**- Virus / Pollution**

# Does polluted air increase transmission?

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Patients with severe Covid-19 are twice as likely to have had pre-existing respiratory diseases and three times as likely to have had cardiovascular problems. And decades of gold standard research have shown air pollution damages hearts and lungs.



So is dirty air, which already kills at least 7 million people a year, turbo-charging the coronavirus pandemic?

The overlap of highly polluted places, such as northern Italy, with pandemic hotspots is stark and preliminary studies point in this direction, while a link between the 2003 Sars outbreak and dirty air is known.

"We don't have the evidence linking directly to mortality yet, but we know if you are exposed to air pollution you are increasing your chances of being more severely affected," said Dr María Neira, director of public health at the World Health Organization (WHO).

Air pollution may be important in three ways, studies show. Higher death rates due to lungs and hearts weakened by dirty air is the best understood. Pollutants also inflame lungs, potentially making catching the virus more likely. Finally, particles of pollution might even help carry the virus further afield.

The studies done so far around the world have not yet been endorsed by independent scientists through the peer-review process.

But these initial findings do raise cause for concern – and may play a crucial role in helping us under stand and an combat the spread of the pand pandemic.

One US U study, by a well-respected group at Harvard University, found that air pollution p is linked to far higher Covid-19 C death rates across the nation. natio Another, analysing European Europea data, concluded that high levels of pollution may be "one of the most im-

portant contributors" to corona coronavirus deaths, while a third hinted at the link in England.

In Italy, Ital coronavirus was detected in air pollution pol samples by scientists investigating investiga if this could enable it to be car carried over longer distances, though it i remains unknown if the virus vir remains viable on pollution particles.

New work, w unreported until now, has revealed strong links in China, where w the pandemic began, including includin a study of 324 cities, which took to into account other factors such s as travel patterns, weather, age, poverty and smoking. It found that places with modestly higher levels le of nitrogen dioxide pollution (10 micrograms per cubic metre) in the five years before the pandemic pandemi had 22% more Covid-19 cases, wh while higher levels of small particle p pollution saw a 15% rise.

Another Anoth Chinese analysis of 120 cities now no published in a journal also found foun a significant link, as do pre-prints pre- print linking air pollution to Covid-19 cases, death rates and the spread sprea of disease. Elsewhere, in London, Londo researchers identified a correlation correla between death rates and air p pollution in different city boroughs, borough though confounding factors were w not assessed.

Howe However, not all air pollution scientist scientists agree that research should be fast-tracked fast-tr while the pandemic is still raging, rag but should rather wait,

whether it be for months or years, to be sure of the results.

Prof Mark Goldberg, at McGill University in Canada, who has criticised the Harvard study, said: "I have nothing against the hypothesis [linking air pollution and Covid-19], it is highly plausible. But if you do a study which is filled with potential biases, you're not doing the public any good by publishing. [Fossil fuel lobbyists] are just going to say, 'Well, why should we believe anything you do?'"

Prof Francesca Dominici, who led the study at Harvard, disagreed: "I think the responsible reaction from a scientist is to respond to a pandemic by doing the best that you can with the data that you have.

"The criticisms are all absolutely valid [but are] very disappointing because none of us is trying to bypass the peer review system at all. All our papers are going to be reviewed and, of course, to make new legislation, the work has to be better. We know that."

Air pollution research has often shown it leads to small increases in people's individual risk of many diseases but, because entire populations are exposed to dirty air, the total increase in health damage is large.

It is not yet clear how big the impact of air pollution is on the Covid-19 pandemic. "That is a really difficult question to answer at the moment," said Prof Anna Hansell, at the University of Leicester. "I suspect it is in line with our general observations of air pollution.

But if you look across a whole population, a small increase in risk is something you might want to do something about and air pollution is a modifiable risk factor."

Researchers hope that the dangers of air pollution and the cleaner skies seen during the lockdowns will lead to lasting change.

At some point, experts will be able to calculate how many extra Covid-19 cases and deaths were due to the world's dirty air. "But whatever the research concludes in the end, the most important issue is that we need to make sure that after Covid-19 the recovery will be a healthy recovery, because we want to reduce vulnerability," said Neira.

'PATIENT 1'

Annalisa Malara, a 38-year-old anaesthetist at Codogno hospital in the northern Lombardy region, was horrified when she saw the image of the lungs of Mattia Maestri, an otherwise healthy person of the same age, as he underwent a CT scan on the morning of 20 February. "The image was monstrous – within less than 48 hours his pneumonia had transformed from being something small into something devastating," she said. "But the idea that this patient could be infected with such severity really threw me – he was young, healthy and athletic. However, this is also what helped to make the diagnosis as the case was so striking."

Malara was looking at the lungs of Italy's "patient 1", the first confirmed case of domestic transmission of the virus in a country where it would go on to kill nearly 29,000 people. Until that day, Malara said, the coronavirus had seemed like something that was so remote, only happening in China and other Asian countries as the rest of the world watched from a distance.

"Yes, we had guidelines and we spoke about it, but nobody could ever have imagined that it would spread so much in Italy," she said.

Testing at the time was only for those who had returned from China, and Malara had to bend the guidelines to order a Covid-19 swab for Maestri. When the result came back it prompted both the closure of the hospital's emergency wing and a government order to quarantine the entire town south of Milan, marking Europe's first coronavirus lockdown.

Maestri had been suffering from symptoms typical of coronavirus – a fever, cough and shortness of breath – for about 10 days before he first visited the hospital. An initial X-ray showed there was slight pneumonia on his right lung. He was given antibiotics and asked if he wanted to stay in hospital, but he declined. His symptoms worsened. A few hours later he returned, was admitted and given oxygen therapy. Malara was called by her colleagues for advice during Maestri's CT scan.

'Nobody could ever have imagined that it would spread so much in Italy'

Another detail that prompted the test emerged during a conversation with Maestri's wife, who was eight months pregnant. Maestri had told doctors several times that his last trip abroad was to New York in September, but his wife then recalled that a few weeks earlier he was at a dinner with a colleague who had recently returned from China. The colleague did not present any symptoms at the time and tested negative for the virus.

The diagnosis caught the whole of Italy off-guard, despite the country's first cases having been detected in late January, when two Chinese tourists had tested positive in Rome. During the intervening period, life had mostly carried on as usual.

Two days after Codogno was quarantined, nine other Lombardy towns went into lockdown, along with one in the Veneto region, where Italy's first coronavirus death occurred.

Massimo Galli, the director of infectious diseases at the Luigi Sacco hospital in Milan, said in the week after the diagnosis that the virus may have been circulating in the quarantined areas of northern Italy for weeks before it was detected by Maestri's test.

Maestri recovered, as did his wife and the two Chinese visitors. But tragically, before he was discharged from hospital, his father died of Covid-19 in his hometown of Castiglione d'Adda.

THE SCALE OF THE HORROR

On 3 March, Costantino Pesatori, the mayor of Castiglione d'Adda, one of the 10 quarantined towns, posted a video appeal for help. Up until that point, most people in Italy were still very confused about the largely unknown threat, at that time mainly known in the west through reports from China. The virus was killing people and beginning to overwhelm hospitals, but the early deaths seemed to reflect a similar pattern: older people with underlying health issues.

While leaders of some towns and cities were encouraging citizens to fight against the fear – by continuing to go to bars, restaurants and shops – Pesatori knew better.

"I knew straight away how serious it was because, from the day the epidemic was discovered in Codogno, people in my town were dying," he said. "If you consider two or three people a day dying in a town of 4,600, this is not normal."

Pesatori's plea revealed details of the virus's devastating impact, which until then had mostly been under the radar. Eighteen people died in the town within less than a fortnight, including a 55-year-old man with no known underlying illnesses. With three of the town's five doctors quarantined and two in hospital, there was nobody to tend to those who were sick.

Two military doctors were sent to the town on 11 March, two days after the whole of Lombardy was quarantined, a move that prompted thousands to flee south. It was also the day Italy became the first country to enforce a nationwide lockdown. By that stage, 827 people in Italy had died and more than 12,000 were infected. It was a move many had believed could never be ordered in a democracy without the means to coerce its citizens, but within weeks it was replicated across the continent and worldwide as the number of deaths rose.

As Pesatori struggled to help the citizens of his town, his family was struck: his mother, who died on 25 March, is among Castiglione d'Adda's 76 fatalities. "I learned through all of this that you have to hold your nerve," he said. "Despite my pain I had to look forward, for our future generation but also to ensure health is protected."

Although people are still in hospital, both the emergency and contagion rate have subsided. "But the virus is still circulating, and so we can't completely drop our guard," said Pesatori.

While attention was focused on Codogno during the first two weeks of its confirmed outbreak, a separate drama was unfolding in Bergamo, a province north of Milan. The first case of coronavirus was detected at a hospital in Alzano Lombardo on 23 February, but Bergamo only went into lockdown with the rest of the Lombardy region on 8 March. It quickly became Italy's most severely affected province.

NO BEDS IN BERGAMO

"There are no more beds here." These were the last words Ettore Consonni, 61, a retired warehouse worker, heard before slipping into a coma at a hospital in Bergamo.

Consonni was admitted on 4 March, not long after returning from the Dominican Republic where he and his wife celebrated their 40th wedding anniversary. Back in Italy, he began developing the Covid-19 symptoms of fever and shortness of breath. A test confirmed the worst.

At that stage of the outbreak, wellresourced hospitals across Lombardy and in the second worst-affected region of Emilia-Romagna were struggling to cope, with the availability of intensive care beds dwindling as the infection spread.

Sick people were placed in operating rooms or hospital corridors, while others were airlifted on military planes to southern Italy.

When Consonni awoke after 23 days in a coma, he was in Sicily.

"I thought it was a joke," he said. "I fell asleep in Bergamo, my city in the extreme north, and I woke up in Palermo, in the deep south. I heard accents among the medical staff, but I thought it was simply the many Sicilian health professionals who work in Bergamo. Then they took me to the window and I saw it was no joke."

Consonni shared a ward at the Benfratelli hospital with other patients from the north. "The doctors told me I almost died," he said.

'I fell asleep in Bergamo, and I woke up in Palermo. I thought it was a joke'

"That's why I'm glad I don't remember anything from those days."

Eventually discharged from intensive care, by early April he was breathing normally. A second test came back negative and on 21 April Consonni left hospital amid resounding applause.

"I'm going to have Sicily tattooed on my skin because I was given a second life here."

Consonni arrived home to more applause from family and neighbours, despite noticing a peculiar look on their faces. "I knew something really bad had happened. My wife sat me down and told me that my brother had died of Covid-19."

Consonni realised that, while he was fighting for survival, life in Bergamo had descended into heartbreak. Doctors compared the situation to war, with one medic claiming that saving a life was decided by age and health conditions.

The sirens never stopped, church bells rang for each of the dead. Coffins stacked up in churches and, with cemeteries full, some were taken by military truck for burial in neighbouring regions. The corpses of those who had died at home were kept in sealed-off rooms for days as undertakers struggled to cope.

A DEATH AT HOME

"He died in my mother's arms as I was on the telephone, trying to get help," said Asia Marchesi, 24. "Watching him struggle to breathe was like watching somebody drown." Her father, Siro, is one of many who died at home, a silent toll that, as with deaths in care homes, has not been recorded in the official statistics. It is thought the 64-year-old may have contracted Covid-19 on 22 February, when he visited the emergency unit of a hospital in Bergamo city for a foot infection.

"He had to take an antibiotic for that but it wasn't anything serious, after a week he was better," his daughter said.

He then travelled to the family's second home in Liguria, but returned to Bergamo on 6 March after he started to feel unwell.

He died on 13 March, and his body was kept at home for one-and-a-half days, covered with a sheet, while the family waited for a doctor to certify the death.

As with many other deaths at home or in residential care, no postmortem test was done for Covid-19.

With funerals banned and physical distancing in place, Asia, her mother and two siblings who live nearby were unable to be physically comforted by relatives and friends, amplifying their grief. "We couldn't even … receive a hug."

Marchesi has joined NOI Denunceremo (We Will Denounce), a Facebook group for relatives of victims who are seeking justice.

"People have lost their loved ones unjustly," she said. "Even if these are difficult economic times I do not want financial compensation as it won't bring my father back. What I want is for whoever made a mistake to take responsibility."

ONLY AMBULANCES IN MILAN

In normal times Milan is Italy's business and fashion hub. The Lombardy capital started to empty out soon after the outbreak began in Codogno but it did not go into quarantine until 9 March.

The only vehicles speeding through the normally clogged streets during lockdown have been ambulances, especially at night, when 33-year-old Matteo Derai joins the hundreds of volunteers responding to callouts. Eighty percent of the calls during the peak were for suspected Covid-19.

"Nobody is forcing me to do this, but above all in these moments we must be courageous," he said. "Only when my shift is over do I realise that I haven't slept for 24 hours."

His partner, Fosca, is a nurse on maternity leave who cares for their newborn son, Tommaso. When Derai returns home, after shuttling suspected Covid-19 patients around hospitals, he lives with the fear of bringing the virus home to his family.

"Roughly eight out of 10 patients who I have seen were suspected cases of Covid-19," said Derai, who works for a watch company during the day. "And often you have no idea what to expect when you reach their homes. When I did my job before the outbreak, I was full of adrenaline. Now I'm fear-stricken.

"Before the outbreak, I tried to support people emotionally as well, now, when you are so concerned about

'Watching him struggle to breathe was like watching someone drown'

your own safety, you let this human connection slip."

It has been common for firstresponders to take relatives of patients already being treated for or dead from Covid-19 to hospital too. "We brought in patients who had already lost their loved ones to the virus," Derai said. "And they are well aware that they, too, will have to face the same sort of odyssey."

He does not know whether the dozens of patients he brought to hospital lived or died.

THE UNCERTAIN FUTURE

After almost two months under lockdown, the longest so far of any European country, Italy began slowly easing restrictions on Monday. But as the health emergency subsides, the next major challenge will be the economic one.

The forecast is bleak. Experts predict a crisis not seen in decades. While industry across the country began to resume from Monday, most retailers will not reopen until 18 May, while bars and restaurants – the backbone of the economy of so many Italian towns – will stay closed until 1 June. Many small businesses may never reopen.

Soemia Ira, 38, a street performer previously making a living in Catania, Sicily, has not worked since the lockdown began and has no idea what the future will hold.

Her livelihood depends on a vibrant street culture. "I live for gatherings," she said. "Without people around me, my work is over. I'm at risk of extinction. I dedicated the last six years of my life to become a street performer, but Covid-19 may take it all away."

Thousands will be at risk of unemployment in the months ahead. The pandemic will have a devastating impact on tourism this summer, a crucial contributor to Italy's economy. Hotels, bars, restaurants and tourist services risk closure.

A few days into lockdown, people across Italy sang and played music from their balconies as they came together to say: "Andrà tutto bene" (Everything will be all right). But lives have changed over the past few months, and a different saying is gathering momentum: "No," Ira said. "Everything will not be all right."