The evidence so far suggests that children are less vulnerable to the effects of the coronavirus, but they can still be infected. Why does the virus seem to affect children differently?

By Michelle Fernandes
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There is much debate about the credibility of a **recent tweet** by entrepreneur Elon Musk suggesting children are "essentially immune" to the coronavirus. So far, the narrative has been that while the coronavirus may cause severe, or even fatal, disease in the elderly, the outcomes for children are reassuring.

Nevertheless, there have been a few concerning reports of young people being seriously affected by the virus. These, together with school closures implemented last week in many countries around the world alongside strict social distancing measures, have made many parents worry about the effect it could have on their children.

Can children be infected with the coronavirus?

Yes. Just as with adults, children exposed to the coronavirus can be infected with it and display signs of Covid-19. “At the beginning of the pandemic, it was thought that children are not getting infected with the coronavirus, but now it is clear that the amount of infection in children is the same as in adults,” explains Andrew Pollard, professor of paediatric infection and immunity at the University of Oxford. “It’s just that when they do get the infection they get much milder symptoms.”

Data from the Chinese Center for Disease Control and Prevention reported that children under 19 years of age comprised **2% of the 72,314 Covid-19 cases** logged by February 20th, while **a US study of 508 patients**, reported no case fatalities among children, with this group accounting for less than 1% of the patients in hospital.

“It could be that the virus has preferentially affected adults at the moment because there has been workplace transmission and transmission during travel,” says Sanjay Patel, a paediatric infectious diseases consultant at Southampton Children’s Hospital. “Now that adults are spending more time with their children we might see a rise in infection in children, but we might not.”

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Overall global trends seem to suggest children are less likely to be infected than adults, especially older adults, but it is very possible the data is biased by the fact that, in some countries, testing is only offered to

those who show up in hospital with severe symptoms of Covid-19, very few of whom are children.

“Clearly, more children are infected than we think,” says Patel. “We are not testing every child in the country.”

How does the coronavirus affect children differently from adults?

“It is a remarkable observation, in the global literature that we have for coronavirus already, that even children with very serious medical conditions, who are on immunosuppressive therapies or on cancer treatments, are much less affected than adults, especially older adults,” says Andrew Pollard, head of the Oxford Vaccine Group, whose researchers have recently identified a **vaccine candidate for Covid-19**.

In general, children with Covid-19 experience milder symptoms than adults. But a **12-year-old girl from Belgium** and a **13-year-old boy from London**, UK, have both died in recent days, making them the youngest victims in Europe. A 14-year-old in China has also been reported to have died after being infected with the virus.

Schools in many countries have now been closed as part of the effort to control the spread of Covid-19 (Credit: Getty Images)

Data from a **Chinese study of Covid-19 in children** confirmed slightly more than half showed mild symptoms of fever, cough, sore throat, runny nose, body aches and sneezing; while around a third showed signs of pneumonia, with frequent fever, a productive cough and wheeze but without the shortness of breath and difficulty breathing seen in more severe cases.

Graham Roberts, an honorary consultant paediatrician at the University of Southampton, explains: "Children (with Covid-19) are predominantly affected in their upper airways (nose, mouths, and throats) so they get cold-like features rather than the virus managing to access their lower airways, ie lungs, and giving the pneumonia and life-threatening Sars picture that we see with adult patients."

The proportion of children who went on to develop severe or critical Covid-19 illness with breathlessness, acute respiratory distress syndrome (ARDS), and shock was much lower (6%) than **among Chinese adults** (19%) – especially older adults with chronic cardiovascular or respiratory conditions. A small proportion of children (1%) did not show any signs of infection at all, despite harbouring the virus. In comparison, only 1% of infected adults remained asymptomatic.

"The million dollar question is whether the majority of infected children just have very mild symptoms, or whether children are actually not getting infected with the virus, certainly not as much as adults are," says Patel.

Why do children infected with the coronavirus fare better than adults?

"The virus is so new that we don't really know", says Roberts, who is also director of the David Hide Asthma and Allergy Research Centre, in Newport, UK.

"One of the likely reasons is that the virus needs a protein on the surface of a cell (a receptor) to get into the inside of a cell and start causing problems," he says. "The coronavirus seems to use the Angiotensin converting enzyme II (ACE-2) receptor for this purpose. It may be that children have less ACE-2 receptors in their lower airways (lungs) than in their upper airways, which is why it is their upper airways (nose, mouths and throats) that are predominantly affected."

> **It is not so much that children are not being as affected, but that something changes as a person gets much older that makes one more likely to be affected – Andrew Pollard**

This may explain why children infected with the coronavirus seem to get more of a cold rather than a pneumonia or the life threatening Sars picture that is seen in adults. The coronavirus's affinity for the ACE-2 receptor was demonstrated in cell lines and in mouse models in **laboratory studies** as early as 2003, and in **genome studies** of novel coronaviruses RsSHC014 and Rs3367 (related, but not identical, to the SARS coronavirus) isolated from Chinese horseshoe bats in 2013.

Pollard says there may be another explanation. "It is not so much that children are not being as affected, but that something changes as a person gets much older that makes one more likely to be affected."

He puts this down to the ageing of the immune system (immunosenescence), which makes the body less able to fight off new infections. “However, we don’t see immunosenescence in young adults, and it’s very clear that even young adults have a higher risk of severe disease than children do so that is probably not the whole answer,” adds Pollard.

There are many ways in which the immune system of a child differs from that of an adult, not least because the immune system of children is still very much a work in progress: children, especially those in nursery or school, are exposed to a large number of novel respiratory infections and this might result in them having higher baseline levels of antibodies against viruses than adults.

The virus needs a certain protein on the surface of cells to infect cells, but it is possible children's lung cells carry less of it than adults (Credit: Getty Images)

“Children seem to mount more intense responses (to viral infections) than adults, such as high fevers that you just don’t see very often in adults,” says Roberts. “It is very possible that the children’s immune systems are better able to control the virus, localise it to their upper airways without it causing too many other problems and eliminate the virus”.

“It might also be that children previously infected with the other four types of coronavirus might experience cross protection from previous infections,” adds Patel.

Additionally, the authors of the study of childhood cases in **China** suggest that because children have fewer chronic cardiovascular and respiratory conditions, they are more resilient to severe coronavirus infection than elderly adults.

Children, with immature immune systems, appear to be less capable of mounting cytokine storms to fight off viral infections

“Very few children have severe Covid-19 infection,” says Pollard. “That does suggest that there is something fundamentally different about the way they are handling the virus.”

There is a third reason as to why children don’t seem to be getting severely ill with Covid-19. In critically ill adults, an overzealous immune response to fight off the virus – termed a **cytokine storm** – appears to do more harm than good, causing multi-organ failure. Children, with immature immune systems, appear to be less capable of mounting cytokine storms to fight off viral infections.

While this hypothesis is yet to be proved in Covid-19, **studies of immune responses in children during the 2003 Sars outbreak** proved that, unlike adults, children did not mount an overtly elevated cytokine response.

Can children, with mild or no illness, transmit the Coronavirus to others?

Yes, they can.

“This is the big issue,” says Roberts. “Many think that children are at low risk and we don’t need to worry about them, and yes, that is true for children who don’t have chronic medical conditions like immunodeficiencies. What people are forgetting is that children are probably one of the main routes by which this infection is going to spread throughout the community.”

The coronavirus is transmitted from an infected person to a non-infected person through direct contact with the respiratory droplets of an infected person (generated through coughing and sneezing), and touching surfaces contaminated with the virus. This means that children infected with the coronavirus, with very mild or no illness, can transmit the infection to others, especially family members and elderly relatives.

Even if they don't show such severe symptoms as adults, children can still carry and spread Covid-19 (Credit: Getty Images)

"Children with very mild disease are probably going to be one of the major contributors to spreading the virus across the population," says Roberts. "This is why schools closing are crucial to reducing the rate at which the pandemic spreads across the UK."

Have we seen a similar pattern, with other viruses, where children experience milder illness than adults but are important spreaders of the infection?

Yes, influenza is one such virus that most of us are familiar with.

"Influenza is often just a runny nose in a child, in the older members of the population it can lead to hospitalisation, intensive care, or can be fatal," says Roberts. He has an important message: "A few years ago the government (in the UK) brought in flu vaccinations for children. That wasn't particularly to protect children in the population, that was to stop children from passing influenza to their elderly relatives who can be much more affected by it."

The principle holds true for the coronavirus. The risk of Covid-19 to children themselves is low, the risk of them transmitting it to vulnerable elderly or ailing relatives, is high.

Chinese data suggests that young children, particularly infants, are more vulnerable to Covid-19 than other age groups

Another example is the swine flu (H1N1) virus, responsible for the flu pandemic of 2009 and 2010. "H1N1 infection was preferentially much worse in pregnant women and the elderly, with children having some tummy symptoms but much milder than in adults," says Patel.

Does Covid-19 affect children of different ages differently?

It appears so. The Chinese data suggests that young children, particularly infants, are more vulnerable to Covid-19 than other age groups. While severe or critical illness was reported in one in 10 infants, these rates decreased dramatically as children grew older so that in children aged five years or older, only three or four in 100 developed severe or critical illness.

"There is a predilection for preschoolers," says Roberts. "They have small airways, and they are less robust that older children in fighting off the infection. They are also more likely to be admitted to hospital because they are so young."

What about teenagers?

"At some stage children turn into adults," says Roberts. "In teenagers, we see a maturation in the immune system into a more adult pattern, which may be less effective at controlling this virus. It is important to remember, however, that we know very little about this virus, we are really speculating in terms of trying to understand why we are seeing the epidemiology that we are seeing."

In the Chinese study, no deaths were reported among children aged nine years and younger, while the **only death in children under 19** occurred in a 14-year-old. On 23 March, the UK also reported a Covid-19 related death in an 18-year-old with an underlying health condition before a 13-year-old was reported to have died on 1 April in London.

Can Covid-19 affect newborns?

Yes.

While the pandemic is still unfolding in many parts of the world, there are at least two cases of confirmed infection in newborns – **one in Wuhan, China** and **one in London in the UK**. It is not yet known whether these babies contracted the infection in the womb, or after being born. In both cases, their mothers tested positive for the virus.

What do we know about how the coronavirus affects babies in the womb?

Not much.

While coronaviruses responsible for severe acute respiratory syndrome (Sars) and Middle East respiratory syndrome (Mers) can affect the pregnant woman as well as her baby, causing miscarriages, premature delivery, and poor growth of the baby, similar patterns have as yet not been reported for mothers with Covid-19.

Children have so far seemed less vulnerable to Covid-19, but that doesn't mean precautions should not be taken to prevent them from becoming infected (Credit: Getty Images)

However, these findings are based on **two small studies** and national guidelines about the risks of Covid-19 in pregnancy, to the mother and to the baby, are being constantly updated. Nevertheless, **Public Health England** advises that pregnant women are at increased risk of severe illness from coronavirus (Covid-19) and recommends them to be particularly stringent in following social distancing measures for up to 12 weeks.

How can families protect children from being infected with the coronavirus?

Good hand washing, social distancing and disinfecting surfaces and objects which may harbour germs are the cornerstones of limiting the spread of the virus. The "catch it, bin it, kill it" practise is as important to decreasing the spread of Covid-19 as flu. "Do the basics properly," says Patel. "If you're in a communal area, if you touch anything, don't touch your face before washing your hands well."

The NHS website contains **information about the measures families can take to protect themselves** from Covid-19. Unicef has produced guidance for parents on **how to protect their children** from catching the coronavirus.

Can families protect elderly and vulnerable relatives from being infected by children?

Yes, but it will not be easy. Of the three measures – good hand-washing, social distancing and disinfecting surfaces and objects – distancing is the only failsafe method to protect elderly and vulnerable relatives from being infected, either by children or by anyone else.

"Looking at family interactions on mother's day, I saw loads of families with grandparents, parents and children together," says Patel. "I think that is absolutely terrifying – the data is very clear about the high risk for severe disease in the elderly, especially those with preexisting medical conditions. Keeping children away from grandparents is just the right thing to do – why take the risk."

In almost all circumstances, children are safe from severe Covid-19 disease – Andrew Pollard

The separation of apparently healthy children from elderly relatives may seem an unnecessarily stoic measure, however it is important to remember that while most children infected with the coronavirus show

only mild signs of illness, or no signs at all, they can still transmit the virus to others.

Limiting the spread of the coronavirus and containing the Covid-19 pandemic will depend as much on the success of social and behavioural changes, as on modern medicine and scientific advances.

Why it's important to talk to children about Covid-19

"With so much of the narrative about Covid-19 taking place at the societal level, one thing we really need parents to do is reassure their children that children are not going to die from Covid-19. It's really important that we get this message out," says Patel. "We know, as paediatricians, that children fear the worst but they don't often articulate that with us."

Pollard agrees. He suggests that parents should reassure their children that "in almost all circumstances, children are safe from severe Covid-19 disease".

"Children and teenagers are worried for their families," says Linnea Karlsson, a professor and child psychiatrist at the University of Turku, Finland. "We need to explain to children and teenagers that these are exceptional circumstances, and that we wouldn't be asking them to make exceptions to their normal routines if it wasn't.

"We need to explain to them that in situations like these we need to think about taking care of everyone, not just ourselves and our families."

** The **Healthier Together** network contains advice for parents on how to talk to children about COVID-19.*