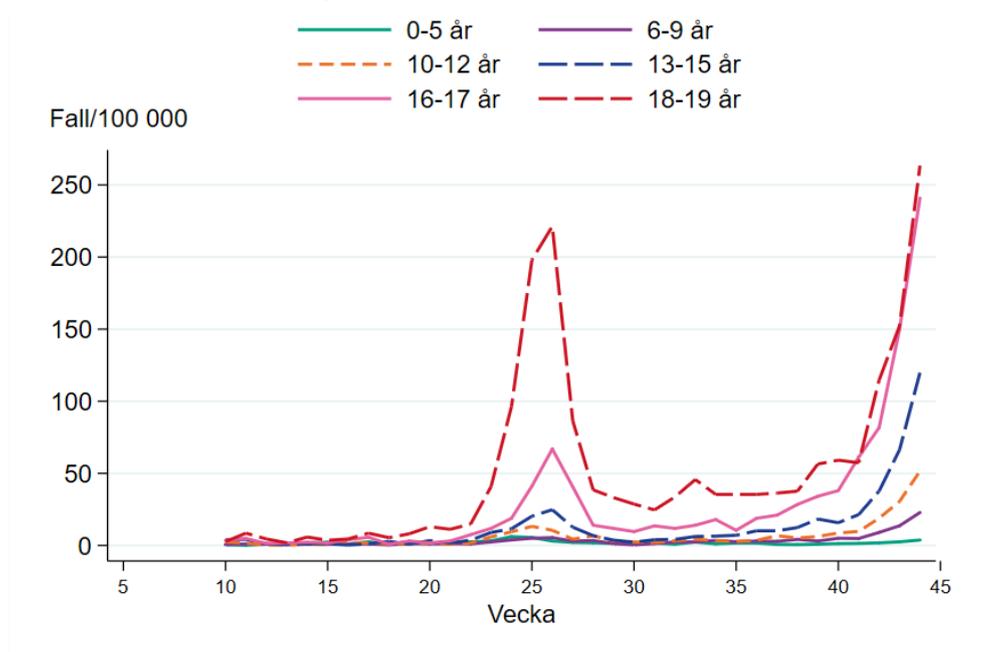
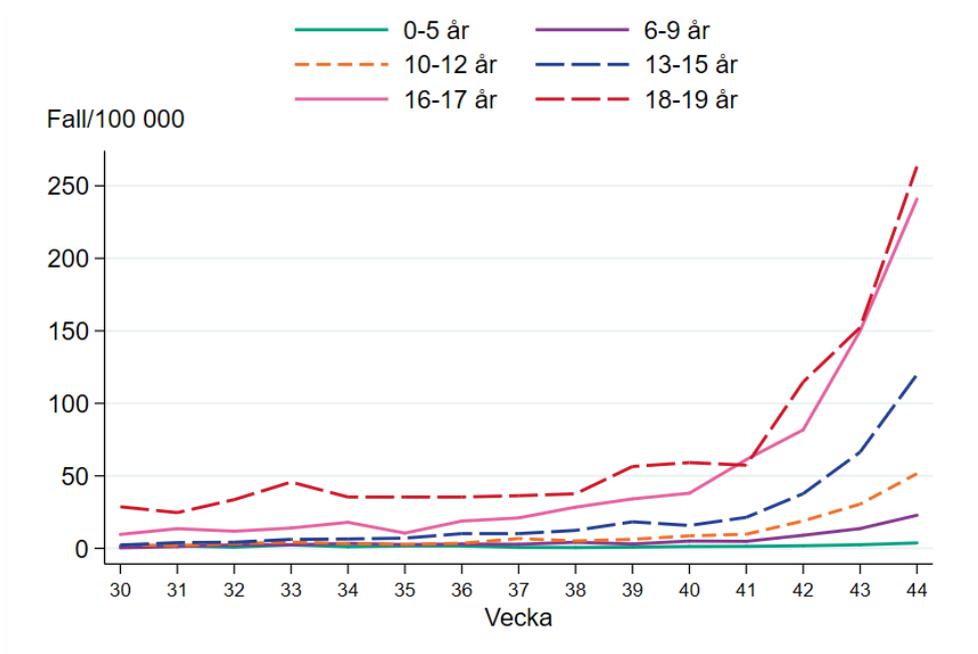


Figure 2 shows the number of diagnosed cases among children and adolescents up to 19 years of age, between week 30 and week 44. We see that the number has remained constant in the youngest age group (0-5 years), while we are seeing an increase among the other age groups in recent weeks. The increase has been strongest in the 16-19 age group. The proportion of positive test responses among tested teens has increased in recent weeks. Updated information on the proportion of positives per age group can be found in the Swedish Public Health Agency's weekly reports.

Figure 2. Number of cases of COVID-19 per 100,000 inhabitants among children and adolescents between weeks 30 and 44, per age group.



Outbreaks in preschool, primary and secondary schools in Sweden

Since 21 September (week 39), the country's infectious disease control units are asked to report COVID-19 outbreaks that have come to their attention to the Public Health Agency. The aim is, among others, that the Public Health Agency should be able to create a national situational picture and identify where the spread of infection takes place in order to identify environments at risk.

The following is the total number of reported outbreaks with at least two confirmed cases in various school environments up to 28 October.

Environment	Number of outbreaks
Preschool	4
Primary and lower secondary school	20
Upper secondary school	14
Workplace & primary and lower secondary school	1
Workplace & upper secondary school	1

Environment	Number of outbreaks
Private gatherings & upper secondary school	3
Leisure activities & upper secondary school	2
Upper secondary school & other environment	1

There are just under 10,000 preschools in Sweden. More than 500,000 children attend preschool and about 120,000 people work in preschools(7). There are approximately 9,000 primary and lower secondary schools in Sweden (including preschool years and equivalent forms of schooling and after-school facilities (7)). Just under 1.1 million children attend and approximately 180,000 teachers work in primary and lower secondary school and equivalent forms of schooling. In the outbreaks reported, both pupils and teachers are involved. In some cases, the spread of infection is linked to activities outside the school premises, such as study trips and leisure activities.

There are approximately 1,500 upper secondary and upper secondary special schools with 360,000 pupils and just under 40,000 teachers. In the reported outbreaks in upper secondary schools, a majority of the spread of infection is linked to sports activities, both in school and in leisure. The outbreaks mainly involve students, but a few teachers have also tested positive for COVID-19.

Morbidity among school staff

The presence of COVID-19 among different occupational groups has been presented previously for the period 13 March - 27 May. During that period, school staff did not have a higher relative incidence of COVID-19 compared to other occupational groups (8).

In the current updated analysis, persons (25 -65 years old) with laboratory confirmed COVID-19 infection between 13 March and 19 October have been identified in the reportable diseases database, SmiNet (n=32,014). These were then matched against Statistics Sweden's register of occupations(9). The analysis shows that occupational groups who encounter large groups of children in school, primary school teachers, preschool teachers and child minders, do not have a higher relative risk of being diagnosed with COVID-19 compared to other occupational groups(10). By contrast, there was a higher relative risk of being diagnosed with COVID-19 among preschool principals and primary and secondary school principals.

The relative risk of being diagnosed with COVID-19 may depend on several factors, such as multiple and close contacts with adults and children in a professional role, leisure activities and increased testing during the period.

Another way of determining whether school staff are more exposed to COVID-19 than other occupational groups is to calculate the relative risk of intensive care for COVID-19. The intensive care risk is not affected by the extended testing that has taken place during parts of the follow-up period. The relative COVID-19 intensive

care risk for child minders and primary school teachers was lower than for other occupational groups. Other occupational groups in school could not be studied because the number of cases was too small to provide a reliable measure of the relative risk (10).

Since the follow-up period (13 March – 19 October) does not cover the entire autumn term, further analyses are needed at the end of the semester. Since upper secondary schools introduced distance learning during spring, the development in this occupational group must also be monitored further in connection with next semester.

Current knowledge in the world about COVID-19 among children and adolescents

Symptoms and morbidity among children and teenagers

Children experience milder symptoms of COVID-19 than adults (11). Fever and a cough are the most commonly reported symptoms, like in adults, while some children also experience diarrhoea, vomiting, fatigue and a runny nose (11-13). Recently, various skin symptoms have also been recorded in children, such as rashes, blisters, urticaria (hives) and frostbite-like skin changes(14).

Children have not been shown to develop severe pneumonia to the same extent, nor have they exhibited low oxygenation in the way that adults have. Cases of COVID-19 in infants have been reported, and although there is no clear evidence that the infection can be transmitted from mother to child at the fetal stage or in connection with childbirth, this cannot be completely precluded (15).

A registry study from Norway between 1 March and 15 May reported that 14 out of 493 people (3 percent) with confirmed COVID-19 under the age of 20 (median age 15), had been hospitalised(16). The authors did not state whether those who had been hospitalised were children or teenagers.

The results of an overview study published in May have been confirmed by several recent systematic reviews from several countries (11, 12, 17). The surveys show that a high proportion of children who became seriously ill and were on a ventilator had other underlying diseases (18), most commonly heart disease.

There are different hypotheses as to why children do not become as seriously ill in COVID-19 as adults. A summary hypothesis is that the immune system in children is still developing and reacts differently than in adults when the virus enters the nose and throat. Thus, the virus does not cause as many symptoms or causes no symptoms at all, which also reduces (19) (20)infectivity.

It is now well known that children and adolescents may be asymptomatic carriers (21) of the virus, thus carrying the virus without having any symptoms, but the proportion of asymptomatic cases varies in different studies. Between 6 and 40 percent of children with COVID-19 have been found to be asymptomatic in various studies (11, 17, 22-25). A systematic review estimated that 14.9 percent of cases

among children with confirmed COVID-19 were asymptomatic (13). An American study that described the prevalence of confirmed COVID-19 cases in asymptomatic children (0-18 years) showed 250 asymptomatic cases, out of 33,041 children who tested positive in 28 different hospitals. Prevalence (0.65 per cent) was deemed to be low(26). A study from Israel showed that in a school with pupils aged 12 to 18 where 13 percent tested positive for COVID-19, 43 percent of children had reported symptoms (27). The most common symptoms were cough, headache, fever, sore throat and muscle aches. No hospitalisations were reported among the confirmed cases. Many of the studies that have studied the proportion of asymptomatic cases among children have so far been conducted in a hospital environment. This means that they include people with severe symptoms, which could underestimate the proportion of asymptomatic persons (28).

The risk of becoming infected and spreading the infection further increases with age and is described in scientific studies mainly from 13 years and above. This is linked to the symptoms. Several studies show a correlation between increasingly severe symptoms and higher infectivity, higher viral load and therefore higher spread of COVID-19(11, 25, 29, 30). The precise role of children and adolescents in the spread of infection needs to be studied further(28).

Both in Sweden and internationally there is an unusual but serious hyper-inflammatory condition described between the ages of 0-19 years, suspected to be connected with a current or recent COVID-19 (31)infection. Most affected children are previously healthy, and have had a COVID-19 infection two to four weeks before the onset of the disease. The degree of disease varies and some children become seriously ill. Treatment is available, and the Swedish Child Rheumatology Association is monitoring this very closely and reports to the Swedish Public Health Agency on the matter continuously(32).

Infectivity among children and teenagers

Although children and teenagers have a milder and shorter illness, there has been a fear that children may infect others in their household. However, the majority of studies published in August, September and October suggest children *do not* spread the virus to any great extent.

In a systematic review of studies aimed at comparing the spread of infection among children and adolescents with adults, 32 studies involving 41,640 children and teenagers and 268,945 adults were included (33). The risk of infection in children under 10 years of age was lower, (OR: 0.56), compared to adults. Children under the age of 10 also tended to have antibodies less frequently, while 10 to 19-year-olds had the same level of antibodies as (33)adults.

Most studies that have shown lower infectivity among children come from high-income countries. A study from India summarises the dispersion dynamics in two Indian states (34) and shows that the spread between children was higher than expected based on data from high-income countries, despite adjusting for demographic differences. The analysis shows a wide variation between individuals'

likelihood of passing on the infection, as 71 percent of the tracked cases did not spread the infection.

According to available knowledge, adolescents and teenagers are more susceptible to infection than children, are more mobile in society and have more contacts(28). Combined with the fact that they usually have mild symptoms, as a result they may play a greater role in the spread of infection than younger children. Analyses of the majority of available data from family clusters show that children were mainly infected by adults in their home environment and not by other children who had brought the infection from outside or from school (35-38).

In conclusion, most studies have shown that the severity of COVID-19 is directly correlated to infectivity and thus transmission of the virus (11, 25). Current knowledge indicates that children are infected to a lesser extent than adults and do not contribute to the spread of infection as much as adults. Adolescents and teenagers transmit the infection more and experience more symptoms than children, though to a lesser extent than adults(28). However, it is important to monitor developments in the world and to compare different contexts, which may exhibit different patterns.

Risk groups for more serious COVID-19

The Swedish Paediatric Society has gathered statements and guidelines regarding COVID-19 from several of its specialist associations. To date, there are no identified risk groups among children and adolescents(39).

The correlation between underlying diseases and the consequences of COVID-19 is continuously investigated. An overview of studies documenting a total of 108 patients under 18 with a serious progression of COVID-19 indicates that there may be a correlation between underlying diseases and COVID-19 in children, i.e. the severity of the disease (18). According to the survey and data from 48 patients under the age of 18 with severe disease progression of COVID-19, 75 percent had an underlying diseases. The survey also reports that 75 percent of deaths where data were available (n = 11) occurred in patients with underlying diseases.

A report from Spain regarding 50 children in intensive care as a result of COVID-19 shows that 54 percent were affected by hyper-inflammatory conditions and 28 percent were on a ventilator. Those who needed a ventilator more often had an underlying disease (40), such as asthma and impaired immune systems.

Many studies report on underlying diseases in children who become seriously ill in COVID-19. However, few studies report which underlying diseases are most common. Heart disease and asthma have occurred in hospitalised children (18). Obesity has also been mentioned as a risk factor (41).

Deaths

There have been few deaths in Sweden among children and adolescents, with two deaths in the age group 0-9 years. Internationally as well, deaths are rare, but there

have been some cases. In the United States, 121 deaths among under-21s were found to be caused by COVID-19 between 12 February and the end of July 2020 (42). A majority were aged 16 to 20, while 12 deaths occurred among infants, 16 were aged 1-6 years, 18 were aged between 7 and 12, and 7 were aged 13-15. Among the young deceased, 75 percent had an underlying disease and 45 percent had at least two underlying diseases. Deaths were more common among lower socio-economic groups and among African Americans and Hispanics. The incidence of COVID-19 has also been shown to be higher among foreign-born adults in Sweden (43).

A large prospective cohort study in the UK among children aged 0-19 who were hospitalised with COVID-19 showed that severe illness was uncommon and deaths even more uncommon (44). However, the results showed that ethnicity appears to be an important factor in relation to the risk of hospitalisation, even among people under the age of 19.

An international systematic review describing the demographics, clinical data and outcomes in children aged 0-17 with COVID-19 shows that the mortality among children who are hospitalised is 0.18 percent (13). Registry-based data from the United States show that 0.007 percent of total COVID-19 related deaths were in children and 0.01 percent of the cases among children were fatal (45).

A registry study from Norway between 1 March and 15 May reports no deaths among children under the age of 20 with confirmed COVID-19 (16).

The spread of infection in preschools and schools

By April 2020, 185 countries worldwide had closed their schools in response to the pandemic (46). This affected 89.4 percent of the world's children. The reason for the massive closure was fear of infection in schools and the assumption that children would be driving the infection within households, as is the case with the annual flu (47). Early data from Shenzhen in China also indicated that children are infected and infect to the same extent as adults (48). Since then, however, we have gained new knowledge.

A Swedish register study indicates that the COVID-19 risk among teachers in lower secondary schools, which remained open during the spring, was twice as high as that among upper secondary school teachers (49). The authors discuss that this increased risk may be due to several factors related to the teachers' interaction with other adults at school or through commuting to school. The increased COVID-19 risk among teachers in secondary schools also showed correlations with confirmed cases among teachers' partners. Furthermore, the authors used statistical models to estimate how many serious cases of illness could have been avoided if lower secondary schools had closed, as upper secondary schools did. Of 79 serious COVID-19 cases requiring hospitalisation, the researchers estimated that 33 could have avoided becoming seriously ill if lower secondary schools had closed. However, the authors did not conclude that secondary schools should be closed, but

that reasonable measures to reduce the spread of infection are needed and must be complied with.

Based on data from infection tracking, Folkhelseinstituttet in Norway notes that there are few cases of infection in schools and preschools in Norway and that there have rarely been more cases in a school or preschool where someone has fallen ill (50).

A study from the United States showed a slightly higher infectivity among children than most other studies. An analysis of infection tracking data identified three outbreaks in preschools that could be linked to adult index cases (51). Infection tracking showed that the infection then spread from children to contacts in the home. In the three outbreaks, 54 percent of the cases were among children, of which 12 children were infected at the preschool. The infection was further identified from these children to at least 12 out of 46 contacts they had outside the preschool, of which one parent was hospitalised. The infection is confirmed to have spread from two of the three children with confirmed asymptomatic COVID-19. The infection was estimated to have spread from children with confirmed COVID-19 in preschool to 25 percent of their contacts outside the preschool, which included an 8 month-old baby who infected both their parents.

Ireland closed schools on 12 March 2020. Before closing, 6 cases were confirmed, including three adults and three children (52). However, none of these were infected at school. In the study, they concluded that schools are not a driving force in the spread of COVID-19.

Germany has observed some minor outbreaks linked to schools since the beginning of the pandemic. However, the proportion of outbreaks in schools is low (0.5 percent) and about half of the cases were among adults. Of the 8,841 COVID-19 outbreaks with a total of 61,540 cases with documented site of infection, 48 outbreaks (0.5 percent) have been linked to schools with a total of 216 cases. About half of the 216 cases were among persons aged 21 or over ($n = 102$), 39 cases among persons aged 15-20 years, 45 cases among pupils aged 11-14 and 30 cases among children aged 6-10 (53).

In Hong Kong, 20 confirmed cases of COVID-19 in schoolchildren aged 5 to 17 were investigated to gain more knowledge about the spread of infection in schools. Through broad school testing and medical monitoring of cases and their close contacts, the study showed that no more cases could be linked to the 20 cases, indicating that the risk of further infectivity in schools is limited (54).

An outbreak of COVID-19 in a school in Israel was documented at the school opening, after a two-month closure (27). After two confirmed cases, testing was performed on almost all pupils and staff. Among pupils aged 12-18 ($n = 1,161$), 13 percent were positive for COVID-19 and among staff the number was 16 percent ($n = 151$). There were more COVID-19 cases among younger pupils (aged 13-15) than older pupils (aged 16-18). 43 per cent of the pupils and 76 per cent of the staff had symptoms. No one was hospitalised. The study is a case study describing

special circumstances that could have contributed to the spread of infection after school opening in the specific school. The week when the school was opened was an extremely hot week that required the teaching to take place in rooms with windows closed and with air conditioning. Other factors that may have contributed to the spread of infection are cramped classrooms with 35–38 pupils per room (and less than 1.5 square meters per pupil), long school days and after-school activities.

The importance of the school and the impact of the pandemic on children and teenagers

Countries where schools and preschools have remained open have had no outbreaks of infection among children, but rather only sporadic cases (3). Adjusted teaching and school absence during the COVID-19 2 pandemic, might entail an increased risk that children and teenagers do not assimilate their education in primary, secondary school and higher. This should be put in relation to the fact that knowledge and education is an essential prerequisite of good health throughout life.

Possible health consequences were identified in relation to the school closures. Rabinowicz and others highlight some in their overview of COVID-19 in children (55). The consequences might differ from country to country depending on economic context. Learning loss seems to be among the biggest consequences affecting children in low-income countries, but also children in medium- and high income countries. Lack of services provided by the school to children such as school meals and social support from adults other than their parents, reduced physical activity and disruptions in the social life of children and adolescents and stimulation are other possible consequences of school closures (55).

In relation to loss of learning, children have different technical and cognitive capabilities that make distance learning easier or more difficult. For example, a study from China shows that children with ADHD experienced more ADHD symptoms during the COVID-19 outbreak and school closure (56).

Other possible effects of the COVID-19 pandemic are the psychological consequences for children (57-59). Studies also show that many households find themselves in a troubled and stressful situation during the COVID-19 pandemic. Children may, for instance, be at higher risk of violence and neglect at home, especially in already vulnerable families. Official statistics in the United States indicate, however, lower than usual reporting of domestic violence during COVID-19. This is probably because school staff, who are the ones who most often report neglect, do not have the same contact with pupils during the pandemic (60).

In high-income countries where quarantine and school closures were introduced, there are signs of more unhealthy lifestyles in the form of increased consumption of unhealthy food and reduced physical activity (61).

Conclusions

This paper describes the epidemiological situation and the current research on COVID-19 and children and adolescents. Since the summer, the number of COVID-19 cases in Sweden has increased. Among children and adolescents, the increase is seen only among teenagers and not among the youngest children. However, teenagers are tested to a greater extent than younger children, which can of course affect the number of confirmed cases. The increase was expected with the return to schools and workplaces after the summer, but also because testing has increased. The increase was sharp in October, most notably among 16 to 19-year-olds.

The Public Health Agency has asked all regional infectious disease control units to report any outbreaks. Due to high workloads, mainly in some regions, it is uncertain whether all outbreaks have been reported. So far, however, few outbreaks have been reported in preschools, primary and lower secondary schools. Current knowledge indicates that schools are not, as such, a risk environment for children and adolescents, but rather that the infection is spread in leisure time, in close-contact sports and in other social contexts such as parties and camps. Schools are also a workplace, and outbreaks to date in schools show that there has been spread of infection among adults in the schools. A number of measures have been taken at schools, such as changing schedules to avoid congestion, not allowing parents to stay on the premises, holding some of the teaching outdoors and allowing teaching of secondary school students to take place partly remotely.

Occupational groups meeting larger groups of children in schools, primary school teachers, preschool teachers and child minders, so far do not have a relatively higher risk of being diagnosed with COVID-19 compared to other occupational groups. There is a higher relative risk of being diagnosed with COVID-19 among preschool principals, as well as among primary and secondary school principals. The relative risk of being diagnosed with COVID-19 may depend on several factors, such as multiple and close contacts with adults and children in the professional role, leisure activities and increased testing during the period.

Since upper secondary schools have had distance learning during the spring, upper secondary school teachers' COVID-19 risk should be further monitored towards the end of the autumn semester.

The latest scientific findings about children and adolescents and COVID-19 largely confirm previous knowledge. Children are not driving the COVID-19 pandemic. Children generally experience milder symptoms than adults, sometimes none at all, and fever and a cough are the most commonly reported symptoms. Very few children have needed intensive care and even fewer have died as a result of COVID-19. Children are rarely index cases, and international studies show that infectivity between children is much lower than between adults. Few studies have indicated widespread contagion in schools or between children.

On the other hand, there is a tendency of increased risk of infection as children grow older. Teenagers seem to be more susceptible to becoming infected than younger children, but develop mild symptoms. As age increases, more cases are seen but numbers are not as high as among people over 19. Teenagers move around more in the community and can have many close contacts. The role of teenagers in the spread of infection needs to be investigated further in outbreak investigations and infection tracking.

So far no clear risk groups have been identified in children, but many seriously ill children have had underlying diseases such as heart disease, asthma and impaired immune systems. Obesity has been suggested as a risk factor, but has not been confirmed. Research is ongoing on underlying diseases and more findings are expected.

The knowledge base regarding COVID-19 is continuously updated. The Public Health Agency is following the national epidemiological development closely and in close cooperation with the country's infectious disease control units. We note that children continue to make up a small proportion of confirmed COVID-19 cases, even after the more extensive testing started. We do not know enough at present about the underlying factors of children and adolescents, such as socio-economic background and country of birth, to identify groups of children who might be at higher risk of COVID-19.

School closures might have adversely affected children and teenagers. On the one hand, there has been a loss of learning and, on the other hand, mental health might have been negatively affected. The negative consequences may also hit hardest against those who are already at risk, such as children with disabilities, children with underlying diseases, children in disadvantaged socio-economic groups and children living in social vulnerability and poverty.

In the light of current knowledge and in a situation where the pandemic is far from over, it is important to take measures allowing children and adolescents to continue to attend preschool and school as far as possible. Completion of education is important to health, and it is important to strike a balance between the needs of children and adolescents of, and their right to, education and the disease control measures taken. For teenagers, it is important to reflect on what is required to reduce the risk of spreading the virus further, even if severe symptoms are not experienced. A reminder regarding the general advice and the responsibility of everyone, including teenagers, to curb the spread of infection, is therefore called for.

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Folkhälsomyndigheten

Solna Nobels väg 18, 171 82 Solna. **Östersund** Forskarens väg 3. Box 505, 831 26 Östersund.

www.folkhalsomyndigheten.se