To : Editors & Health Journalists

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Bacteria in airway shapes air pollution health risk

Air pollution leads to different risk of bacterial pneumonia, sepsis, and meningitis, depending on the subtype of bacteria a person has, new research suggests. The study from the Wellcome Sanger Institute, the National Institute for Communicable Diseases (NICD), the Barcelona Supercomputing Center, and collaborators, suggests that the subtype of the bacteria, *Streptococcus pneumoniae (S. pneumoniae),* together with air pollution exposure, impacts the rate and timing of invasive disease. With some strains linked to immediate infection after air pollution exposure, and some taking several weeks.

Published on Monday, 14 September 2026 in *Nature Microbiology*, the researchers also found that older adults and young children are more vulnerable during periods of high air pollution, and that improving air quality could lower disease risk. They also suggest that understanding what type of bacterial strains are circulating and how environmental factors shape infection rates could inform future public health policies, protect those most at risk, and prepare hospitals for outbreaks.

S. pneumoniae is found in the respiratory microbiome, the collection of microbes that live in the human nose and throat, in almost 20 per cent of adults globally[1]. While many adults and children carry the bacteria without any symptoms, when *S. pneumoniae* gets into the lower respiratory tract or bloodstream, it can lead to invasive pneumococcal disease (IPD)[2].

IPD includes bacterial sepsis, pneumonia and meningitis. It is a major cause of disease and death globally and often peaks during colder months[2]. In South Africa, there were over 1800 reported cases of IPD in 2022[3], and in England, the UK Health Security Agency reports that there are more than 5,000 cases per year, particularly impacting children under the age of five, people over 65 years old, and those with underlying conditions[2]. There are currently over 100 different serotypes, which are specific subtypes of *S. pneumoniae*[4].

While it is known that different subtypes of *S. pneumoniae* can lead to varying infection rates in different populations, important gaps remain in our collective understanding of how things such as humidity, temperature, and air pollution impact the timing of disease, and how risks vary by individual age and bacterial subtype.

The study examined around 59,000 cases of IPD across 19 years from South Africa's national GERMS-SA surveillance programme. In South Africa, between 40-60 per cent of children carry *S. pneumoniae*[5,6].

The researchers found that different subtypes of *S. pneumoniae* responded differently to higher air pollution exposure, noting three subtypes (14, 19A, and 8) were linked to the greatest risk of IPD following exposure.

Additionally, they found that different subtypes were linked to differences in the timing of disease risk. While the highest risk of IPD peaked roughly two weeks after air pollution exposure, in areas where subtypes 4, 8, 23F, and 19F were common, there was an immediate increase in disease risk, occurring within the same week.

Importantly, the team accounted for other factors, including temperature, humidity, and population density, to ensure the effects were measured as accurately as possible. They also noted that high temperatures were associated with an immediate increase in disease risk, and cold temperatures led to a delayed rise in cases. The team suggest that cold weather slows bacterial transmission or that damage from seasonal viruses could make it easier for bacterial infections to follow.

The authors suggest that integrating environmental monitoring with genomic surveillance of *S. pneumoniae* could help predict infection spikes, inform vaccination strategies, and support healthcare providers prepare during periods of poor air quality. The study also provides further evidence that reducing air pollution may yield important benefits for infectious disease prevention, particularly in areas with high levels of exposure, such as cities.

Professor Anne von Gottberg, co-senior author at the NICD, said: "Invasive pneumococcal diseases are a significant public health issue in South Africa and globally. This research adds to the ongoing evidence that air quality greatly impacts our health and shows that it has different effects depending on the strain of bacteria that is found in an area. We need to focus on monitoring and improving air quality in areas with high disease risk to prevent or reduce some of these infections."

Professor Rachel Lowe, co-senior author at the Barcelona Supercomputing Center and the Catalan Institution for Research & Advanced Studies, said: "Climate change and rapid urbanisation are fundamentally altering the environmental conditions that influence risk of infectious disease. By linking long-term climate and air quality monitoring with health outcomes, this work highlights how shifting environmental patterns can amplify public health risks. Protecting communities most at risk will require cross-sector collaboration and adaptive health strategies that can keep pace with a changing environment."

Dr Sophie Belman, first author previously at the Wellcome Sanger Institute, and Barcelona Supercomputing Center, currently at Yale School of Public Health, said: "While we found that temperature and air pollution generally increase the risk of invasive pneumococcal diseases, such as bacterial meningitis, our research also suggests that it is the bacterial subtypes a person is carrying that modulate infection rates. The strain of bacteria impacts the timing of disease and who might be more at risk depending on their respiratory microbiome, meaning that the risk is not the same in every situation or for every person. By extending our findings to other parts of the globe, we will better understand who has the highest health risk from environmental

exposures, and what factors need to be addressed in different regions, such as improving air quality in cities."

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Notes to Editors:

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6. S.L. Downs, S. L. *et al*. (2023) Streptococcus pneumoniae and other bacterial nasopharyngeal colonization seven years post-introduction of 13-valent pneumococcal conjugate vaccine in South African children. International Journal of Infectious Diseases. DOI: 10.1016/j.ijid.2023.05.016

Publication:

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Selected websites

The Wellcome Sanger Institute
The Wellcome Sanger Institute is a world leader in genomics research. We apply and explore genomic technologies at scale to advance understanding of biology and improve health. Making discoveries not easily made elsewhere, our research delivers insights across health, disease, evolution and pathogen biology. We are open and collaborative; our data, results, tools, technologies and training are freely shared across the globe to advance science.
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National Institute for Communicable Diseases
The National Institute for Communicable Diseases (NICD) is South Africa's leading public health institute responsible for disease surveillance, outbreak response, reference laboratory services, and public health research. GERMS-SA is its national laboratory-based surveillance programme that monitors invasive bacterial diseases, including invasive pneumococcal disease across South Africa. More information: https://www.nicd.ac.za

Barcelona Supercoputing Center

Barcelona Supercomputing Center (BSC) specialises in high-performance computing (HPC) and operates MareNostrum, one of Europe's most powerful supercomputers. Within BSC's Earth Sciences Department, the Global Health Resilience (GHR) group works to strengthen preparedness for and response to emerging climate-sensitive

health threats worldwide. GHR develops approaches to anticipate how climate extremes, environmental degradation and social inequalities interact to shape disease risk across regions and populations. More information: https://www.bsc.es/discover-bsc/organisation/research-departments/global-health-resilience