MINISTRY OF HEALTH
MANATŪ HAUORA
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COVID-19 in children

Note: This working paper formed part of background work commissioned by the Ministry of Health to help inform the ongoing response to COVID-19. It provided a rapid summary of the evidence relating to COVID-19 in children in early 2020 which continues to emerge. See more at: https://www.health.govt.nz/publication/covid-19-modelling-and-other-commissioned-reports

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Executive summary

This working paper forms part of background work commissioned by the Ministry of Health (via the Director of Public Health) to help inform the ongoing response to COVID-19. It provides a rapid summary of the evidence relating to COVID-19 in children.

The evidence of COVID-19 in children is incomplete and rapidly emerging. This review needs to be updated regularly. We can see the following from the current evidence we have.

Low numbers internationally

Internationally, the number of cases of COVID-19 reported in children is considerably lower than adults. Aotearoa/New Zealand currently has approximately 10 percent of cases in those under 20 years (2% aged 0-9 years, and 8% aged 10-19 years). This is a greater incidence than reported in other countries; likely because of COVID-19 clusters that involve school aged children.

Age-specific patterns and symptom profiles unclear

It is difficult to draw conclusions regarding age-specific incidence patterns and different symptom profiles between adults and children. This is because the current evidence relies on cases being tested, and children have been under-represented in testing internationally. For an accurate picture of the true incidence of SARS-CoV-2 infection in Aotearoa/New Zealand, we need to have population-based testing that includes a sufficient number of children and appropriate samples sizes with Māori and Pacific children.

Mild COVID-19 symptoms

Current international evidence indicates that children are more likely to have mild COVID-19 symptoms compared to adults. Cough and fever remain the most common symptoms in children. Children appear to more likely report gastrointestinal symptoms than adults. Mild disease or lack of a clinical presentation may contribute to why most countries detect relatively fewer cases in children, compared to adults.

Severity of COVID-19 and susceptibility needs further research

Further research is also needed to understand the role of single and multiple co-morbidities and other vulnerabilities (including prematurity and disability) in COVID-19 severity in children. There is evidence from a Chinese study to suggest that younger children (particularly infants) may be at higher risk of COVID-19 severity, but this is based on a high proportion of non-laboratory diagnosed cases and needs to be further clarified.

In terms of susceptibility to infection from SARS-CoV-2, there is conflicting evidence from two large Chinese studies regarding whether children are equally or less susceptible than adults. There is insufficient data yet to determine whether vertical transmission is possible.

Transmission is not fully understood

The role of children in SARS-CoV-2 transmission is not yet fully understood. While children do transmit the infection, current evidence suggests they are less likely to transmit the infection than adults.

Faecal-oral transmission needs more investigation

The potential for faecal-oral transmission of SARS-CoV-2 in children is another issue needing more investigation. Faecal PCR swabs have been shown to test positive for SARS-CoV-2 for a longer duration than nasopharyngeal swabs, even in children with no gastrointestinal symptoms, but the role of faecal swabs in assessing infectivity is not clear.

Living conditions may influence transmission

If children are important in transmission this would likely exacerbate existing health inequities for families living in crowded or multigenerational households, as well as those living with individuals who are elderly or with chronic disease. Living conditions may also influence the transmission dynamics for SARS-CoV-2, and it is imperative that this is investigated to prevent any disproportionate impact on Māori and Pacific peoples.

Purpose of this document

The purpose of this document is to provide a rapid summary of the evidence relating to COVID-19 in children. It looks at how the disease affects children, and what is known about the infectivity/transmission of the SARS-CoV-2 virus from children to other children and adults.

Children's contribution to infection has important implications for decisions around COVID-19 pandemic control measures in New Zealand, especially for the opening of schools and early childhood education (ECE). Implications for health inequities, especially for Māori and Pacific populations, will also be discussed. This review does not cover the clinical management of children with COVID-19.

This is one of a number of papers prepared by the COVID-19 Public Health Response Strategy Team (a group of epidemiologists and public health medicine specialists seconded temporarily to the Ministry of Health).

We thank the peer reviewers for their helpful comments and suggestions.

Incidence

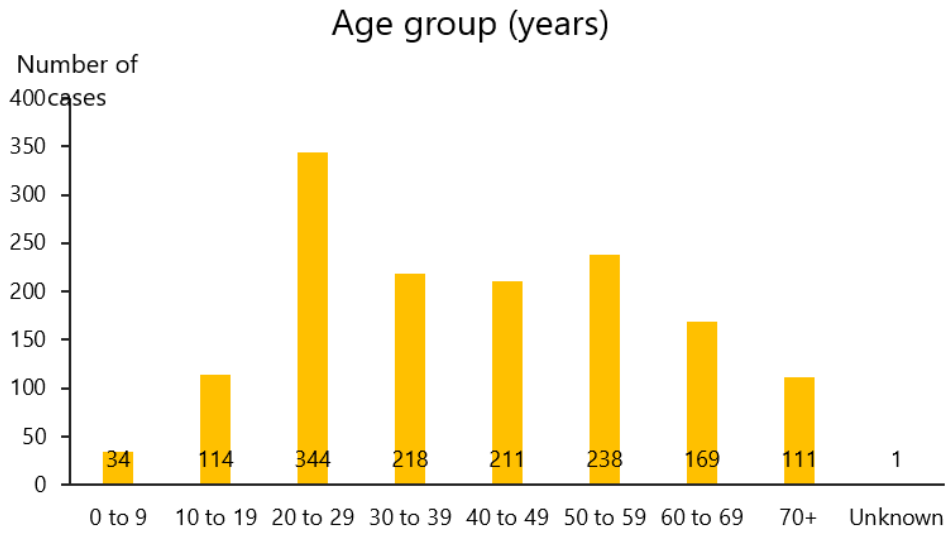
Early analyses of COVID-19 epidemiology internationally show a low incidence of cases among children and youth, and less severe disease for those children who are infected. However, given that children infected with SARS-CoV-2 are more likely to have no or very mild symptoms[1], and that case definition and testing criteria often require symptoms or more severe disease, cases in children are more likely to be missed. There is a lack of evidence on the incidence of COVID-19 on indigenous children and children from marginalised or minority groups.

A systematic review of papers between 1 January and 18 March 2020[1] on COVID-19 and children found 45 relevant articles and letters, with children accounting for 1-5 percent of the diagnosed COVID-19 cases reported. The largest epidemiological cohort reported in China was 72,314, of which 44,672 were confirmed cases of COVID-19, and approximately 2 percent were children aged 0-19 years. Of these, 0.9 percent were under the age of 10 years at diagnosis.[2] In Italy, analyses of 22,512 cases reported on 18 March 2020 included 1.2 percent children (aged 0-18 years).[3] In a review of the 149,760 laboratory-confirmed COVID-19 cases in the United States occurring between 12 February and 2 April 2020, 2,572 (1.7%) were in infants, children, and adolescents aged under 18 years.[4]

In Australia (as at 20 April 2020) there were 74 of 6566 COVID-19 cases (1%) diagnosed in children aged 0-9 years and 195 (3%) cases in children aged 10-19 years[1]. In Aotearoa/New Zealand (as at 20 April 2020), 34 of 1440 confirmed and probable cases (2%) were in children aged 0-9 years, and an additional 114 (8%) of confirmed and probable cases were in those aged 10-19 years. Aotearoa/New Zealand, therefore, is currently reporting a greater incidence of COVID-19 child cases than presently seen in the international epidemiology.

[1] Number of COVID-19 cases in Australia April 20, 2020, by age group. Accessed 22nd April: https://www.statista.com/statistics/1104012/australia-number-of-coronavirus-cases-by-age-group/

Figure 1: Age group of probable and confirmed cumulative cases in Aotearoa/New Zealand, 20 April 2020



Source: New Zealand Ministry of Health[2]

Large outbreaks and clusters involving children, such as those in schools, have been a feature of COVID-19 surveillance across the globe, and in Aotearoa/New Zealand. These clusters influence the relatively high proportion of school-aged children in cases in this country, compared to other countries where children with COVID-19 are predominantly the result of household transmission.

Further epidemiological analyses of cases in Aotearoa/New Zealand (such as age-specific cases stratified by ethnicity, testing rates stratified by age, and details of the school-related cases and clusters) are critical to inform our COVID-19 response, but are not yet available. Importantly, the young population age structure of Māori and Pacific communities in Aotearoa/New Zealand needs to be carefully considered in further investigation into the impact of COVID-19 disease on health outcomes and equity.

Clinical symptoms and disease course

A meta-analysis of COVID-19 clinical features in children was published on 17 April 2020 with a total of 1667 patients described in 25 case reports, 23 case series and one cohort study of children with diagnosed COVID-19.[5]

The main symptoms described in children were fever (48%) and cough (39%), and 30 percent of children had both cough and fever. Diarrhoea was described for 7 percent, and 6 percent of cases had nausea and/or vomiting. Over a third (35%) of children experienced more than one symptom.

Similarly, another systematic review (which included some of the same studies) of COVID-19 in children published on 23 March 2020[1] described cough and fever as the most common symptoms, with diarrhoea, fatigue, rhinorrhea and vomiting reported for 6-8 percent each in children.

It is important to note that many of the studies included in these meta-analyses may include cases that are duplicated across studies, and some of the children who were diagnosed with COVID-19 did not have their diagnoses verified by laboratory tests. This gap has implications for the summaries of symptoms, severity and prognoses.

[2] New Zealand Ministry of Health. COVID-19 Current Cases. Accessed 21 April https://www.health.govt.nz/our-work/diseases-and-conditions/covid-19-novel-coronavirus/covid-19-current-situation/covid-19-current-cases

For the 149,760 laboratory-confirmed cases in the USA between 12 February and 2 April 2020, data were available for a small proportion of patients on many important variables, including symptoms (9.4%), underlying conditions (13%), and hospitalisation status (33%). Among those with available information, children (under 18 years) had fewer symptoms of fever, cough, or shortness of breath compared with adults [4].

Severity of symptoms in children

These data support findings from other countries that children with COVID-19 might not have reported fever or cough as often as adults. The case definition for suspected COVID-19 in Aotearoa/New Zealand includes clinical criteria of acute respiratory infection with at least one of the following symptoms: cough, sore throat, shortness of breath, coryza, anosmia with or without fever. As these acute respiratory symptoms are less severe in children with COVID-19 than in adults the current proportion of COVID-19 cases in childhood may not be indicative of the true incidence of the disease in children.

Most children with COVID-19 are described as having mild symptoms. In the large case series of 2143 children in China diagnosed with laboratory-verified or clinically diagnosed COVID-19[6], more than 90 percent had asymptomatic, mild or moderate disease. There were 5 percent described with severe disease, and less than 1 percent described as critical.

In the recent Chinese meta-analysis[5], 19 percent of cases were described as asymptomatic. It is not clear whether those children described as asymptomatic in this study remained asymptomatic (never developed symptoms) over time or if some of them were tested in the incubation period of the disease (pre-symptomatic) and later developed symptoms.

Only 3 percent of children in the meta-analyses are described as having severe illness, with 'severe' disease typically defined in the Chinese epidemiological studies as dyspnoea, central cyanosis and an oxygen saturation of less than 92 percent.

There is some evidence that younger children, particularly infants, may be more vulnerable to severe COVID-19 disease. A retrospective study of 2143 paediatric patients with COVID-19 in China found that the proportion of severe and critical cases by age groups was 10.6 percent (for under 1 years), 7.3 percent (for 1-5 years), 4.2 percent (for 6-10 years), 4.1 percent (11-15 years) and 3.0 percent for those aged ≥16 years. However, many of the children in this study did not have laboratory-confirmed COVID-19 disease and there are other illnesses in the under 1 age group that can also cause severe respiratory disease. In addition, there is no information provided on the presence of comorbidities (including concurrent respiratory infections) and other important features (including prematurity) for the cases described as severe.

While most COVID-19 illness in children is milder than adults, serious COVID-19 illness resulting in hospitalisation still occurs in this age group. In the USA case series of 149,760 laboratory-confirmed cases, 5.7 percent of all children with COVID-19 (20% of those for whom hospitalisation status was known) were hospitalised.[4]

Internationally, the reported case-fatality rate of COVID-19 in children is low. Of the 965 deaths from 44,672 confirmed COVID-19 cases reported in China up to 11 Feb 2020, no children under the age of 10 years were reported to have died, and one child aged 10-19 years had died.[2] In the United States there were three deaths in the child (under 18 years) population from the 149,760 laboratory-confirmed COVID-19 cases occurring between 12 February – 2 April 2020[4].

Disease severity data, including hospitalisation rates, for COVID-19 in Aotearoa/New Zealand are not currently available by age or ethnicity. It is important that we further understand the case incidence, symptoms and severity for our children. Māori and Pacific children have existing inequities in access to health care as well as in access to the determinants of health that influence respiratory disease severity (such

as quality housing). Therefore, these children are more likely to be disproportionately affected by COVID-19. These inequities must be monitored and mitigated.

Infectivity and transmission

Susceptibility of infection

There is conflicting evidence whether children are equally or less susceptible than adults to infection with the SARS-CoV-2 virus.

One study of 391 cases and 1286 close contacts in Shenzen, China, found that children were just as likely to be infected as adults when exposed to a household case.[7] Another Chinese study of 4919 contacts of COVID-19 cases found that children were 2.7 times less likely as adults in their households to test positive ($p<0.002$).[8]

Widespread testing of the Icelandic population identified as high-risk of COVID-19, found children under 10 years of age were less likely to test positive compared to those over 10 years of age (6.7% and 13.7% respectively). Similarly, population screening of individuals, who were symptom-free or who had mild symptoms of the common cold, found younger children were less likely to test positive for SARS-CoV-2. Among this group no children under 10 years tested positive compared to 0.8 percent of children over 10 years of age.[9]

There are very few studies on COVID-19 in pregnancy and neonates to clarify whether babies can become infected in utero. A case series of 31 pregnant women with COVID-19 found none of their infants or placentas tested positive for the virus.[10] There is one case of a newborn baby born by caesarean section with a positive SARS-CoV-2 swab (PCR) test 16 hours after birth, with no detectable maternal antibodies for SARS-CoV-2 until after delivery, suggesting possible vertical[3] transmission.[11]

Role of children in transmission

A crucial point to understand is the role of children in transmission. Whilst it is clear that children can and do transmit SARS-CoV-2 infection, it is unclear whether children transmit the infection at a lower or at a similar rate to adults.

An analysis of household clusters from China, Singapore, South Korea, Japan, and Iran identified 9.7 percent (3 out of 31) as having a paediatric index case.[12] Even if it was assumed that all asymptomatic children in these families were in fact the index case, only 6/28 (21%) children were identified as the index case in the household cluster.

In Australia, the National Centre for Immunisation Research and Surveillance and the NSW Ministry of Health have commenced an investigation into the transmission of COVID-19 in school and child care centre settings. Preliminary findings suggest low onward transmission among children with 1.9 percent of close contacts who were children testing positive for the virus, although further details are not currently available.[13]

In Aotearoa/New Zealand, there has been one COVID-19 cluster associated with a secondary school in Auckland and although the index case in this cluster was an adult, there have been no data published to assess whether transmission has occurred from children. At 22 April 2020, there are 93 cases associated with this cluster (however, not all these cases are children).

[3] Vertical transmission is transmission from mother to baby during pregnancy or birth.

Variants in shedding

Despite being asymptomatic or having very mild symptoms, infected infants and children may have high viral loads in their nasopharynx, as well as faecal shedding of the virus for longer periods.[14] Viral shedding has also been reported in children without gastrointestinal symptoms[16]. The possibility has been raised of faecal-oral transmission.[17] SARS-CoV-2 RNA has been found in stool specimens and rectal swabs, often with a higher number of positives than oral samples in a later phase of disease.[18]

Viral loads show that shedding from the gastrointestinal tract may be higher and more long-lasting compared with the respiratory tract.[8] It is unclear at this stage whether the virus particles shed in faeces is sufficient to cause infection. Currently, droplets are considered to be the main mechanism of human-to-human transmission of COVID-19, but if faecal shedding with environmental contamination plays a role in viral spread, this could be especially relevant in the context of young children.

Coinfection

Is it also possible that coinfection with other respiratory pathogens could increase the risk of transmission, due to increasing droplets. The coinfection rate in children is not known, but it is thought to be reasonably high in all ages[19] and children are at high risk of respiratory infections.

Modes of transmission

To determine whether children were transmitting SARS-CoV- 2 'silently' (because they had no symptoms and/or higher rates of transmission and/or different modes of transmission compared to adults) we would need to specifically monitor for the following:

- higher rates of COVID-19 in households where children live (compared to similar households with no children, and adjusted for occupancy)
- higher rates of COVID-19 in professions with higher exposure to children eg, teachers, ECE staff
- outbreak clusters in, and associated with, schools and ECEs.

There are also important gaps in our knowledge regarding SARS-CoV-2 transmission for Māori and Pacific children. We have evidence that the transmission of other infectious diseases for these groups is higher than the population average, and therefore they are important groups to test, report on and proactively protect.

Infectivity and transmission summary

In summary, at this stage the international evidence on transmission and infectivity suggests that while children can transmit SARS-CoV-2, they may do so at a lower rate than adults. This needs to be clarified in the Aotearoa/New Zealand context, informed by robust population testing and information on PCR test validity in children. Most children, even in school clusters, appear to have been infected by adults. The significance of the faecal-oral route of transmission is unclear. More studies are needed to understand the role children play in SARS-CoV-2 transmission.

Testing for SARS-CoV-2 in children in Aotearoa/New Zealand

To get an accurate picture of the true incidence of SARS-CoV-2 infection in Aotearoa/New Zealand children, we need population-based testing that includes sufficient numbers of children, and has adequate sample sizes of Māori and Pacific children.

To date, the limited sentinel testing that has been conducted has focused on sampling from supermarkets (staff and customers). This approach is likely to under-test children (as children are asked not to attend supermarkets under Alert Level 4 control measures). Further testing is under-way and it will be critical to understand the testing by age and ethnicity.

There are a number of challenges to better test for SARS-CoV-2 in children. A nasopharyngeal swab is challenging/distressing to take from a child, so this is a barrier to population-based testing of children. In addition, we could not find confirmation of whether the sensitivity of swab (PCR) testing is different in children compared with adults. There is also the potential for serology testing to have more false positive results in children due to cross-reactivities between antibodies against SARS-CoV-2 and common circulating coronaviruses[15.] This needs to be clarified before serology testing is introduced in Aotearoa/New Zealand.

The national capacity to test for SARS-CoV-2 is not unlimited. Children experience frequent respiratory infections that have a similar symptom profile to that seen for COVID-19. As it gets colder these infections are likely to be more frequent, control measures reduce, and there is increased contact between children and others (including in education settings).

In addition, ECE and schools will have increased vigilance and concern regarding children with respiratory symptoms. A safe but pragmatic approach will be needed to determine when to test children for COVID-19, that considers community safety, testing capacity and equity.

Control measure implications

Our review of control measures in educational settings[20], while limited by a lack of relevant evidence, suggested that the potential impact of closing schools on the pandemic is modest.

The adverse wellbeing and equity impact of prolonged closure of schools needs to be carefully weighed up against any benefits. There may be alternative interventions that could be put in place to reduce risks of transmission and inequities (exacerbated or new, educational and health) within school settings. It is difficult to implement effective interventions to reduce the risk of COVID-19 transmission across education settings, particularly for young children, without adversely impacting on children. This work needs to be continuously reviewed as more local and international evidence emerges.

The presence of diarrhoea and/or nausea/vomiting in children has implications for both the case definition for this age group, and guidance in educational settings. Whilst fever remains the most common clinical sign, consideration should be given to adding diarrhoea and vomiting to the case definition for COVID-19. Control measures generally focus on droplet spread as the primary mechanism for transmission. If faecal shedding plays an important role in transmission, public health advice for COVID-19 may need to reflect the precautions required for other pathogens transmitted in this way.

The evidence of risk for COVID-19 transmission in ECE and schools appears low. However, if children in ECE and school are important for transmission this has implications for individuals (children, staff and household bubbles) at high risk of COVID-19 severity, and exacerbation of inequities for families living in crowded and/or multigenerational households. Māori and Pacific peoples have young age structures, making up 25

percent and 13 percent (respectively)[4] of the proportion of children in Aotearoa/New Zealand, and experience existing inequities in health and living conditions. The inequitable distribution of these determinants may influence the transmission dynamics for SARS-CoV-2, and it is imperative that this is investigated to prevent any disproportionate impact on Māori and Pacific peoples.

There is an urgent need for better understanding of the role children have in the chain of COVID-19 transmission. There are also important knowledge gaps regarding the co-morbidities and vulnerabilities (including disability and prematurity) that may increase the risk of COVID-19 severity in children. It is important to gain a clearer understanding of our current testing rates and hospitalisations by age and ethnicity, and to continue to monitor the evolving international literature. There is a need for better investigation of Aotearoa/New Zealand data on COVID-19 in infants, children and youth, and implications for equity. This investigation could include the following sources:

- COVID-19 population surveillance that includes children, and has adequate sample size for Māori and Pacific children in Aotearoa/New Zealand
- COVID-19 sentinel surveillance in ECE and school settings in Aotearoa/New Zealand
- detailed analysis of the existing cases involving children and youth in Aotearoa/New Zealand, particularly the school cluster, to inform any lessons relevant for control measures in educational settings
- when methods for serological confirmation of SARS-CoV-2 infection are established, an assessment can be made of the relative sensitivity of swab (PCR) testing in children, compared with adults. This validation data will provide vital information for interpreting test data to understand the true incidence of COVID-19 in children who are close contacts or potential index sources for cases.

[4] 2013 Census, total response ethnicity

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