16-31 MAY, 2020

Down To Earth

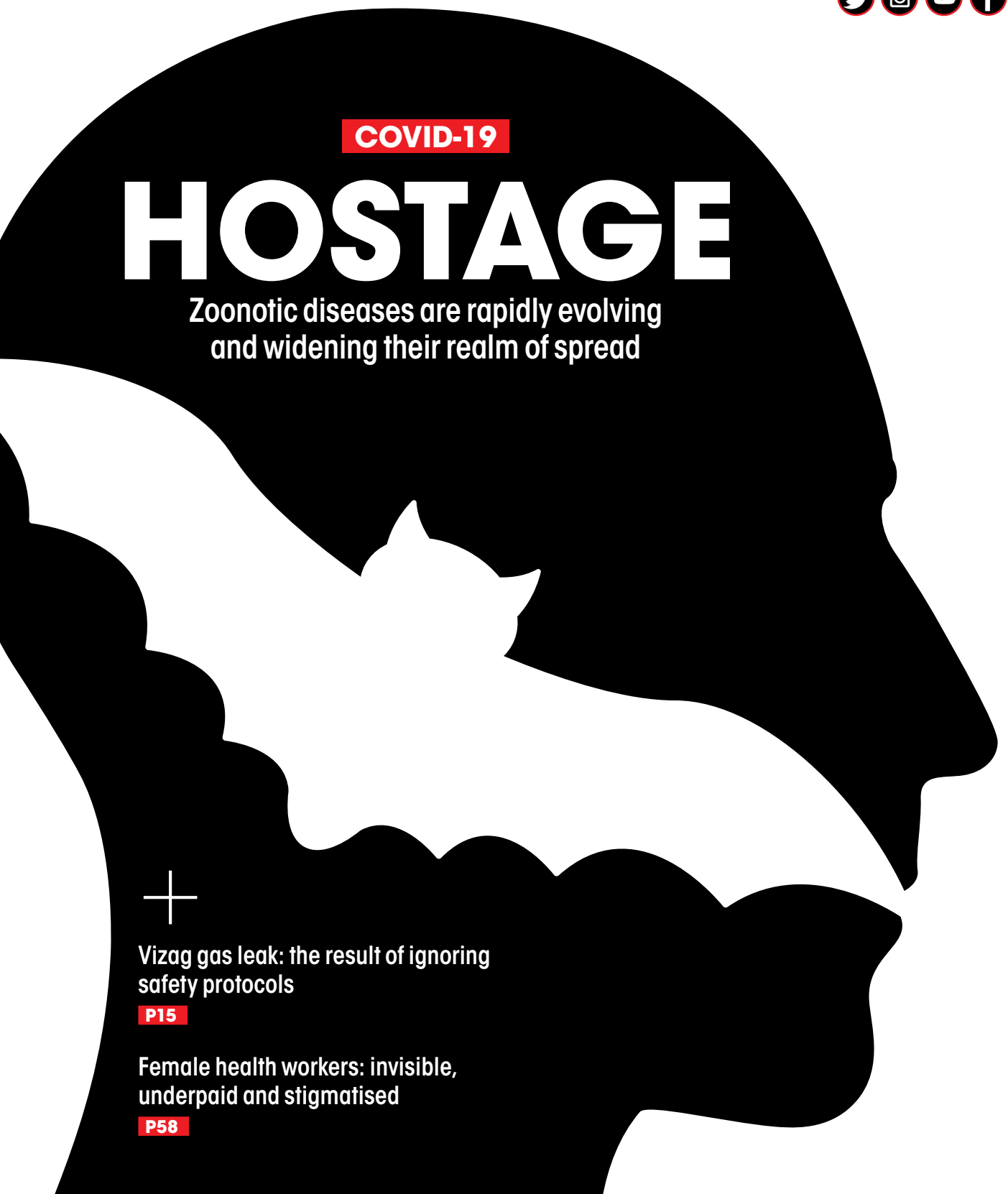
FORTNIGHTLY ON POLITICS OF DEVELOPMENT, ENVIRONMENT AND HEALTH

₹60.00

COVID-19

HOSTAGE

Zoonotic diseases are rapidly evolving and widening their realm of spread



Vizag gas leak: the result of ignoring safety protocols

P15

Female health workers: invisible, underpaid and stigmatised

P58

HAVE WE GIVEN IN?

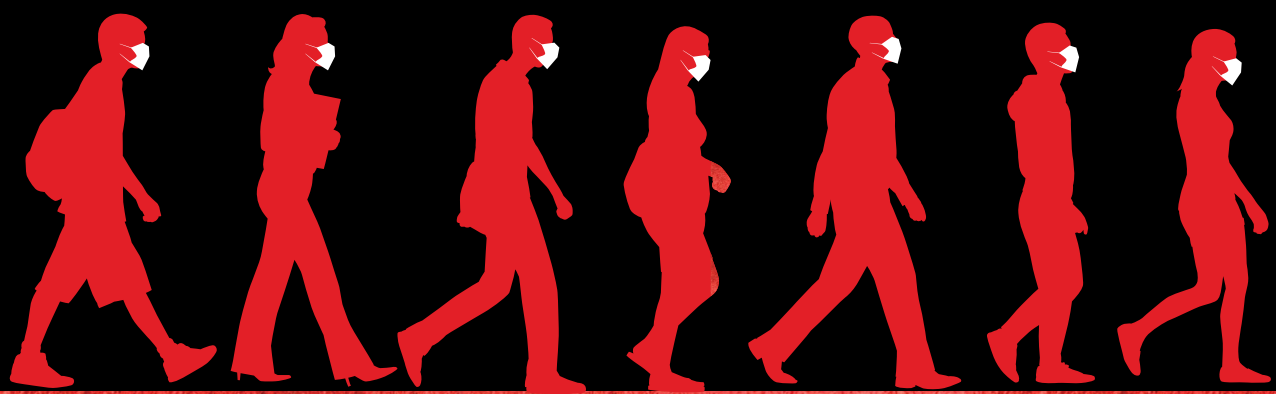
Countries are taking a leap of faith to return to normalcy and get the economy going. India is desperately trying to follow suit. But can it do so without letting its guard down?

BANJOT KAUR

ILLUSTRATION: AJIT BAJAJ

WE HAVE to live with the virus. These words have somewhat become like an anthem in this time of despair. There has not been a day since March 8, when the world, barring a few countries, has not reported record spike in COVID-19 cases. Yet, it has become ingrained in our collective consciousness that we have to live with this novel coronavirus, like over a thousand other pathogens, including HIV, Ebola, cholera and rabies, that are now part of our ecosystem and keep cropping up from time to time (see 'Bats spread viruses, so do humans', *p*38). This mood of resigned acceptance also reflects in the strategies of political leadership across countries, including India.

On May 8, while holding a press briefing, Lav Agarwal, India's official spokesperson on the COVID-19 crisis, said: "It is important that today when we are talking about relaxation, when we are talking about return of migrant workers, we have a great challenge and we need to understand that we have to learn to live with the virus." Earlier on May 4, as the Union government extended the nationwide lockdown, dubbed the biggest in world history, to 54 days, Chief Minister of Delhi Arvind Kejriwal also used "living with the virus" as a truism while urging the Union government for dilution of the lockdown rules. With 7,998 cases and 106 deaths as on May 11, Delhi is the third worst affected state in the country.



BACK TO CONTENT

Looking at states like Kerala, Odisha and even the worst-affected Maharashtra, where activities have been kickstarted to bring the economy back on the rails, it seems we have come to terms with the worst pandemic of the century. Prime Minister Narendra Modi had set the tone for this in his address to the nation as early as on April 14, at the culmination of lockdown 1.0, when he said that "*jaan* (life)" and "*jahaan* (economy and livelihood)" both are equally important. By the first week of May, the country was divided into three zones—red, orange and green on the basis of the number of COVID-19 cases—and certain economic activities were allowed depending on the colour code. Though the government has not introduced any codified lockdown exit plan yet, the focus is fast shifting from managing the health emergency to reviving the economy.

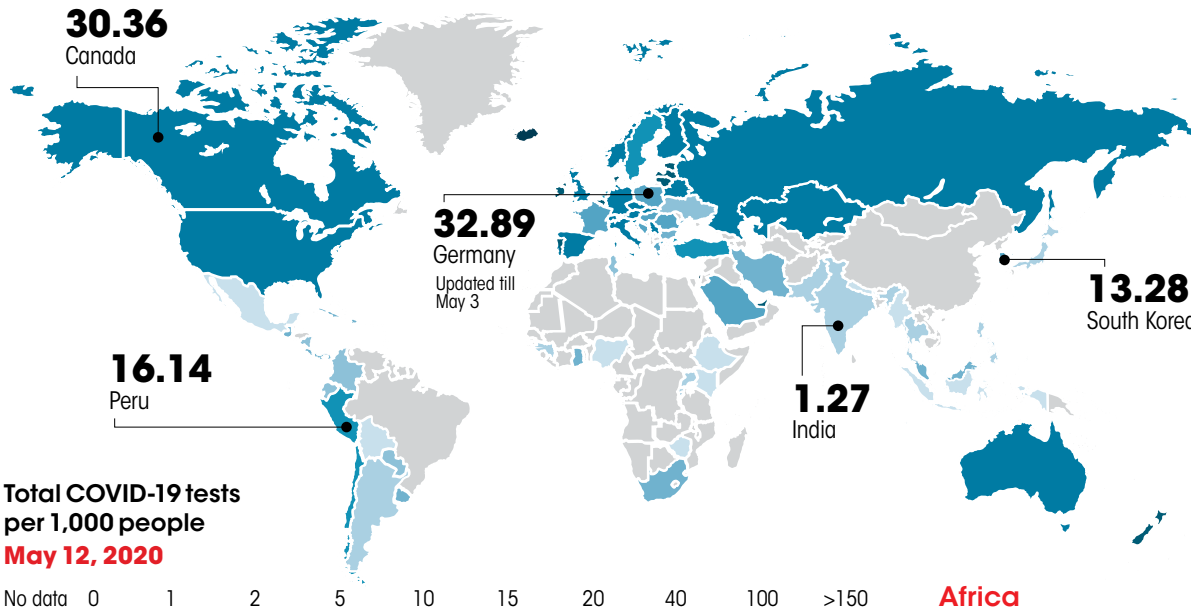
In fact, this is a defining moment for the world. Several countries, despite being ravaged by the pandemic, are getting ready to take a leap of faith to return to normalcy—it's another matter that no one knows if the pre-December-2019-world-normalcy still exists! And they are doing so wielding the certificate of "flattened curve", a term that has not only become popular during the pandemic but has also assumed a positive connotation. In a pandemic, flattening the curve means reducing the number of new cases from one day to the next and then stabilising it before it becomes zero. So, since COVID-19 cases started appearing outside China, the country of origin, governments have been directing their efforts towards achieving this magical phase. Some efforts include imposing strict curbs on mobility through weeks of lockdowns, aggressive containment and quarantine strategies offering near-imprisonment experience, enforcement of social distancing up to the level of personal habits and aggressive screening regime. So, have these helped achieve the objective? Let's examine.

So far, China and South Korea have been able to flatten the curve of new infections. Several European countries have also claimed to have achieved it, implying that cases are on the sliding path now. Germany began levelling its curve about six weeks into the outbreak, while France started seeing results in seven weeks. In Italy, the curve has not flattened yet but there has been a slowdown in new cases. However, in the UK, experts don't foresee it in the near future as cases continue to rise. The UK's initial response to COVID-19 was marked by a series of missteps. The government pursued a controversial "herd immunity" strategy before finally ordering an Italy-style lockdown to regain control over the virus's transmission. In the US, even though New York, the epicentre of coronavirus in the country, has not convincingly proclaimed this status, President Donald Trump on May 6 declared that the country has flattened the curve and is now in the next stage of the battle, which is a "very safe phased and gradual reopening".

In India, as lockdown 3.0 began on May 4, Agarwal, also the joint-secretary at the Union Ministry of Health and Family Welfare, said: "The COVID-19 curve in India is relatively flat as of now and if work is done collectively, the peak may never come." That day India recorded the

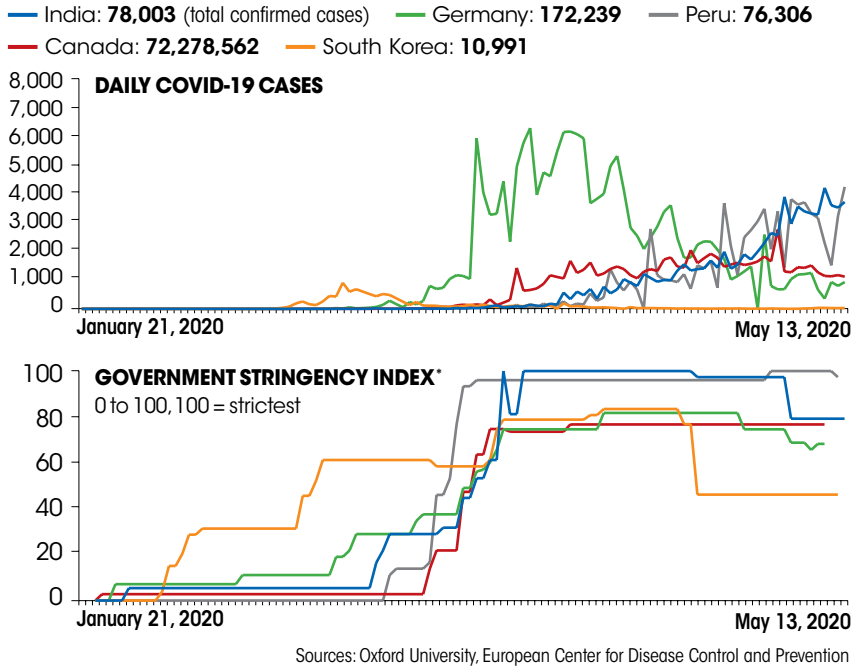
TEST SCORE

India has one of the lowest testing rates in the world, which means little is known about the spread. This is the reason the country's case count is going up despite a strict lockdown



STRICTNESS UNDERMINED

Countries that are fairing better against the pandemic have managed to keep a strict response till the time they flattened the curve. India, on the other hand, is relaxing lockdown despite an upward march in daily cases



Sources: Oxford University, European Center for Disease Control and Prevention

Africa
72,539 cases | **2,490** deaths

Asia
713,740 cases | **23,165** deaths

America
1,889,851 cases | **113,827** deaths

Europe
1,623,586 cases | **151,749** deaths

Oceania
8,394 cases | **126** deaths

696 cases and **7** deaths have been reported from an international conveyance in Japan

(Updated till May 13, 2020)

*Government Stringency Response Index is based on nine indicators: school closing, workplace closing, cancel public events, restrictions on gatherings, close public transport, stay at home requirements, restrictions on internal movement, international travel controls and public information campaigns

REALITY CHECK

A DTE analysis shows India has been adding nearly 5,000 new cases every 2 days since April 30

JAN 30: 3 CASES

Days 67	APRIL 6	5,000
Days 7	APRIL 13	10,454
Days 5	APRIL 18	15,725
Days 3	APRIL 21	20,082
Days 3	APRIL 24	24,448
Days 3	APRIL 27	29,458
Days 3	APRIL 30	34,866
Days 2	MAY 2	39,826
Days 2	MAY 4	46,434
Days 2	MAY 6	52,987
Days 3	MAY 9	62,808
Days 1	MAY 10	67,176
Days 2	MAY 12	74,330

Source: Ministry of Health and Family Welfare; 00: Cumulative cases on that day

highest spike of 3,900 new cases and 200 COVID-19 deaths. It, in fact, broke the previous record spike of 2,293 new cases, documented just two days ago. On March 24, the day the nationwide lockdown was announced, India had only 571 cases. By May 13, the country had 78,003 cases, or 136 times hike in cases.

Government officials, however, claim that significant achievements have been made. One of the most significant gains, they say, is cutting the chain of transmission by achieving a long doubling rate—this rate denotes the number of days in which cases double, indicating a slow spread of infection. On the face of it, this is a prologue to the still elusive objective of "flattened curve". Agarwal, who holds daily pressers, has claimed several times over the past month that doubling rate, which was three days when lockdown began, has increased beyond 12 days; on May 10, he lowered the figure to 10.

But several experts do not think that it is a valid indicator. "You have to look at the baseline figure," T Sundararaman, former head of the Union health ministry's National Health Systems Resource Centre, tells *Down To Earth* (DTE). Cases, when in hundreds, would take fewer days to double as compared to cases that are in thousands. Now, saying that the 45,000 cases have taken more than three days to reach the 90,000-mark and calling it an achievement is nothing but a farce, he says, adding that counting the number of days it takes for every 5,000 or 6,000 new cases to appear would offer a more realistic scenario.

Using 5,000 new cases as the base, DTE did an analysis to understand how the pandemic has progressed in the country and found that 5,000 new cases are being reported every two days since April 30 (see 'Reality check'). This indicates that the spread is far from slowing down.

Another tool that epidemiologists often employ for assessing progression of a pandemic involves comparing three-day rolling average, or the average number of new cases reported every three days. Worldometer, a private COVID-19 tracker, shows that the three-day average was 76 for India at the beginning of the lockdown; as on May 5, it was 3,060. Worse, when compared with 10 countries that ranked just above India in terms of higher COVID-19 cases that day, all of them had fewer three-day averages, with the exception of Brazil and Russia.

Explains T Jacob John, senior clinical virologist and emeritus professor at Christian Medical College, Vellore: there were 571 total COVID-19 cases in the country when the lockdown was announced. Forty days later, on May 5, the number of cases increased by 80 times to 45,000. If the government says the situation is better compared to its fear of a 200-time rise, then this is a manufactured good news, he says. India incidentally remains the only country, as per daily situation updates given by the World Health Organization, which does not report community transmission despite more than 60,000 cases. All countries that have reached this threshold or have fewer cases have accepted that the infection is spreading in new communities with no clear source of origin.

Another indicator of the progression of a pandemic is recovery rate, which according to the Union health ministry's official briefing on May

5, stood at 27.41 per cent. The global average is 32 per cent. Peru, a close cousin of India in terms of cases, has a recovery rate of 30 per cent.

By now, it is a cliché to say that lockdowns only help buy time so that there is no sudden pressure on the limited health infrastructure while preparing for the post-lockdown situation when the infection could spiral out of control. Ramping up testing was one of the most important fronts in which preparation was needed. The Union government did increase it to more than 60,000 samples a day in the first few days of May from a few thousands in the beginning of the lockdown. And with 1.27 tests per 1,000 populations, India now stands at the base of the testing spectrum in the world, above only to Bolivia, Kenya, Ethiopia, Nigeria, Nepal, Myanmar, Indonesia and Mexico (see 'Test score'. Even countries like Senegal, Uganda, Zimbabwe and neighbouring Pakistan fare better than India, according to Our World In Data, an online publication based at the University of Oxford that tracks the number of covid-19 tests among others.

Government officials, however, refuse to accept that they were testing inadequately. Only 5.7 per cent people tested were found positive to SARS-CoV-2 before the lockdown, says C K Mishra, who chairs one of the 11 COVID-19 groups empowered by the Prime Minister's Office, in a presentation on April 23. On April 22, the proportion was nearly the same, at 4.5 per cent, despite an increase in testing. This, he claimed, indicated that the government was not missing out on cases.

Testing has increased significantly in India. While the government still needs to increase its scope, the strategy needs to change, says epidemiologist and economist Ramanan Laxminarayan, who heads the Center for Disease Dynamics, Economics & Policy (CDDEP) at the University of Washington, US. India has so far tested to identify individual cases for containment and to observe growth of the outbreak. Going forward, the purpose would be to identify the elderly population who are at risk and to bring them in for treatment. India will probably need about half a million tests a day at that point," he tells DTE. India has so far picked up only about 10 per cent of all infections and half of all symptomatic infections, says Laxminarayan, citing CDDEP's estimates.

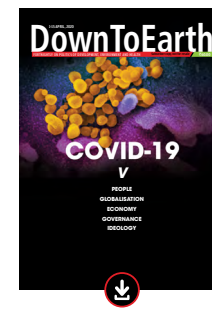
All public health experts DTE spoke to agreed that it was inappropriate to test only those with travel or contact histories and symptoms of influenza-like illnesses. Tests should be offered to anybody with fever and cough, especially once the lockdown is phased out.

The fact is, the pandemic is yet to reach its peak in India. A group of researchers who studied the landscape of the epidemic in India, write in medRxiv, a preprint server for research papers, that the country's COVID-19 curve is likely to peak around mid-July and early August. India, thus, still has around two months to prepare for its worst phase. It must not let its guard down in the rush to return to normalcy. DTE

@Banjotkaur

PREVIOUS EDITIONS ON COVID-19

CLICK TO DOWNLOAD



BATS SPREAD VIRUSES, SO DO HUMANS

Pathogens that trigger infectious zoonotic diseases are fast learning how to expand their realm. The COVID-19 pandemic is a costly wake-up call for the world to get its act together

ISHAN KUKRETI

IF VIRUSES were capable of emotion, they would commemorate the day the World Health Organization (WHO) declared coronavirus 2019 (COVID-19) a pandemic, and celebrated each time a country announced a lockdown to contain the spread of the respiratory illness. For what SARS-COV-2, or severe acute respiratory syndrome coronavirus 2, has achieved is no mean feat for its family.

Yes, there exist hundreds of coronaviruses out there. Till the early 21st century, they were mostly known to circulate among pigs, camels, bats and cats and caused mild forms of common cold in humans. They caught the attention of virologists in 2002, when one member jumped from a horseshoe bat to a human, possibly via a civet cat, and went on to cause severe acute respiratoy syndrome (SARS) among 8,500 people and killed 900. Just like COVID-19, symptoms included fever, sore throat, shortness of breath and pneumonia. A decade later, another coronavirus, believed to have originated from bats but transmitted to humans via camels, caused a similar outbreak in Saudi Arabia. It was named the Middle

ILLUSTRATIONS: RITIKA BOHRA / CSE

East Respiratory Syndrome (MERS). Despite high fatality rates—9.5 per cent in case the of SARS and 34 per cent for MERS—none of these coronaviruses managed to cause large-scale outbreaks. While SARS-CoV appears to have disappeared in 2004, MERS-CoV causes limited outbreaks. Now, call it a third time lucky or the outcome of an evolutionary strategy, SARS-CoV-2, despite a low fatality rate of 2-5 per cent, has emerged as the most devastating pandemic since the 1918 Spanish flu.

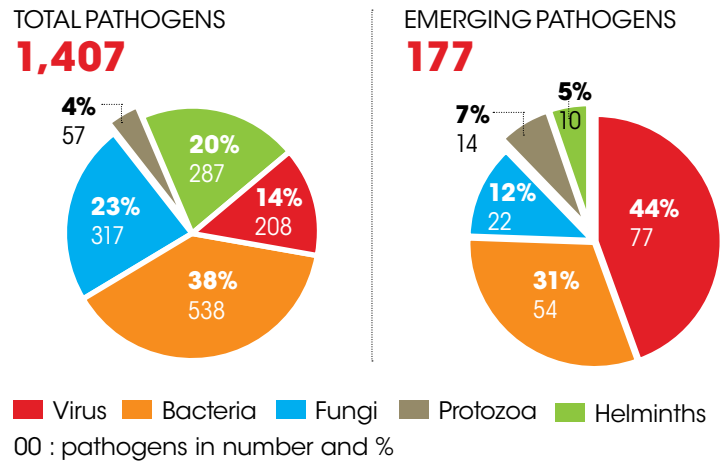
The success of SARS-CoV-2 is no mean achievement, when compared with other thousands of pathogens that naturally get transmitted between animals and humans but more often than not fail to establish a disease in human populations, let alone cause epidemics (see 'Pathogen load').

Most of these zoonotic pathogens, be it a virus, bacterium, fungus or parasites (protozoa and helminths), are believed to be host-specific. This means they usually restrict themselves to a limited number of species, such as bats, pigs, rats and chimpanzees, and prefer residing in them by creating a life cycle reservoir. This trait of pathogens is due to species barriers. Along with the human body's resilience system against diseases, species barriers help us most of the times lead a life free from infections, despite the fact that we live in a pathogen-filled world. Crossing it is not easy as these barriers are determined by the level of human exposure to pathogens—directly through faeces or body fluids like saliva, blood and urine, of an infected animal, or indirectly through areas where they live and roam, or contaminated surfaces—and the ability of pathogens to infect a human and cope with the new host's immune response. It thus requires the pathogen to undergo specific changes through mutation or genetic exchanges with the host.

However, these mutations are not always successful. Thus, a vast majority of animal-to-human spillover most likely results in a dead-end for the virus (and other pathogens), says Abi Tamim Vanak,

Pathogen load

Viruses form just 14% of the total human pathogens. But among new and emerging pathogens, they account for 44%



Source: US Centers for Disease Control and Prevention

EPIDEMIC, PANDEMIC PRONE DISEASES

ANTHRAX
TYPE
Zoonotic Bacteria
DEADLINESS*
Very High
80%
Vaccine available

PLAGUE
(pneumonic, untreated)
TYPE
Zoonotic Bacteria
DEADLINESS*
Very high
100%
Spreads from human to human

*Case Fatality Rate

a disease ecologist at the Ashoka Trust with the Research in Ecology and the Environment (ATREE), a Bengaluru-based non-profit. This means the pathogen does not get transmitted beyond the infected person, he adds.

There have been instances when the pathogen has managed to hop on to humans, but did not cause mortality or morbidity. Early this year, researchers in the Brazilian states of Tocantins and Amapa identified one Ambidensovirus in patients with symptoms similar to dengue or Zika. "Viral species in this genus have been described only in insects, shellfish and other invertebrates; never in mammals," the researchers wrote in the March issue of journal *PLOS ONE*. They are, however, not sure if Ambidensovirus is responsible for the patients' morbidity.

THEN WHO AILS AND WHY

The US Centres for Disease Control and Prevention recognises 1,407 human pathogens; 60 per cent of them are zoonotic.

These pathogens have managed to cross species barriers and establish diseases in human population. However, most of these pathogens maintain their life cycle

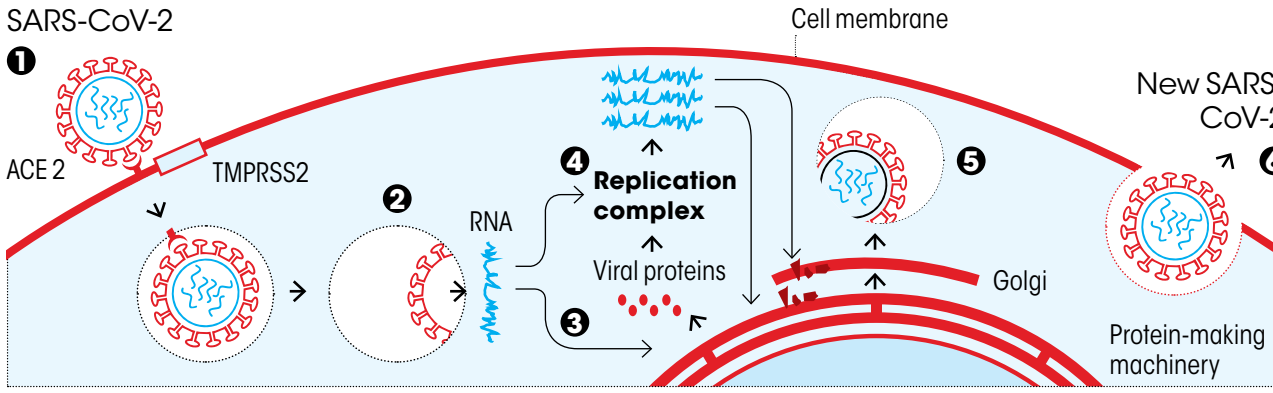
Invincible mutant

In its journey from a bat to a pangolin or a snake and then to humans, SARS-CoV-2 mutated to iron out any glitches

Angiotensin-converting enzyme 2 (ACE2) is an enzyme attached to the outer surface of human cells in the lungs, arteries, heart, kidney, and intestines. Both SARS CoV and SARS CoV2 use these cells as receptors to infect humans

But SARS-CoV-2 went through mutations which has enabled it to **bind with ACE2 more efficiently,** making it more successful at human-to-human transmission

This invisible feature on the crown of SARS-CoV- 2 is the reason why it has a death toll of **265,000, compared to 914 by its cousin, SARS-CoV**



Source: "The spike glycoprotein of the new coronavirus 2019-nCoV contains a furin-like cleavage site absent in CoV of the same clade", published in *Antiviral Research* in April, 2020

reservoir in an animal and infect humans when they get a chance. For instance, avian influenza v irus (H5N1) c aused t he bird flu outbreaks in humans when people came in direct contact with infected poultry or surfaces and objects contaminated by droppings or during slaughter, de-feathering and butchering. While the World Health Organization (WHO) maintains that the virus does not transmit efficiently from person-to-person, experts worry. "Animal-human interfaces where humans frequently get in contact with wild animals allow viruses to evolve and jump into humans leading to the emergence of a new virus," says Pranav Pandit, a veterinary epidemiologist at the University of California, USA. H5N1 is considered endemic in poultry in six countries and at least 15 countries have reported human infections since 2003. It might not be long before the virus mutates to establish a life cycle reservoir in humans and spreads from person to person, infecting even those who have never come in contact with poultry. That would result in a catastrophe as H5N1 can kill 60 per cent of those infected.

EPIDEMIC, PANDEMIC PRONE DISEASES

AVIAN INFLUENZA

TYPE
Zoonotic virus

DEADLINESS*
High
60%

CONTAGIOUSNESS**
1.2
Spreads from human-to-human; vaccine available

*Case Fatality Rate
**Number of people an infected person will infect

Most human pathogens that have caused epidemics like measles, smallpox, tuberculosis, flu and whooping cough have actually had a low-key beginning like H5N1. Initially, they stayed relatively contained by restricting their jumps to humans from animal hosts like cattle, pigs, ducks and dogs. Their virulence increased as they eventually created a life cycle reservoir in humans.

What's worrying is that more and more zoonotic pathogens are now establishing themselves in human populations. In the past 30 years, they have been responsible for 75 per cent of the 177 emerging or re-emerging infections that the world is now grappling with. In fact, of the 23 infectious diseases that WHO lists as "epidemic and pandemic-prone", as many as 17 are capable of human-to-human transfer; no treatment or vaccine is available for nine of these diseases.

HIV1, which is responsible for a majority of HIV infections worldwide, is one such virus. It made the jump from African primates to humans as a result of bush-meat eating in the 1970s. Subsequently, it has established a life cycle reservoir in humans. The Ebola virus, which causes a severe haemorrhagic fever with a fatality rate of up to 90 per cent, however, shows what a virus is capable of to ensure its transmission. Since its first detection in 1976 in Sudan and the Democratic Republic of Congo, the virus has managed to cause outbreaks without establishing a natural reservoir in humans. It has rather mutated to develop the ability to transmit from human-to-human. This newfound ability of Ebola came to light during the 2013 outbreak when it spilled over, possibly from a bat to a 18-month-old boy in Guinea. Within months, it became a global epidemic.

But the ongoing pandemic by SARS-CoV-2 shows how zoonotic pathogens are constantly honing their genome to expand their realm. A study published in *Antiviral Research* in April this year, throws some light on this. Despite a genome sequence highly similar to that of other SARS-like coronaviruses, SARS-CoV-2 differs from SARS-CoV in its interaction with ACE2 (angiotensin-converting enzyme 2), a crucial enzyme that remains attached to the outer surface of human cells in the lungs, arteries, heart, kidney and intestines. Both SARS-CoV and SARS-CoV-2 use these cells as receptors to infect humans. As per the study, somewhere in its journey from a bat to a pangolin or a snake and finally to humans—the pathway still remains shrouded in mystery—the SARS-CoV-2 went through mutations which has enabled it to bind with ACE2 more efficiently, making it more successful to infect a person and ensure human-to-human transmission, despite a low reproduction rate of 2 and fatality of 2-5 per cent (see 'Invincible mutant' on *p*40). By comparision, SARS-CoV had a reproduction rate of 2.8 and fatality rate of 9.5 per cent. In many ways, these mutations are the reason SARS-CoV-2 has had a death toll of over 265,000 in just five months till the first week of May compared to its older cousin that killed 914 over two years.

Emergence of such robust and intelligent pathogens are worrying for another reason. This global coup is largely led by viruses, particularly RNA viruses that can exploit all known mechanisms of genetic variation to cause epidemic spread.

EPIDEMIC, PANDEMIC PRONE DISEASES

EBOLA

TYPE
Zoonotic virus

DEADLINESS*
High
50%

CONTAGIOUSNESS**
1.9
Spreads from human-to-human

AIDS/HIV

TYPE
Zoonotic virus

DEADLINESS*
High
53%

CONTAGIOUSNESS**
6.0
Spreads from human-to-human

*Case Fatality Rate
**Number of people an infected person can infect

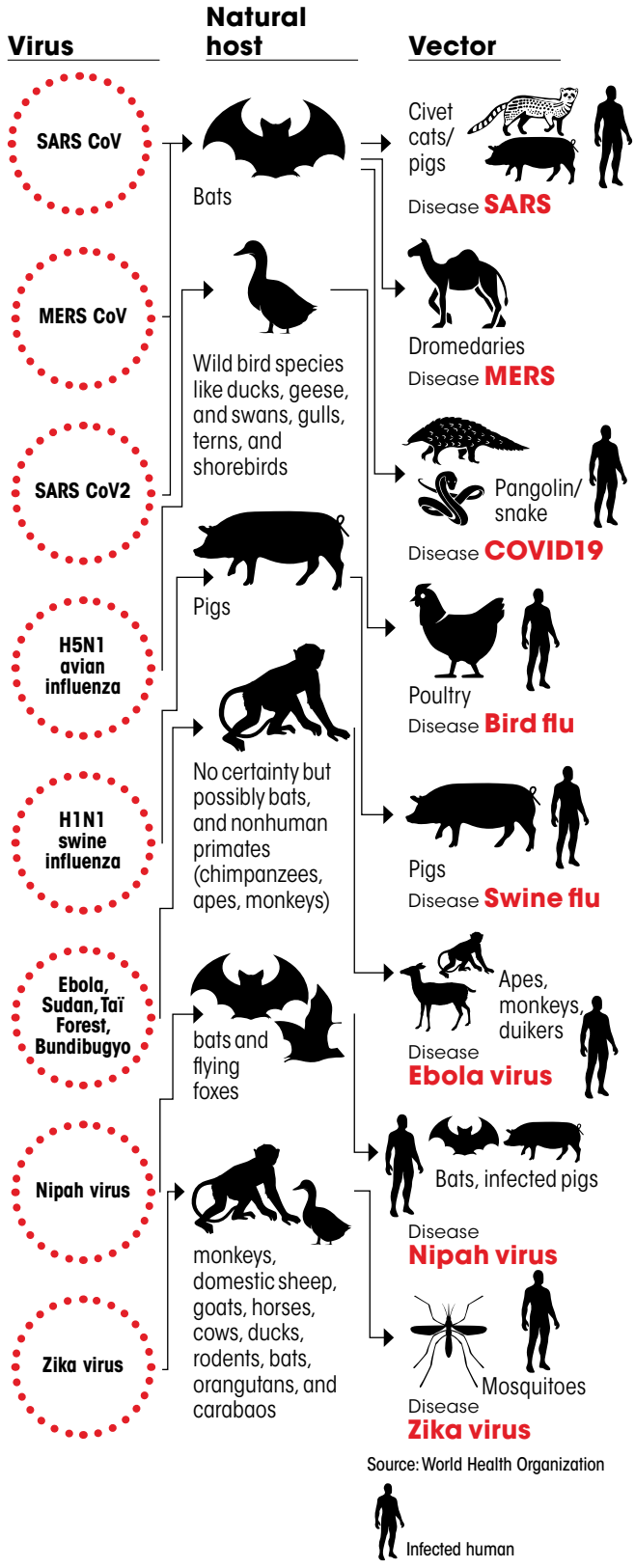
VIRUSES LEAD THE COUP

Considered often a non-living entity, viruses can infect all life forms, including microbes like bacteria.

This is probably because this submicroscopic particle, made either of RNA or DNA as its genetic material, can replicate or produce multiple copies of itself only when inside a living host cell. Most of the jumps to humans are, however, made by RNA viruses that account for some 37 per cent of emerging infectious diseases, says a study, published in *ILAR Journal* in 2017. In fact, some of the biggest zoonoses like chikungunya, dengue, Zika, avian influenza, Lassa fever, Ebolavirus, MERS and

SOME DANGEROUS NEXUS

Of the 23 infectious diseases WHO lists as "epidemic and pandemic-prone", 17 can spread from human to humans



SARS are all caused by RNA viruses (see 'Some dangerous nexus').

These RNA viruses are considered recent evolutionary origins. Their mutation rate can be 100,000 times higher than DNA viruses. "RNA viruses show remarkable ability to adapt to new environments and confront different selective pressures they encounter. This not only include the host's immune system and defense mechanisms, but also the current artificial challenges devised by the biomedical community," notes the *ILAR Journal* study. This high rate of mutation of a RNA virus is because of the way it replicates. In DNA viruses, several proteins correct themselves if there is any faulty genome replication. But RNA viruses replicate without this proofreading process and this increases their mutation rates. But this has a downside too: any undesirable mutation can negatively impact the fitness of the virus.

Among the RNA virus group, coronaviruses have been found to have overcome this tradeoff between mutation rate and incorrect replication. A study published in *PLOS Pathogens* in May 2010 says SARS-CoV had mutated to produce an enzyme that diminishes the number of mutations. "The viruses might switch the proofreading mechanisms on or off depending on the context, allowing them to rapidly adapt to new environments without losing replicative fidelity," the study says.

OUR TRANSGRESSION

Ulimately, it's about humans and their interactions with other species, whether in the wild or in farming.

It's also about how we transgress into the habitat of wild species or "manufacture" food from domesticated animals. For instance, villages in the eastern foothills of the Western Ghats in India regularly experience outbreaks of the Kyasanur forest disease (KFD), a viral haemorrhagic fever similar to Ebola and dengue that is spread by ticks (*Hemaphysalis*

spinigera) living on monkeys. Here, people mostly depend on forests for a living (see 'Forest fever' on *p*47). SARS and COVID-19 outbreaks have also been linked to exposure to the viruses in Chinese wet markets. Interconnectedness of the world has only made the spread massive and instantaneous.

It's not just the interface with wildlife, livestock also plays a role. In the case of Spanish flu, it is widely held that the avian influenza virus jumped from a pig on a military farm in Kansas, USA, to the first known human case. Though there are other theories about where the "jump" took place, from Europe to China, what's clear is that the virus mutated from animals and was taken across the world by the movement of soldiers during the World War I. Ultimately, the Spanish flu killed more people than the war.

So, it is a combination of factors—movement of people, living conditions, population density and, of course, eating habits—that makes the virus more deadly in its new host. Ebola, for instance, was not new to parts of Africa even though outbreaks were reported way back in 1976. What changed between then and the outbreaks of 2013-14 was the demography in the affected countries, says Sanath Muliya, a scientist with the Wildlife Institute of India, Dehradun. Between the 1960s and early 2010s, population density increased by 223 per cent in Guinea, 178 per cent in Sierra Leone and by 275 per cent in Liberia, particularly in the urban parts that experienced high rural-to-urban migration. All major outbreaks occurred in such urbanised set-ups with high human densities, says Muliya.

A similar devlopment in Indonesia in 1998-1999 led to the first outbreak of the Nipah virus infection, but in neighbouring Malaysia. The virus is naturally harboured by pteropid fruit bats. But in the months before the outbreak, large-scale deforestation was going on in Indonesia for pulpwood. Palm oil industries had also prompted slash-and-burn of forests for setting up industrial plantations. While deforestation destroyed the bat's habitat, the haze reduced flowering and fruiting of forest trees. Reduced rainfall caused by the severe 1997-1998 El Niño conditions exacerbated the situation, resulting in mass migration of pteropid bats to Malaysia, which was experiencing an upsurge of large-scale piggeries with fruit orchards on their edges. A combination of factors led to the spillover of a novel virus from the bat to the domestic pig and then to pig farmers.

The scope and scale of deforestation and the opening of new interfaces with forests and wildlife increase the chances of spillovers, says Prashanth N S, public health expert at the Institute of Public Health, Bengaluru, adding, "The way in which we interact with our environment has increased the exposure to newer pathogens that would have otherwise not come into contact with large populations."

DIPHTHERIA

TYPE
Non zoonotic bacteria
DEADLINESS*
Low
11.3%
CONTAGIOUSNESS**
2.5
Spreads from human-to-human

POLIOMYELITIS

TYPE
Non zoonotic bacteria
DEADLINESS*
Low
11.3%
CONTAGIOUSNESS**
2.5
Vaccine available

MENINGITIS

TYPE
Zoonotic Bacteria
DEADLINESS*
Low
11.5%
CONTAGIOUSNESS**
1.3
Spreads from human-to-human, vaccine available

MERS

TYPE
Zoonotic virus
DEADLINESS*
Low
35%
CONTAGIOUSNESS**
0.5
Spreads from human-to-human

*Case Fatality Rate
**Number of people an infected person can infect

INDUSTRIAL CHURNING

Even as subsistence farmers and herders coped with zoonoses, the very nature of industrial food business has exacerbated the issue.

The influenza A(H1N1) virus—swine flu — is not transmitted from human to humans by eating pork, and that remains its saving grace. Today, it is widely accepted that swine flu was first found in human beings in La Gloria, a little town in Mexico. It is known that a young boy suffering from fever in March 2009 became the first confirmed victim of the outbreak, which then spread from country to country. But then, when the disease broke out, what was quickly lost in this tragedy was the location of the ill-fated town—right next to one of Mexico's biggest hog factories, owned by the world's largest pig processor Smithfield Foods. What was also not reported that people in the town had repeatedly protested about water pollution, terrible stench and

waste against the food giant. While this fact was never followed up or uncovered, what was reported was that food majors wanted WHO to change the name of the contagion so that pork eating would not be affected. Virologists at the US CDC, however, based on genetic fingerprinting found that the strain of this swine flu is the same as first identified on industrial pig farms in North Carolina, the hub of industrial pig farms in USA.

The H1N1 strain is high on the evolutionary ladder. In 1998, when there was an outbreak of swine flu among pig herds in North Carolina, it was a triple hybrid—containing gene segments from human, bird and classical swine influenza viruses—that spread across pig herds of the integrated world. Then it mutated further. Today, it is believed that the common flu virus infecting humans has got mixed with this hybrid, creating an altogether a new human-animal virus.

In 1997, when the world first caught avian flu (H5N1), wild migratory birds that are the natural carriers of the virus, had been widely indicted for the spread, but with little evidence. It was easier to blame wild birds with no defenders in agribusiness, than birds produced in poultry factory farms. The problem stemmed from the model of growing chicken in an environment that is highly conducive for the virus. The birds are

EPIDEMIC, PANDEMIC PRONE DISEASES

PLAGUE (bubonic)

TYPE
Zoonotic Bacteria

DEADLINESS*
Low
15%

CONTAGIOUSNESS**
3.5

Vaccine available

*Case Fatality Rate
**Number of people an infected person can infect

raised in tightly confined, often poorly ventilated enclosures with regular exposure to chemicals, blood and faecal matter. Diseases can spread, and spread fast, in such conditions. Since the birds also have lowered immunity because of their genetic uniformity, they are almost literally sitting ducks when a disease hits.

But after avian flu hit Asia, the Food and Agriculture Organization (FAO) told governments that while it would be possible to tighten biosafety in commercial poultry farms, it would be impossible to do it in non-commercial enterprises, such as backyard production systems where flocks forage outdoors. It recommended animal production should move to larger farms where surveillance is possible. Danielle Nierenberg, who researches this sector at Washington-based Worldwatch Institute, reports that this prompted Vietnam in April 2005 to impose a ban on live poultry markets and asking farms to convert to factory-style methods.

This is when, the need of the hour was to regulate the industrial processes of growing chicken so that the virus does not breed and does not grow. The business needed to improve the genetic stock of birds and raise their immunity against diseases, just the way traditional backyard poultry farmers do. But instead of reforming the poultry industry, the containment of the flu ended up promoting the very industry and its practices and destroyed the livelihoods of small and marginal farmers.

THE INEVITABLE

It's time the world planned in a prudent manner as zoonotioc pathogens are ever-increasing and becoming unpredictable.

Studies also show how viruses are ever-adapting and ever-expanding via new susceptible hosts and additional transmission routes. S Abdul Rahman, executive director, Commonwealth Veterinary Association, says, unlike the old diseases like cholera and pneumonia, which we know how to deal with, these diseases are highly unpredictable. "With factors like climate change, zoonoses are emerging as the single-biggest threat to human health and we are not prepared, as is evident from COVID-19 pandemic," he says.

But the pathogens are honing their genome and preparing for their next mutation, and there is no doubt about it. A study published in *Nature* in October 2015, titled "Spillover and pandemic properties of zoonotic viruses with high host plasticity" says that pathogens, present in animals belonging to 10 biological orders, are 12 times more likely to transmit from human-to-human than those found in only one animal order. This is because the evolutionary process which equips a virus to rapidly adapt to new hosts also makes it capable of inter-species transmission. Many viruses, like Ebola, SARS-COV and MERS-COV, before jumping to humans were limited only to animals. When all conditions were met, they made the jump. Small wonder, most jumps have been made by RNA viruses.

The next step would be finding the right transmission route for easier, faster and effective dispersals.

So far, oral, aerosols, direct contact, fomite and vectors have been the five primary routes of disease transmission for zoonotic pathogens. These routes are crucial for determining their contagiousness, which is measured through reproduction rate (R0) or the number of secondary cases one case would produce in a susceptible population. In a way, they are responsible for taking a pathogen from the level of transmission to the level of epidemic spread. Cholera, a water-borne zoonotic bacterial disease, has a very high R0 of 9.5. By comparison, the R0 of Zika is 4.2; R0 of COVID-19 is 2.

A reasons for this low R0 of COVID-19 is that the virus is still only hitching rides on droplets, expelled from the body through coughs and sneezes. Since respiratory droplets are heavy, they

SARS

TYPE
Zoonotic Virus
DEADLINESS*
Low
9.6%
CONTAGIOUSNESS**
2.8
Spreads from human-to-human

CHOLERA

TYPE
Non zoonotic bacteria
DEADLINESS*
Very Low
3.2%
CONTAGIOUSNESS**
9.5
Spreads from human-to-human; vaccine available

ZIKA VIRUS

TYPE
Zoonotic Virus
DEADLINESS*
Very Low
0.00003%
CONTAGIOUSNESS**
4.2
Spreads from human-to-human

YELLOW FEVER

TYPE
Zoonotic virus
DEADLINESS*
Very Low
5.5%
CONTAGIOUSNESS**
4.3
Spreads from human-to-human; vaccine available

*Case Fatality Rate
**Number of people an infected person can infect

cannot travel more than 1 metre. At least, that's what WHO believes as of now. However, with studies finding t hat SARS-CoV-2 can travel up to 8 metres, several virologists seem to disagree that it is not airborne.

As the jury is still out on how SARS-CoV-2 travels, the fact remains that airborne transmission is the most lethal of all routes that can make a virus most contagious. Pandit says multiple factors determine if a pathogen is able to transmit with airborne droplets. First, an infectious person should be able to create droplets that are of appropriate size so that they can become aerosolised droplets with the help of particulate matter in the air. Then enough viable infectious dose has to remain in the air for a significant time so that either wind or air currents transmit it to other places where it can infect another susceptible person.

Once in the air, the success of the virus to remain infections depends both on the virus and the particle. Environmental factors like temperature, ultraviolet radiation, relative and absolute humidity, and air movement are important drivers influencing virus viability. Factors like temperature and humidity also impact the size of droplets which, in turn, affect the viability of virus.

EPIDEMIC, PANDEMIC PRONE DISEASES

SWINE FLU

TYPE
Zoonotic Virus

DEADLINESS*
Very Low
0.2%

CONTAGIOUSNESS**
1.5
Spreads from human-to-human

*Case Fatality Rate
**Number of people an infected person can infect

So far, Q fever among animals like goat, sheep and cattle, caused by zoonotic bacteria *Coxiella burnetii* is believed to be the only disease that is transmitted through airborne dispersal. While it remains to be seen as to how long other pathogens can resist this temptation to go airborne, a study published in the *Cell* in 2014 found evidence of airborne transmission of avian influenza among ferrets. The researchers discovered that the ability to go airborne only took five substitutions in the virus.

DON'T PANIC, PREVENT

The threats zoonoses pose to the public health, global economy, food security and geopolitics are well established.

In what may sound like prophesy now, a 2014 study published by the Bank of American Merrill Lynch, after extrapolating historic examples, estimated that, "a severe and prolonged global pandemic could kill 180-360 million and hit global GDP by as much as 5-10 per cent in the first year, with most industry sectors adversely affected."

Pandemics aside, between 1997 and 2009, the economic cost of six major zoonoses outbreaks was estimated to be about US $80 billion by the World Bank, report *People, Pathogens and our Planet: The Economics of One Health, 2012*. The cost would have been much higher had these outbreaks metamorphosed into pandemics. A 2011 report by the Organisation for Economic Co-operation and Development showed that pandemics are a prime global catastrophic threat. Potential losses resulting from a severe influenza pandemic, for instance, can be about 71 million human fatalities and $3 trillion, or 4.8 per cent of global GDP. Zoonoses such as leptospirosis cause an estimated 1.03 million human infections and 60,000 deaths annually across 34 countries, for which there is adequate surveillance data, says Bethan Purse, an ecologist at the UK Centre for Ecology and Hydrology. In 2000, WHO estimated that more than a billion people are at the risk of scrub typhus and over one million cases occur annually. Since then, South-Asian countries with good surveillance have shown a rising incidence of scrub typhus.

Muliya says zoonoses kill the most number of people, second only to non-communicable diseases. In terms of years lost due to premature death or to disability for living with the health condition or its consequences, they are second to none.

Unfortunately, though most of the major disease outbreaks have been caused by zoonotic viruses, Pandit says viral infections, in general, are difficult to treat. Very few antiviral drugs are effective against them, unlike antibiotics which we use against bacterial infections as they are broadly effective. Besides, since emerging viruses are novel, developing vaccines or antibodies related treatments take a lot of time, he adds.

FOREST FEVER

KFD is India's endemic zoonotic disease

BETWEEN AN enemy of unknown prowess and a familiar foe, constantly perfecting its assault techniques, it's difficult to tell who is more dangerous. Yet Karnataka recently found itself grappling with such a dilemma. Over the past few months, as it engaged in a desperate battle against the novel coronavirus (COVID-19), the worst infectious-disease emergency since the Spanish flu of 1918, another infection that it had thought to have thwarted to an extent, made people sick across the Western Ghats. The Kyasanur Forest Disease (KFD), as the tick-borne viral infection is known because of its origin in the Kyasanur forest, spreads through monkeys, causing haemorrhagic fever among some and killing about 10 per cent of those who get infected. To contain KFD, health authorities had conducted a door-to-door vaccination last year. But some 12 per cent of those who were vaccinated against the disease have contracted the infection again. The per centage of children in the total number of positive cases is also high at 8.6 per cent this year, compared to the usual 2 per cent.

COVID 19

TYPE
Zoonotic Virus

DEADLINESS*
Very Low
0.2%

CONTAGIOUSNESS**
2
Spreads from human-to-human

TYPHOID

DEADLINESS*
Very Low
1%

CONTAGIOUSNESS**
1.2
Spreads from human-to-human, vaccine available

*Case Fatality Rate
**Number of people an infected person can infect

THE GREATEST RESERVOIRS OF VIRUSES

A RECENT study identifies domesticated species, primates and bats, to be harbouring more zoonotic viruses than other species. Three mammalian orders (rodents, bats and primates) have together been implicated as hosts for the majority (75.8 per cent) of the zoonotic viruses, while about 88 per cent of the mammal species have not been recorded with a zoonotic virus, says the study published in the *Proceedings of the Royal Society Biological Sciences* in April this year. Species listed as endangered on IUCN due to exploitation of habitat have also been found to share more viruses with humans than others. Yet more than any other species, bats have always been implicated in the emergence of most zoonotic diseases.

There's a reason. Bats are hosts to more zoonotic viruses per species than any other species, particularly those causing Ebola, SARS and now COVID-19. "Bats have a very good immune system and for their size, they live long, for around 30 years. They live in large colonies and are long distance migrants, which make it easy for the virus to spread," says Sanath Krishna Muliya, a project scientist with the Wildlife Institute of India, Dehradun. Many bat species are gregarious and some live in dense aggregations. Some Mexican free-tailed bat colonies can reach densities of 3,000 bats per square metre, in populations of up to a million individuals per roost. "Roosting sites can house diverse assemblages of multiple bat species. High intra- and interspecific contact rates can facilitate rapid transmission of pathogens and large population sizes could sustain acute-immunising infections," says a study published in *Proceedings of Royal Society Biological Sciences* in April 2013. It says since bats are ancient mammals in evolutionary terms, they might have co-evolved with pathogens to become immune to them.

Another study has focused on the feeding habit of bats as a reason for the spread of viruses. "Bats' feeding habits are constrained by the aerodynamics of flight, so they can't ingest huge amounts of food. Yet many bats are frugivorous— that is, they meet their energy requirements by ingesting fruits. But they merely chew them to extract the sugars and higher energy components, and then spit out the partially digested fruits. Other animal species ingest these fruit remnants and may consequently become infected with virus particles in residual bat saliva," says a study published in *Science* in 2005.

"Dealing with zoonoses is tricky because they keep mutating, forcing us to restart the effort to control it anew," says Muliya. This also makes it difficult to promote a permanent cure.

Another reason for the difficulty in treatment is that many zoonotic outbreaks are underreported. Zoonoses mostly infect people living under poverty with little access to healthcare. WHO's report on neglected diseases also notes a correlation between living in proximity with livestock and the emergence of zoonoses. "Although one or more of these diseases can be found in almost every livestock-keeping community in the developing world, they are often simply forgotten," acknowledges a 2015 report titled "The control of neglected zoonotic diseases", prepared by WHO,

Since these diseases are neglected, adequate efforts have not been made to curb them. Consider Ebola and Zika. Before they caught the global attention with outbreaks in 2013 and 2015, these diseases were, for a long time, considered tropical neglected diseases. But despite the attention, vaccines have not been developed for them so far. Ironically, before the outbreak, two promising candidates, the adenovirus-vectored (Ad5-GP) and the vesicular stomatitis virus-vectored (vsvag/ebovgp) were tested on non-human primates in 2003 and 2005. Although the trials produced positive immunogenicity and safety data, Ad5-GP was not investigated further.

PLAN AND PREPARE

Experts had been warning about a COVID-19-like pandemic for a long time. Yet, no one could say when it was going to strike.

The potential for future pandemics is vast. As many as 1.7 million unidentified viruses of the type known to infect people are believed to still exist in mammals and water birds. Any one of these could be the next "Disease X", and it could be potentially more disruptive and lethal

than COVID-19. Since such pandemics are a direct consequence of irresponsible human activity, we need to act now, when we are in the middle of a pandemic, caused by a zoonosis.

Rampant deforestation, uncontrolled expansion of agriculture, mining and infrastructure development as well as unregulated trade in wild animals have created a "perfect storm" for the spillover of diseases from wildlife to people. Unfortunately, communities who live on the fringes of forests are most vulnerable to such infectious diseases and pay the price of resulting outbreaks.

Experts at the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES), an independent intergovernmental body, in a recent article thus suggest to ensure that the actions being taken to reduce the impacts of the current pandemic are not themselves amplifying the risks of future outbreaks and crises. First, ensure the strengthening and enforcement of environmental regulations and deploy only those stimulus packages that offer incentives for more sustainable and nature-positive activities. Second, recognise the complex interconnections among the health of people, animals, plants and our shared environment. Third, fund health systems and incentivise behavioural change on the frontlines of pandemic risk. It may be politically expedient at this time to relax environmental standards and to prop up industries such as intensive agriculture and fossil-fuel-dependent energy sectors, but doing so without requiring urgent and fundamental change, essentially subsidises the emergence of future pandemics, say the IPBES experts.

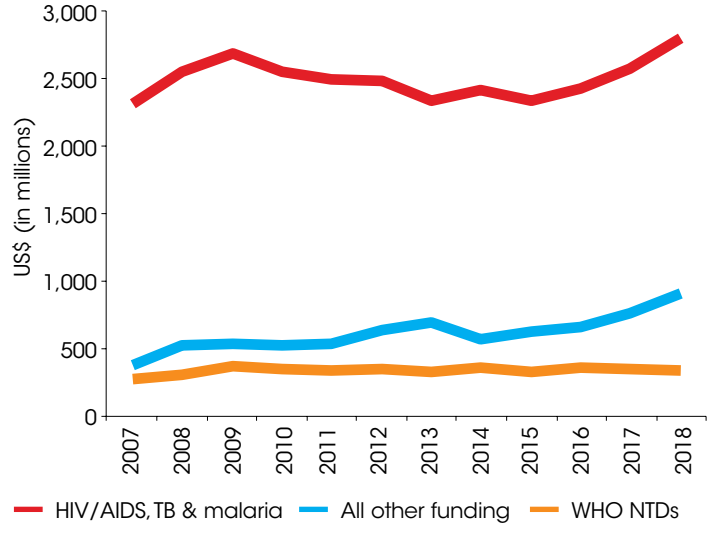
WHO has already floated a globally recognised response framework for dealing with zoonoses. According to WHO, "One Health" is an approach to design and implement programmes, policies, legislation and research in which multiple sectors communicate and work together to achieve better public health outcomes. Purse says, "We need to first understand how people come into contact with zoonotic infections as they use ecosystems for their livelihoods, what are their priorities and means of coping with diseases. Only by taking this joined up approach, can we understand what changes in policy, behaviour or systems might be required to reduce risks of infection and mitigate impacts."

There is also a need to pump in more funds for neglected tropical diseases, which include zoonoses (see 'Neglected even in funding'). As part of pandemic preparedness, surveillance programmes need to be initiated of species like bats that are known sources of zoonotic pathogens (see 'The greatest...', *p*48) and studies need to be done to understand "zombie" viruses and microbes that are being released as the Arctic thaws.

COVID-19 pandemic has offered us a opportunity to prepare for much bigger threats that are yet to come. Let's not waste it. DTE @ikukreti

Neglected, even in funding

While funding for HIV/AIDS, TB, malaria has increased since 20014-15, funding for neglected infectious diseases has remained flat for almost a decade



Source: "Neglected Disease Research and Development: Uneven Progress" by G-FINDER in 2019