(see 'Surging cases of COVID-19').

"The second wave has made the last one look like a ripple in a bathtub," says Zarir Udwadia, a clinician-researcher in pulmonary medicine at P D Hinduja Hospital & Medical Research Centre in Mumbai, who spoke to *Nature* during a break from working in the intensive-care unit. He describes a "nightmarish" situation at hospitals, where beds and treatments are in extremely short supply.

Shahid Jameel, a virologist at Ashoka University in Sonipat, agrees that the intensity of the current wave is startling. "I was expecting fresh waves of infection, but I would not have dreamt that it would be this strong," he says.

Studies that tested for SARS-CoV-2 antibodies — an indicator of past infection — in December and January estimated that more than 50% of the population in some areas of India's large cities had already been exposed to the virus, which should have conferred some immunity, says Manoj Murhekar, an epidemiologist at the National Institute of Epidemiology in Chennai, who led the work. The studies also suggested that, nationally, some 271 million people had been infected — about one-fifth of India's population of 1.4 billion (M. V. Murhekar *et al*. Preprint at SSRN https://doi.org/f73d; 2021).

These figures made some researchers optimistic that the next stage of the pandemic would be milder, says Ramanan Laxminarayan, an epidemiologist with Princeton University in New Jersey who is based in New Delhi. But the latest urge is forcing them to rethink.

One explanation might be that the first wave mainly hit the urban poor. Antibody studies might not have been representative of the entire population and potentially overestimated exposure in other groups, he says.

The antibody data did not reflect the uneven spread of the virus, agrees Gagandeep Kang, a virologist at the Christian Medical College in Vellore, India. "The virus may be getting into populations that were previously able to protect themselves," she says. That could include wealthier urban communities, in which people isolated during the first wave but had started mingling by the second.

Fast-moving variants?

But some researchers say that the speed and scale of the current outbreak suggest a new ingredient: emerging variants of the virus.

Udwadia has anecdotally observed that entire households are now getting infected — unlike in the first wave of COVID-19, when single individuals would test positive. He attributes this to the presence of more-infectious variants. "If one person in the family has it, I can guarantee that everyone in the family has it," he says.

Genomic surveillance data show that the variant B.1.1.7, which was first identified in the United Kingdom, has become the dominant form of the virus in the Indian state of Punjab.

And a new and potentially concerning variant first identified in India late last year, known as B.1.617, has become dominant in the state of Maharashtra. B.1.617 has drawn attention because it contains two mutations linked to increased transmissibility and an ability to evade immune protection. It has now been detected in 20 other countries. Laboratories in India are trying to culture it to test how fast it replicates, and whether blood from vaccinated individuals can block infection, says Jameel.

The situation in India looks similar to that late last year in Brazil, he adds, where a resurgence of COVID-19 in the city of Manaus coincided with the spread of a highly transmissible variant known as P.1, which might have been able to evade existing immunity.

But others say that the existing sequencing data are not sufficient to make such claims. "As the numbers of sequences available are low, relative to the number of cases in India, we do need to be cautious," says David Robertson, a virologist at the University of Glasgow, UK.

Some say that emerging variants account for only a small part of India's surge in infections. In many regions that are experiencing outbreaks, they don't make up the majority of genomes sequenced, says Anurag Agrawal, director of the CSIR Institute of Genomics and Integrative Biology in New Delhi.

Mixing, moving and travelling

Srinath Reddy, an epidemiologist and head of the Public Health Foundation of India in New Delhi, argues that people letting their guards down is a bigger driver. "The pandemic resurfaced in a fully open society where people were mixing and moving and travelling," he says.

With cases declining after last September's peak, "there was a public narrative that India had conquered COVID-19", says Laxminarayan. In recent months, large crowds have gathered indoors and outdoors for political rallies, religious celebrations and weddings.

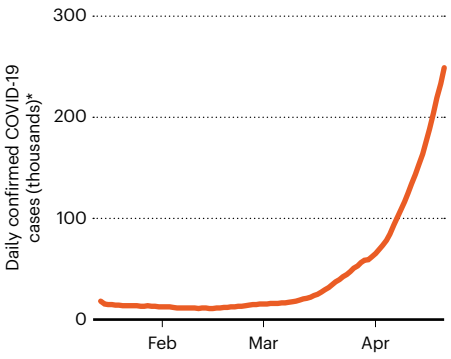
India's vaccination campaign might even have contributed to an uptick in cases, if it caused people to ease public-health measures. "The arrival of the vaccine put everyone into a relaxed mood," says Laxminarayan.

More than 140 million doses have been administered, mostly of an Indian version of the Oxford–AstraZeneca vaccine called Covishield. But that covers less than 10% of India's population, and vaccinations must be ramped up in the hardest-hit regions, says Kang.

Some people might have become infected while getting vaccines, says Udwadia, because crowds often share clinic waiting areas with ill people who are waiting to be seen.

SURGING CASES OF COVID-19

New daily cases in India have been rising rapidly since March and have now far surpassed last September's peak of around 100,000 new cases per day.



*Seven-day rolling averages, up to 20 April.

SOURCE: OUR WORLD IN DATA

LIFT OFF! FIRST FLIGHT ON MARS LAUNCHES NEW WAY TO EXPLORE WORLDS

NASA's Ingenuity helicopter successfully hovered for 40 seconds in Mars's thin atmosphere.

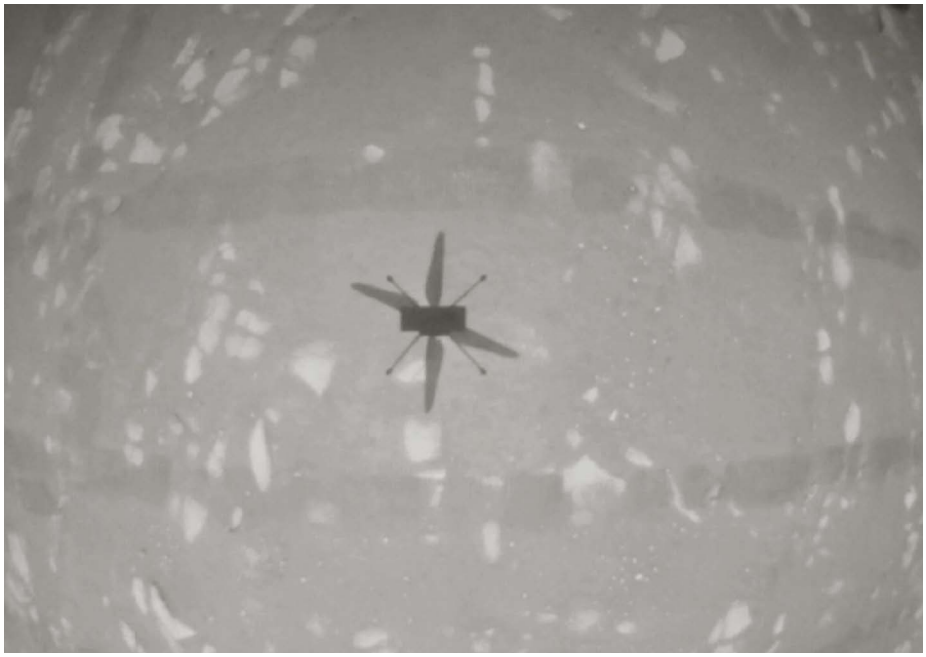
By Alexandra Witze

NASA has pulled off the first powered flight on another world. Ingenuity, the robot rotorcraft that is part of the agency's Perseverance mission, lifted off from the surface of Mars on 19 April, in a 39.1-second flight that is a landmark in interplanetary aviation.

"We can now say that human beings have flown a rotorcraft on another planet," says MiMi Aung, the project's lead engineer at the Jet Propulsion Laboratory (JPL) in Pasadena, California.

Ingenuity's short test flight is the off-Earth equivalent of the Wright brothers piloting their aeroplane above the coastal dunes at Kitty Hawk, North Carolina, in 1903. In tribute, the helicopter carries a postage-stamp-sized piece of muslin fabric from the Wright brothers' plane. "Each world gets only one first flight," says Aung.

The flight came after a one-week delay, because software issues stopped the



NASA/JPL-CALTECH

NASA's Mars helicopter Ingenuity took this shot of the Martian surface during its first flight.

helicopter transitioning into flight mode two days ahead of a planned flight attempt on 11 April. During its first flight, Ingenuity successfully spun its counter-rotating carbon-fibre blades at more than 2,400 revolutions per minute to give it the lift it needed to rise 3 metres into the air. The US$85-million drone hovered there, and then, in a planned manoeuvre, turned by 96 degrees and descended safely back to the Martian surface. "This is just the first great flight," says Aung.

In its second and third flights on 22 and 25 April, Ingenuity went higher, rising 5 metres above Mars's surface. During its third flight, the helicopter flew laterally for 50 metres, at a top speed of 2 metres per second, before heading back to its take-off point. A fourth flight is planned for the coming days. Each successive flight will push Ingenuity's capabilities, to see how well the drone fares in Mars's thin atmosphere, which is just 1% as dense as Earth's. "We will be pushing the envelope," says Aung — probably to the point that Ingenuity will ultimately crash, by design.

Future explorer

Space agencies have sent drifting aircraft to other planets before; for example, the Soviet Union's Vega 1 and Vega 2 missions sent balloons into Venus's atmosphere in 1985. But Ingenuity is the first craft to undertake controlled flight on another planet. "I'm just thrilled with the way it has turned out," says John Grunsfeld, a former astronaut who approved the Ingenuity programme when he served as NASA's associate administrator for science.

Ingenuity's purpose is to test whether helicopters could be used to explore other worlds. As it flies across the terrain, the craft snaps black-and-white images of the surface below, and colour images looking towards the horizon. Future helicopters could help rovers, or even astronauts, to make their way across the planet's surface, by scouting for interesting areas ahead and relaying images of what the landscape looks like.

Big rotorcraft could also get into areas that are inaccessible to rovers rolling across the ground, says Anubhav Datta, an aerospace engineer at the University of Maryland in College Park who has been working on Mars helicopter concepts for decades. "If we are serious about human missions to Mars, we should be serious about sending large helicopters to truly explore what awaits there," he says. "The most interesting places we want to explore are not on flat land but up the slopes, on the cliffs, down the craters and into the caves." Cameras and other instruments aboard helicopters could capture information about such places.

"We can now say that human beings have flown a rotorcraft on another planet."

NASA is already building a car-sized octocopter named Dragonfly that it plans to send to Saturn's moon Titan. Set to launch in 2027, the copter would explore Titan's atmosphere, which is four times denser than Earth's and is rich in primordial organic compounds. That's a very different environment from the one that Ingenuity is experiencing on Mars. But the early flight lessons from Ingenuity will inform Dragonfly's design. "We're looking forward to learning from the Ingenuity team's experience flying in an extraterrestrial sky," says Elizabeth Turtle, a planetary scientist at the Johns Hopkins University Applied Physics Laboratory in Laurel, Maryland, who is Dragonfly's principal investigator.

Ingenuity arrived in Mars's Jezero Crater in February, nestled under the belly of the Perseverance rover. From its landing site, Perseverance drove to a flat 'airfield' in the crater that is relatively free of rocks, and deposited Ingenuity there. The rover then rolled to a slight rise 65 metres away, a vantage point from which it watched and videoed Ingenuity's first take-off and flight.

The biggest challenge in designing Ingenuity was making it small and light enough to be carried under Perseverance's belly, while still being capable of flight, says Aung. The helicopter ended up weighing just 1.8 kilograms. Engineers tested it on Earth in a special chamber at JPL from which nearly all the air had been sucked, to simulate the thin Martian atmosphere.

Into thin air

Compared with a similar-sized helicopter on Earth, Ingenuity has larger blades that spin much faster, to lift it into the thin Martian air. Datta says that he will be anxiously awaiting information on how much power the helicopter takes to hover; this knowledge will help engineers to better understand the aerodynamics on Mars.

Another researcher, William Farrell at NASA's Goddard Space Flight Center in Greenbelt, Maryland, is crossing his fingers that Ingenuity will help scientists to gain a better idea of the electrical properties of the Martian atmosphere. To do this, it would need to fly — or at least spin its blades — near dusk on Mars. Farrell and his colleagues have calculated that the moving helicopter blades could become electrically charged through contact with the dust in the surrounding air (W. M. Farrell *et al. Planet. Sci. J.* **2**, 46; 2021), much as helicopter blades on Earth can build up charge in sand storms. That could cause a faint blue-purplish glow along the blades, best visible in the dim light of dusk.

The thin Martian atmosphere means that winds there are not particularly strong. Ingenuity can handle winds of a little over 10 metres per second while flying, and stronger winds when it's sitting on the ground. It is powered by solar panels to keep it warm during the freezing Martian nights, when temperatures can sink to −90 °C at Jezero Crater.

The rotorcraft is designed to last for just 30 Martian days, which end on 4 May. After that, team scientists will return their attention to Perseverance. Ingenuity will rest in perpetuity in Jezero Crater as the rover trundles off on its main mission to collect rock samples for eventual return to Earth.