

The pandemic generation

Child-development researchers are investigating whether the pandemic is shaping early brain development and behaviour.
By Melinda Wenner Moyer



A teacher in a biosecurity suit gives a lesson to a girl in her home in Cali, Colombia.

LUIS ROBAYO/AFP/GETTY

Like many paediatricians, Dani Dumitriu braced herself for the impact of the SARS-CoV-2 coronavirus when it first surged in her wards. She was relieved when most newborn babies at her hospital who had been exposed to COVID-19 seemed to do just fine. Knowledge of the effects of Zika and other viruses that can cause birth defects meant that doctors were looking out for problems.

But hints of a more subtle and insidious trend followed close behind. Dumitriu and her team at the New York–Presbyterian Morgan Stanley Children’s Hospital in New York City had more than two years of data on infant development – since late 2017, they had been analysing the communication and motor skills of babies up to six months old. Dumitriu thought it would be interesting to compare the results from babies born before and during the pandemic. She asked her colleague Morgan Firestein, a postdoctoral researcher at Columbia University in New York City, to assess whether there were neurodevelopmental differences between the two groups.

A few days later, Firestein called Dumitriu in a panic. “She was like, ‘We’re in a crisis, I don’t know what to do, because we not only have an effect of a pandemic, but it’s a significant one,’” Dumitriu recalled. She was up most of that night, poring over the data. The infants born during the pandemic scored lower, on average, on tests of gross motor, fine motor and communication skills compared with those born before it (both groups were assessed by their parents using an established questionnaire)¹. It didn’t matter whether their birth parent had been infected with the virus or not; there seemed to be something about the environment of the pandemic itself.

Dumitriu was stunned. “We were like, oh, my God,” she recalled. “We’re talking about hundreds of millions of babies.”

Although children have generally fared well when infected with SARS-CoV-2, preliminary research suggests that pandemic-related stress during pregnancy could be negatively affecting fetal brain development in some children. Moreover, frazzled parents and carers might be interacting differently or less with their young children in ways that could affect a child’s physical and mental abilities.

Lockdowns – which have been crucial for controlling the spread of the coronavirus – have isolated many young families, robbing them of playtime and social interactions. Stressed out and stretched thin, many carers also haven’t been able to provide the one-to-one time that babies and toddlers need.

“Everyone wants to document how this is impacting child development, and parent–child relationships and peer relationships,” says James Griffin, chief of the Child Development and Behavior Branch at the Eunice Kennedy Shriver National Institute of Child

Health and Human Development in Bethesda, Maryland. “Everyone has concerns.”

Some of the teams looking into these issues around the world are starting to publish their findings. New studies have begun. Firm answers are hard to come by, not least because many child-development research laboratories shut down during the pandemic.

Some babies born during the past two years might be experiencing developmental delays, whereas others might have thrived, if carers were at home for extended periods and there were more opportunities for siblings to interact. As with many aspects of health during the pandemic, social and economic disparities have a clear role in who is affected the most. Early data suggest that the use of masks has not negatively affected children’s emotional development. But prenatal stress might contribute to some changes in brain connectivity. The picture is evolving and many studies have not yet been peer reviewed.

“The magnitude is massive – it’s just astonishing.”

Some researchers propose that many of the children falling behind in development will be able to catch up without lasting effects. “I do not expect that we’re going to find that there’s a generation that has been injured by this pandemic,” says Moriah Thomason, a child and adolescent psychologist at the New York University Grossman School of Medicine.

A precipitous drop in play

One lab that managed to stay open during the COVID-19 pandemic was Brown University’s Advanced Baby Imaging Lab in Providence, Rhode Island. In it, Sean Deoni, a medical biophysicist, and his colleagues use magnetic resonance imaging (MRI) and other techniques to study how environmental factors shape brain development in infants.

Although the pandemic changed how they conducted their research – fewer visitors and more cleaning – they continued inviting babies to their lab, to track motor, visual and language skills as part of a seven-year National Institutes of Health study on early childhood development and its effects on later health.

However, as the pandemic progressed, Deoni began hearing worrying comments from his colleagues. “What our staff began to tell me, anecdotally, was ‘Man, it’s taking these kids a lot longer to get through these assessments,’” Deoni recalled.

He was mystified, so asked his researchers to plot and compare the yearly averages and variances from the infants’ neurodevelopmental scores. That’s when they discovered that the scores during the pandemic were

much worse than those from previous years. “Things just began sort of falling off a rock the tail end of last year and the beginning part of this year,” he said in late 2021. When they compared results across participants, the pandemic-born babies scored almost two standard deviations lower than those born before it on a suite of tests that measure development in a similar way to IQ tests. They also found that babies from low-income families experienced the largest drops, that boys were more affected than girls² and that gross motor skills were affected the most.

At first, Deoni assumed that selection bias was at play: perhaps the families who made the effort to come in for testing during the pandemic were those whose children were at risk of developmental problems or were already showing them. But, over time, he grew convinced that selection bias wasn’t explaining the findings, because the children coming in did not have different backgrounds, birth outcomes or socio-economic statuses compared with previous participants.

These effects appeared drastic, but some researchers argue that they are not necessarily predictive of long-term problems. “IQ, as babies, doesn’t predict much,” says Marion van den Heuvel, a developmental neuropsychologist at Tilburg University in the Netherlands. “It’s really hard to say anything about what that will mean for their future.” She points to a study³ showing that Romanian girls who started life in orphanages but were then adopted by foster families before 2.5 years of age were less likely to have psychiatric problems at 4.5 years of age than were girls who remained in institutional care. That situation is different from a pandemic, but suggests that babies could make up for hardship once restrictions are lifted.

Worryingly, however, Deoni has found that the longer the pandemic has continued, the more deficits children have accumulated. “The magnitude is massive – it’s just astonishing,” Deoni says of the findings, which are now under revision in *JAMA Pediatrics*.

When Deoni first posted his results on a preprint server², there was a flurry of worrying media coverage – and backlash from the research community. There was “a real concern about the fact that these results were being put out without proper peer review,” Griffin says.

But, assuming the findings do have merit, why might babies born during the COVID-19 pandemic be experiencing significant cognitive – and especially motor – deficits? Deoni suspects that the problems stem from a lack of human-to-human interactions. In follow-up research that has not yet been published, he and his team have recorded parent–child interactions at home, finding that the number of words spoken by parents to their children, and vice versa, in the past two years has been

lower than in previous years. He also suspects that babies and toddlers are not getting as much gross motor practice as usual because they aren't regularly playing with other children or going to playgrounds. "And the unfortunate thing is that those skills kind of lay the foundation for all the other skills," he says.

Other recent research supports the idea that lack of peer interactions could be holding some kids back. In a study published earlier this year, researchers in the United Kingdom surveyed 189 parents of children between the ages of 8 months and 3 years, asking whether their children received daycare or attended preschool during the pandemic, and assessing language and executive functioning skills. The authors found that the children's skills were stronger if they had received group care during the pandemic, and that these benefits were more pronounced among children from lower-income backgrounds⁴.

Those most at risk seem to be children of colour or those from low-income families. For instance, a growing body of research suggests that among school-aged children, remote learning might be widening the already-large learning and development gaps between children from affluent and low-income backgrounds and between white kids and children of colour. In the Netherlands, researchers found that kids did worse on national assessments in 2020 – compared with the three previous years – and that learning losses were up to 60% larger for children from less-educated families⁵.

In parts of sub-Saharan Africa – including Ethiopia, Kenya, Liberia, Tanzania and Uganda – research suggests that some children have lost as much as a full year of learning⁶. And in the United States, after the first lockdown, a report by the consultancy firm McKinsey suggested that students of colour began school in autumn three to five months behind in learning, whereas white students were only one to three months behind (go.nature.com/3fauntp).

Masked effects

Children who have attended school or other group settings during the pandemic have typically been interacting with others who wore face masks. One important question is whether masks, which obscure parts of the face important for expressing emotions and speech, might also be affecting kids' emotional and language development.

Edward Tronick, a psychologist at the University of Massachusetts Boston, has been bombarded with e-mails from parents and paediatricians concerned about the potential developmental effects of masking. Tronick is famous for his 1975 'Still Face' experiment, which showed that when birth parents suddenly remained straight-faced when interacting with their infants, their kids at first tried to

get their attention, and then slowly withdrew and grew increasingly upset and wary⁷.

Tronick decided to see whether masks had a similar effect. With his colleague, psychologist Nancy Snidman, he conducted an experiment (which has not yet been peer reviewed) in which parents used smartphones to record interactions with their babies before, during and after they put on face masks. Although babies noticed when their parents put on masks – they would briefly change their facial expression, look away or point at the mask – they would then continue interacting with their parents as they had before⁸. The mask is blocking only one channel of communication, Tronick says. "The parent wearing a mask is still saying, 'I'm interacting with you, I'm still here for you, I'm still connecting to you.'"

"Children are so adaptive. They should be able to be resilient to a lot of what's happened."

Face masks don't seem to interfere all that much with emotional or language perception, either. A study published in May reported that two-year-olds were still able to understand words spoken by adults in opaque face masks⁹. Children "compensate for information deficits more readily than we think", says study lead author Leher Singh, a psychologist at the National University of Singapore. Researchers in the United States found that, although face masks made it harder for school-age children to perceive adults' emotions – about as difficult as when adults were wearing sunglasses – the kids were still, for the most part, able to make accurate inferences¹⁰.

"There's a lot of other cues that kids can use to parse apart how other people are feeling, like vocal expressions, body expressions, context," says study author Ashley Ruba, a postdoctoral fellow at the University of Wisconsin–Madison.

Pregnant and stressed

Other researchers are keen to know whether the pandemic could be affecting children's development before they are born. Catherine Lebel, a psychologist who runs the Developmental Neuroimaging Lab at the University of Calgary in Canada, and her colleagues surveyed more than 8,000 pregnant people during the pandemic. Nearly half reported experiencing symptoms of anxiety, while one-third had symptoms of depression – a much higher percentage than in pre-pandemic years. How was this stress affecting babies in the womb?

To find out, the researchers used MRI imaging to scan the brains of 75 of the babies 3 months after birth. In a preprint posted in October, they found that babies born to people

who reported more prenatal distress – more anxiety or depression symptoms – showed different structural connections between their amygdala, a brain region involved in emotional processing, and their prefrontal cortex, an area responsible for executive functioning skills¹¹.

In a previous, small study, Lebel and her team had made the link between prenatal depression and brain connectivity differences in those same areas, and had suggested that in boys, these brain changes correlated with aggressive and hyperactive behaviour at preschool age¹². Other teams have found that changes in connectivity between these areas in adults are risk factors for depression and anxiety¹³. "Those are the areas that are involved in emotion processing, and lots of different behaviours," Lebel says.

Other research has found similar associations between prenatal pandemic stress and child development. Livio Provenzi, a psychologist at the IRCCS Mondino Foundation in Pavia, Italy, and his colleagues observed that three-month-old babies of people who reported experiencing more stress and anxiety during pregnancy had more problems regulating their emotions and attention – they were less able to maintain their attention on social stimuli, for instance, and were less easily soothed – than were babies of people who were less stressed and anxious during pregnancy¹⁴.

Thomason is running her own study to assess the effects of maternal stressors on children's brains and behaviour. She notes that, although there is a lot of concern about how prenatal stress might affect pandemic babies, early findings such as these do not mean that children are going to struggle for the rest of their lives. "Children are so adaptive, and elastic. And we do expect that things are going to improve and that they should be able to be resilient to a lot of what's happened," she says.

Indeed, research on historical disasters suggests that, although stress in the womb can be harmful to babies, it doesn't always have lasting effects. Children born to people who experienced considerable stress as a result of the 2011 floods in Queensland, Australia, showed deficits in problem-solving and social skills at six months of age, compared with children born to people who experienced less stress¹⁵. However, by 30 months, these outcomes were no longer correlated with stress, and the more responsive that parents were to their babies' and toddlers' needs after birth, the better the toddlers did¹⁶.

Caution and action

The research on pandemic babies presents a mixed picture, and scientists say it's too early to draw meaningful interpretations. For one thing, some of these early, often unpublished findings might not reflect reality, says Catherine Monk, a medical psychologist who works with Dimitriu at New York–Presbyterian.



A mother with mask interacts with her daughter while waiting for her PCR results in Houston, Texas.

The parents who chose to participate in some early studies, for instance, might not be a representative sample, Monk says. Perhaps they were already worried about their kids on the basis of the behaviours they are seeing. Furthermore, she says, the results of in-person studies such as Deoni's could be affected by the wearing of face masks – perhaps not a lot, but enough to skew results.

As Thomason wrote last year in a commentary¹⁷ in *JAMA Pediatrics*, the incentive to publish interesting findings might also be shaping these early studies. “Scientists are quick to go look for a harmful difference. It’s the thing that’s going to get the attention of the media; it’s the thing that’s going to get published in a high-impact journal,” she says.

Researchers and funders are launching large studies and collaborations that could help to build a clearer picture. The US National Institute on Drug Abuse is funding a handful of studies through its Healthy Brain and Child Development Study. These will look at how maternal stress and substance use during the pandemic affect child development. In addition, alliances and conferences have been formed to bring researchers together and share emerging data. In March 2020, Thomason launched the international COVID Generation Research Alliance, which brings together researchers from 14 countries studying families

with young children during the pandemic. The alliance, which held a research summit in November 2021, includes researchers in North and South America, Europe, Australia, Asia, the Middle East and Africa.

Even if kids’ brains are truly being affected by the pandemic, there is still time to steer them back on course, Dumitriu notes. “We can totally get ahead of this becoming a public-health emergency,” she says. “The brains of six-month-olds are very plastic, and we can get in there, and we can change their trajectory.”

Parents can make headway by playing and talking with their young children regularly, and giving them opportunities to play with others in safe settings. Policy changes aimed at supporting families and children could make a difference, too. Lebel’s research¹¹ found that meaningful social support, such as from a partner or close friend, during pregnancy resulted in much less prenatal distress. “We could do so much more of that in the prenatal care ecosystem,” says Monk.

Overall, researchers maintain that most children will probably be OK – but more than usual might currently be struggling. And if we want to support those who are falling behind, we should ideally intervene soon. “Kids are certainly very resilient,” Deoni says. “But at the same time, we also recognize the importance

of the first 1,000 days of a child’s life as being the crucial early foundations.” The first pandemic babies, born in March 2020 are, at this point, more than 650 days old.

Children “are a product of their environment”, Deoni says. “The more that we can stimulate them and play with them and read to them and love them – that’s what it’s going to take.”

Melinda Wenner Moyer is a science writer based in New York.

1. Shuffrey, L. C. et al. *JAMA Pediatr.* <https://doi.org/10.1001/jamapediatrics.2021.5563> (2022).
2. Deoni, S. C. L., Beauchemin, J., Volpe, A., D’Sa, V. & the RESONANCE Consortium. Preprint at medRxiv <https://doi.org/10.1101/2021.08.10.21261846> (2021).
3. Zeanah, C. H. et al. *Am. J. Psychiatry* **166**, 777–785 (2009).
4. Davies, C. et al. *Infant Child Dev.* **30**, e2241 (2021).
5. Engzell, P., Frey, A. & Verhagen, M. D. *Proc. Natl. Acad. Sci. USA* **118**, e2022376118 (2021).
6. Angrist, N. et al. *Int. J. Edu. Dev.* **84**, 102397 (2021).
7. Tronick, E., Als, H., Adamson, L., Wise, S., Brazelton, T. B. *J. Am. Acad. Child Psychiatry* **17**, 1–13 (1978).
8. Tronick, E. & Snidman, N. Preprint at SSRN <https://doi.org/10.2139/ssrn.3899140> (2021).
9. Singh, L., Tan, A. & Quinn, P. C. *Dev. Sci.* **24**, e13117 (2021).
10. Ruba, A. L. & Pollak, S. D. *PLoS ONE* **15**, e0243708 (2020).
11. Manning, K. Y. et al. Preprint at medRxiv <https://doi.org/10.1101/2021.10.04.21264536> (2021).
12. Hay, R. E. et al. *J. Neurosci.* **40**, 6969–6977 (2020).
13. Holmes, A. J. et al. *J. Neurosci.* **32**, 18087–18100 (2012).
14. Provenzi, L. et al. *Dev. Psychopathol.* <https://doi.org/10.1017/S0954579421000766> (2021).
15. Simcock, G. et al. *Infancy* **22**, 282–302 (2017).
16. Austin, M.-P. et al. *Infant Behav. Dev.* **49**, 296–309 (2017).
17. Thomason, M. E. *JAMA Pediatr.* <https://doi.org/10.1001/jamapediatrics.2021.5168> (2021).