

FROM STORM TO FLOOD: THE RESPIRATORY HEALTH IMPACT

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ERS
EUROPEAN
RESPIRATORY
SOCIETY



WE WILL DISCUSS

Aim 1: Recent climate catastrophies – are they increasing – why are they happening (Acute)

Aim 2: Reasons for increased rainfall – frequency and severity (chronic)

Aim 3: Impact on respiratory health

Aim 4: What can we do?

EXTREME WEATHER IS BECOMING MORE COMMON AND LINKED TO CLIMATE CHANGE



Extreme weather: floods droughts and heatwaves

Modified 04 Dec 2024

Image © Matteo Della Torre, Well with Nature/EEA

Share

- Around two million people across Central Europe were affected by the **severe flooding** in September 2024 alone
- Floods in Valencia in October 2024 killed 230 people and destroyed homes and businesses
- Parts of Europe are experiencing **intense downpours**, flooding buildings infrastructure within a matter of minutes



- Instant devastation changing people's lives
- Wide reaching health effects including many deaths
- Mostly viewed as economic catastrophes (\$10-20 billion)
- Longer term health effects of flooding poorly understood

DEADLY AHR VALLEY FLOODS JULY 2021 – GERMANY/BELGIUM/NETHERLANDS/FRANCE/AUSTRIA



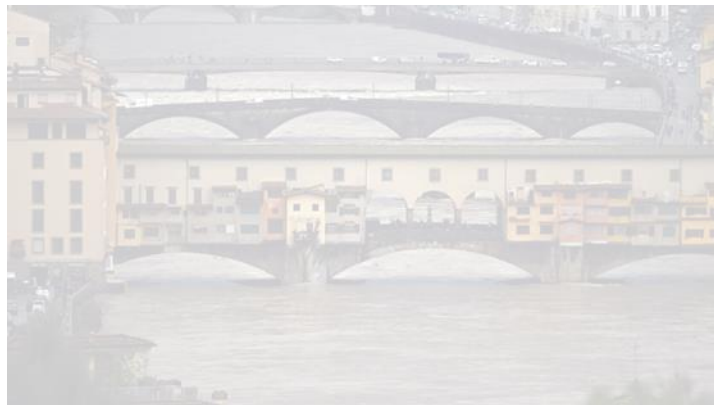
Cost: \$43 billion

FLOODS CENTRAL EUROPE SEPTEMBER 2024





NOT JUST A EUROPEAN PROBLEM



Argentina 2025 March 2025

GLOBAL WARMING AND RAINFALL – THE CLAUSIUS-CLAPEYRON EQUATION

- Used in meteorology and climatology
 - Atmospheric water vapor that drives many important meteorologic phenomena, including rainfall
- The Clausius–Clapeyron equation is:

Clausius Clapeyron Equation

$$\ln\left(\frac{P_1}{P_2}\right) = -\frac{\Delta H_{vap}}{R} \left(\frac{1}{T_2} - \frac{1}{T_1}\right)$$

ln is natural log

P_1 = vapor pressure at temperature T_1 (Kelvin)

P_2 = vapor pressure at temperature T_2 (Kelvin)

ΔH_{vap} = enthalpy of vaporization for the substance

$R = 8.314 \text{ J/mol K}$

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Clausius Clapeyron Equation

Why is this Important?

- Warm air holds more water, so a warmer climate leads to an increase in rainfall
- For every 1C of warming, the atmosphere can hold about 7% more moisture

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AND - IS IT CLIMATE CHANGE? LESSONS FROM AUSTRALIA

- Australia has warmed by almost 1.5C since 1910
- The warmer atmosphere holds more water and rainfall is increasing in line with warming
- **But not outside expected variation in the natural climate**
- However, when analysing the **intensity of hourly rainfall**, the trend is much clearer
- Across the continent, the amount of rain falling over hourly periods is increasing at about double – and in some places triple – of that expected from the Clausius-Clapeyron equation
- While storms in some regions are decreasing, there is a trend for them to dump more rain up to 40% in some areas like Sydney

2 VERY DIFFERENT PROBLEMS RELATED TO INCREASED RAINFALL

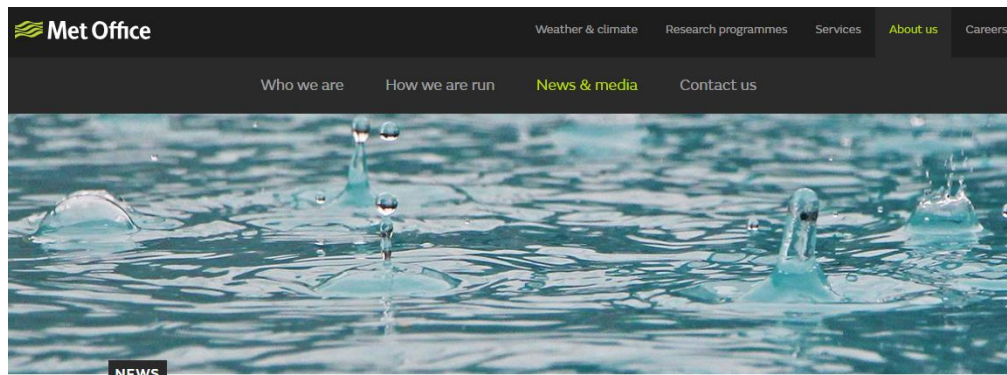
- 1. Greater number of storms with extreme rainfall (acute)
 - Local and regional flooding
- 2. Generally more frequent events of heavy rainfall often on the background of extended drought periods (chronic)
 - Overwhelms house defences especially of cheaper and older housing stock
- All on the background of many places becoming much drier

STORMS WITH EXTREME RAINFALL - VALENCIA 2024

- Valencia was caused by a "cut-off low-pressure storm system"
- Unusually **warm surface temperature of the Mediterranean** provided the storm with a large amount of moisture, intensifying the rainfall.
- a "gota fría" or "cold drop", which occurs when **cold air moves over the warm waters** of the Mediterranean Sea, creating atmospheric instability and heavy rainfall
- A year's worth of rain fell in just a few hours
- This, combined with the region's geography (river catchment areas, proximity to mountains, dry soil) led to flash flooding

UK SITUATION - WINTER FLOODS AND GENERALLY MORE RAIN

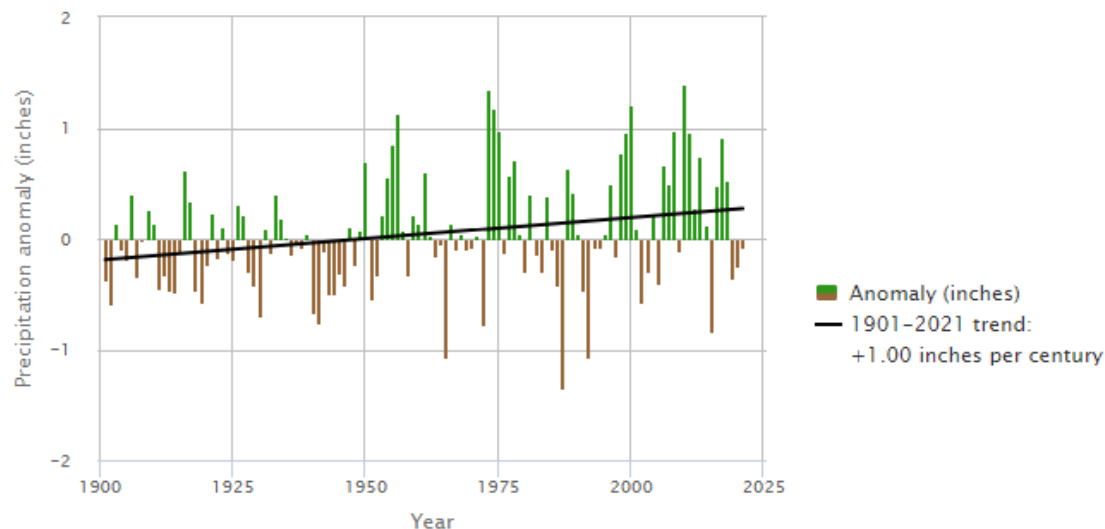
- The UK is now facing frequent record-breaking winter floods
- These do untold damage to homes and livelihoods
 - Sometimes in the same places, year after year
- Severe flooding often follows long droughts – because dried-out soil cannot absorb heavy rains



Climate change drives increase in storm rainfall

22 May 2024

Exhibit 6. Annual precipitation anomalies worldwide, 1901–2021

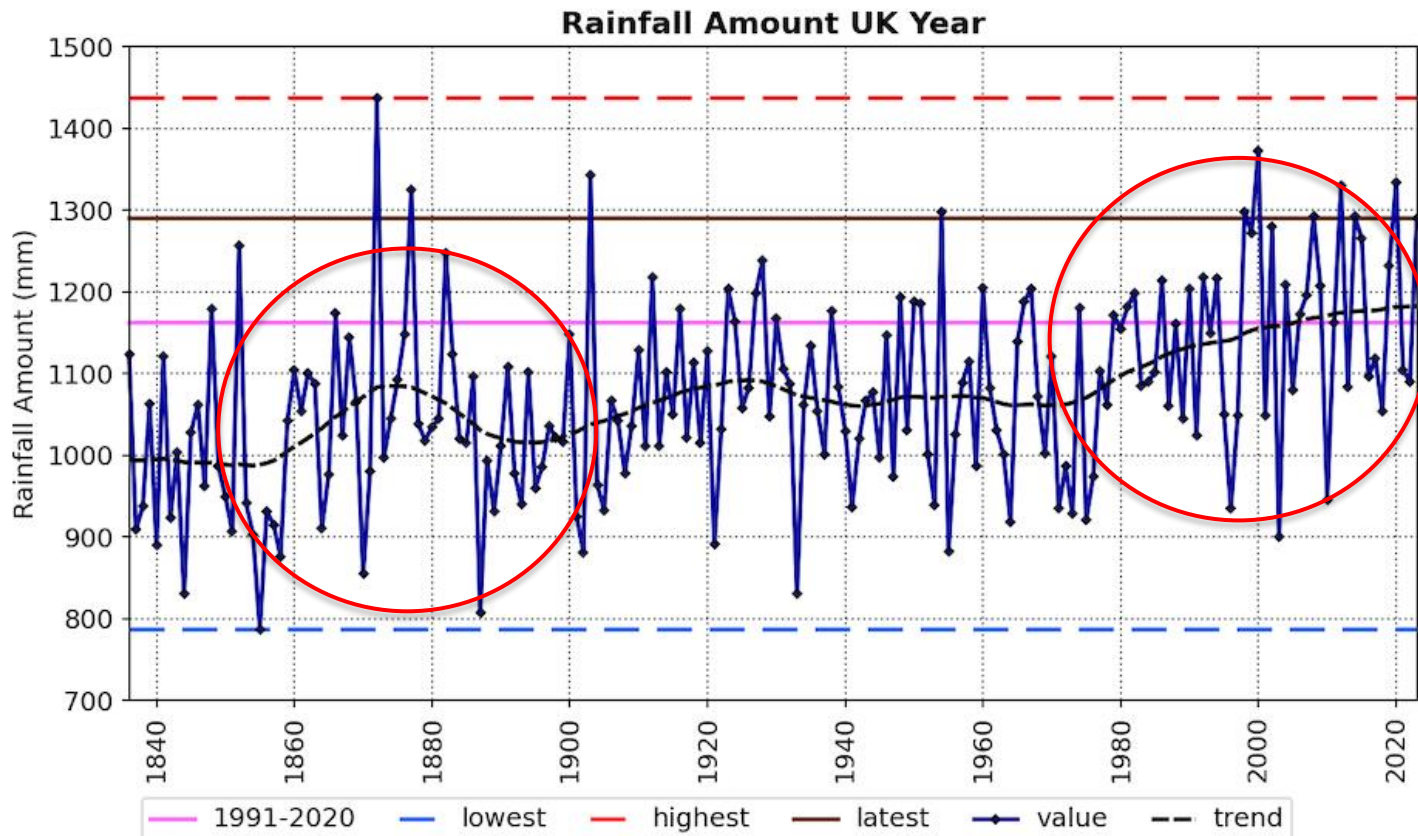


Anomalies are calculated with respect to the 1901–2000 average.

Analysis shows that this trend is statistically significant. For more information about uncertainty, variability, and statistical analysis, view the technical documentation for this indicator.

Data source: NOAA, 2022a

UK ANNUAL RAINFALL 1836 TO 2023

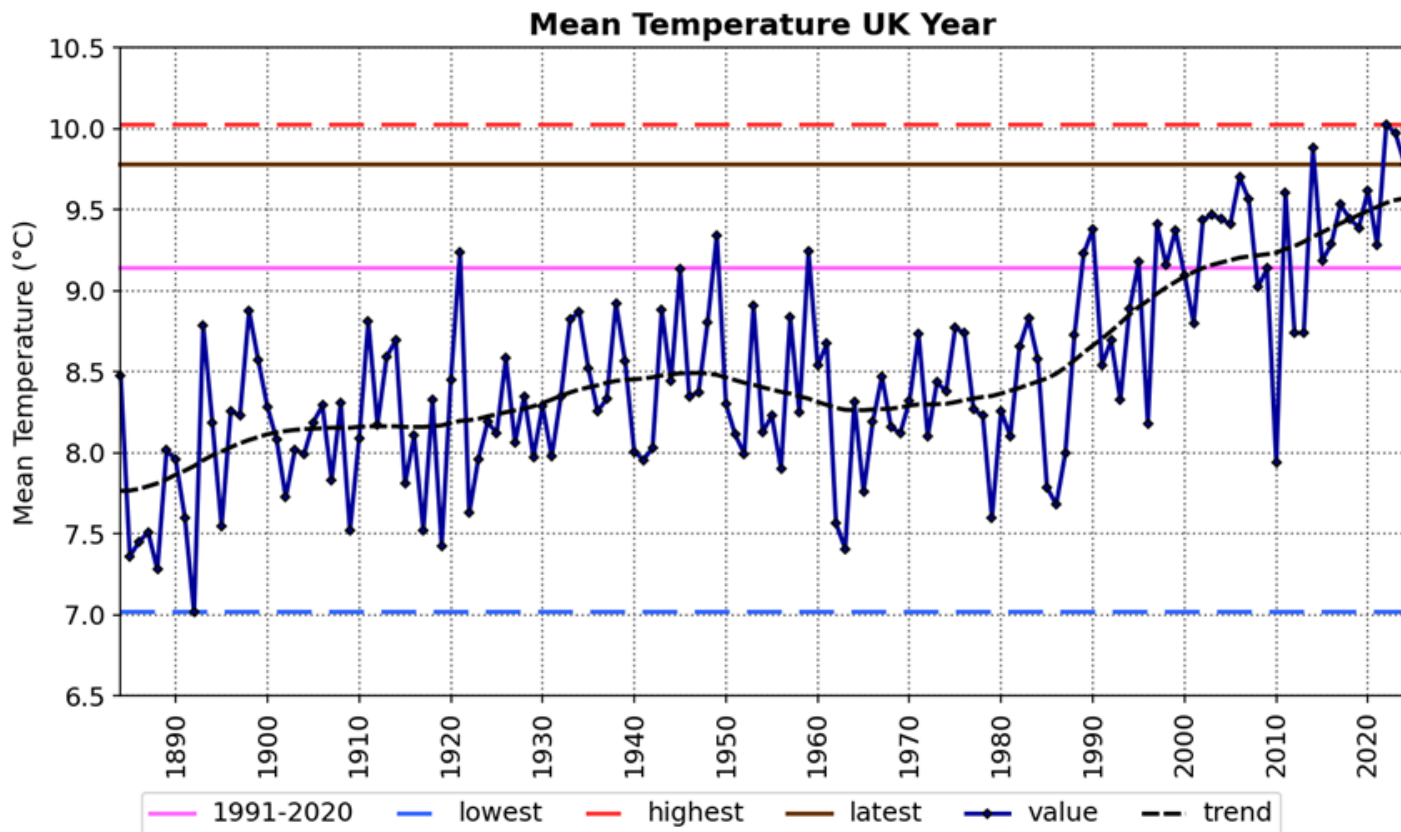


UK MEAN ANNUAL TEMPERATURE 1880 TO 2023



Source: HadUK-Grid 01/01/2025 10:44

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HOW DOES INCREASED RAINFALL AFFECT RESPIRATORY HEALTH

- Damp and wet housing
- Mould indoor air pollution



WET/DAMP HOUSES CAN BE CAUSED BY

- Overflowing rivers
- ‘Storms’
- **Heavy rain overwhelming house defences**
- A generally wetter weather in an already damp and cool climate such as Northern Europe





Ministry of Housing,
Communities &
Local Government



Department
of Health &
Social Care



UK Health
Security
Agency

Guidance

Understanding and addressing the health risks of damp and mould in the home

Updated 15 August 2024

Applies to England

- Damp and mould primarily affect the airways and lungs
WHO guidelines for indoor air quality : dampness and mould
- Even without visible mould, dampness alone increases the health risk
- Damp promotes the growth of microorganisms such as mould, certain species of house dust mites, bacteria or viruses
- The more serious the damp and mould problem and the longer it is left untreated, the worse the health impacts and risks are likely to be
- Respiratory effects include cough, wheeze and shortness of breath
Karvala K 2011, Int Arch Occup Environ Health
- Increased risk of airway infections, including airway aspergillosis

Schimmel in Wohnungen

Stadtentwicklung und Wohnen

Schimmel in Wohnungen

In vielen Fällen von Schimmelbildung kann die Dienststelle für Wohnraumschutz nicht auf der Grundlage des Hamburgischen Wohnraumschutzgesetzes einschreiten.

 Sie lesen den Originaltext

 Leichte Sprache

 Gebärdensprache

 DE ▼



2023

Risk factors for moisture damage presence and severity in Finnish homes

JONATHON TAYLOR ANNIINA SALMELA MARTIN TÄUBEL 

ANTTI HEIMLANDER

ANNE M. KARVONEN TONI PAKKALA JUKKA LAHDENSIVU JUHA PEKKANEN 

*Author affiliations can be found in the back matter of this article



RESEARCH

]u[ubiquity press

- Just under 15,000 houses underwent standardised moisture assessment of interior spaces
- Study found confirmed moisture damage in 19% of surveyed Finnish homes.

IMPACT OF MOULDY/DAMP HOMES ON RESPIRATORY HEALTH - ASTHMA





ERS

DOES INDOOR DAMP/MOULD INCREASE ASTHMA RISK?

GUIDELINES



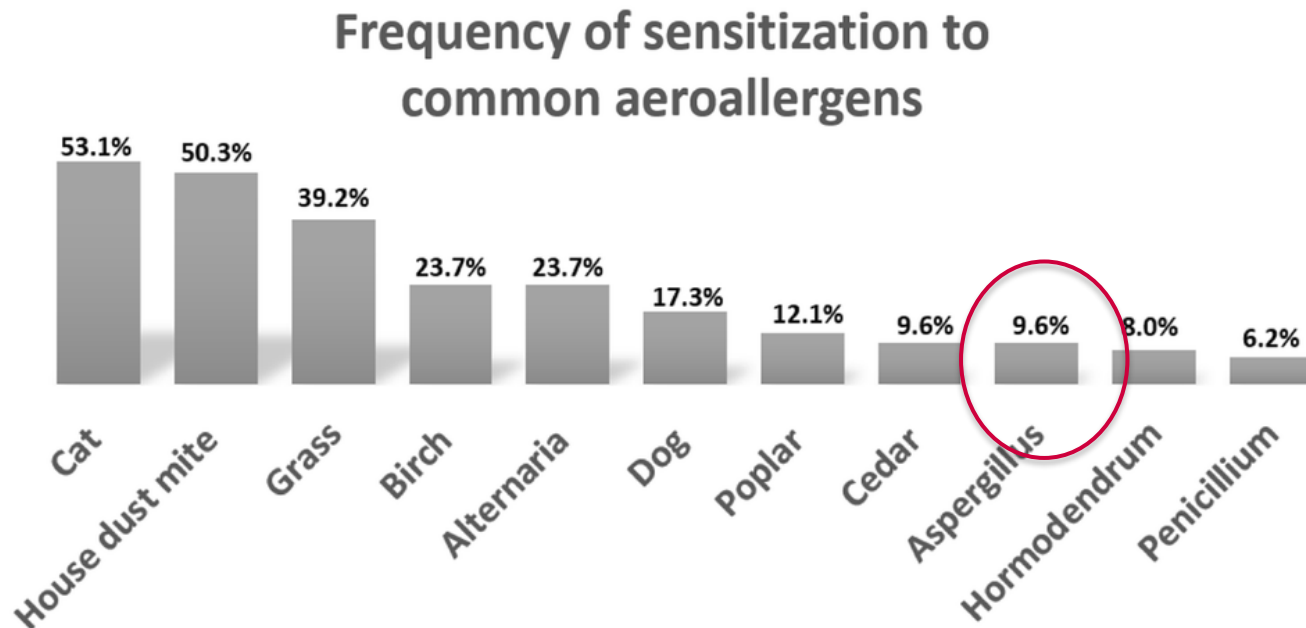
EAACI Guidelines on Environmental Science for Allergy and Asthma—Recommendations on the Impact of Indoor Air Pollutants on the Risk of New-Onset Asthma and on Asthma-Related Outcomes

Allergy 2025

Ioana Agache¹ | Isabella Annesi-Maesano² | Lorenzo Cecchi³ | Benedetta Biagioni⁴ | Fan Chung⁵ | Gennaro D'Amato^{6,7} | Athanasios Damialis⁸ | Stefano del Giacco⁹ | Javier Dominguez Ortega¹⁰ | Carmen Galán¹¹ | Stefanie Gilles^{12,13} | Stephen Holgate¹⁴ | Mohamed Jeebhay¹⁵ | Stelios Kazadzis¹⁶ | Kari Nadeau¹⁷ | Nikos G. Papadopoulos^{18,19} | Santiago Quirce¹⁰ | Joaquin Sastre¹³ | Claudia Traidl-Hoffmann^{12,20} | Jolanta Walusiak-Skorupa²¹ | Magdalena Zemelka-Wiacek²² | Marek Jutel^{22,23} | Cezmi A. Akdis²⁴

Only for mould exposure there was **moderate certainty** of evidence for new-onset asthma

COMMON AEROALLERGENS CAUSING SENSITISATION



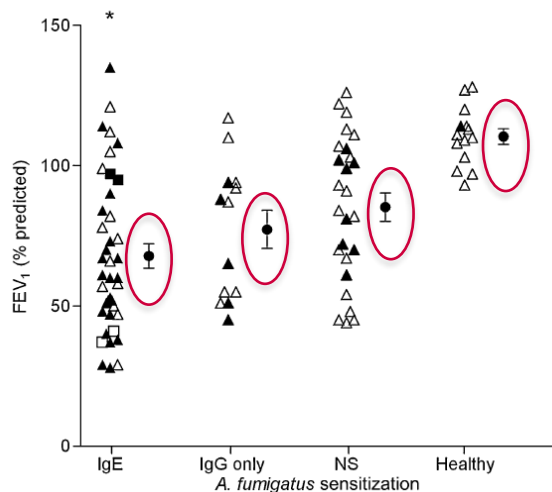
Data from 627 patients attending a respiratory clinic in Canada – SPT data

IgE Sensitization to *Aspergillus fumigatus* Is Associated with Reduced Lung Function in Asthma

AJRCCM 2010

Abbie Fairs^{1*}, Joshua Agbetile^{1*}, Beverley Hargadon¹, Michelle Bourne¹, William R. Monteiro¹, Christopher E. Brightling¹, Peter Bradding¹, Ruth H. Green¹, Kugathasan Mutalithas¹, Dhananjay Desai¹, Ian D. Pavord¹, Andrew J. Wardlaw¹, and Catherine H. Pashley¹

¹Institute for Lung Health, Department of Infection, Immunity and Inflammation, University of Leicester and Department of Respiratory Medicine Glenfield Hospital, Leicester, UK.



Lung function worse in asthmatics with
Af IgE sensitisation

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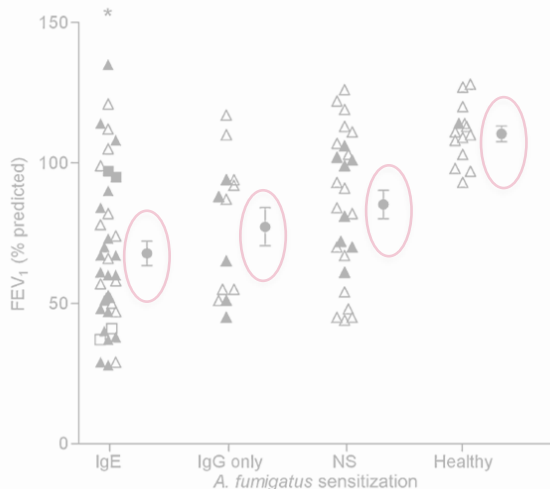
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- Isolation of *Aspergillus fumigatus* from sputum is associated with higher airborne levels in homes of patients with asthma

Fairs A 2013, Indoor Air

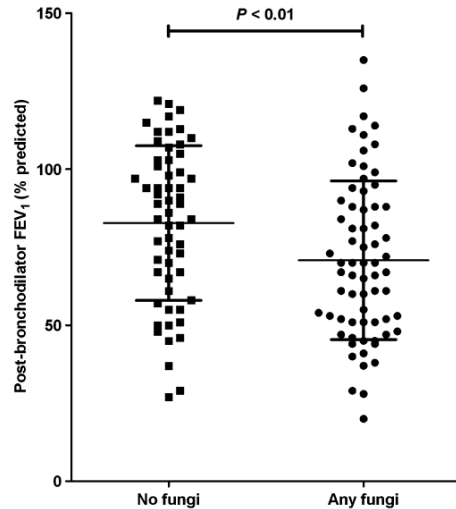


Lung function worse in asthmatics with Af IgE sensitisation

Isolation of filamentous fungi from sputum in asthma is associated with reduced post-bronchodilator FEV₁

J. Agbetile^{1,2,*}, A. Fairs^{1,*}, D. Desai^{1,2}, B. Hargadon², M. Bourne², K. Mutalithas^{1,2}, R. Edwards^{1,2}, J. P. Morley¹, W. R. Monteiro², N. S. Kulkarni², R. H. Green², I. D. Pavord², P. Bradding^{1,2}, C. E. Brightling^{1,2}, A. J. Wardlaw^{1,2} and C. H. Pashley¹

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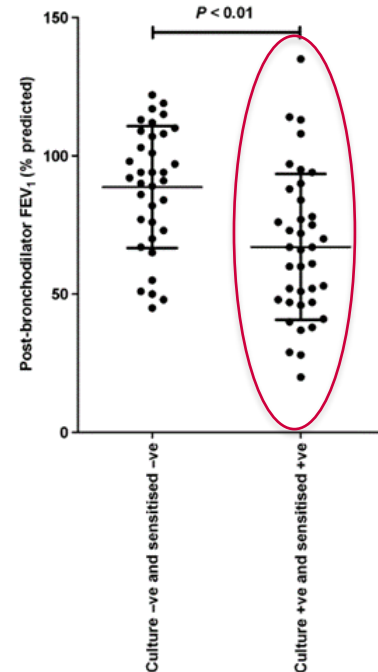
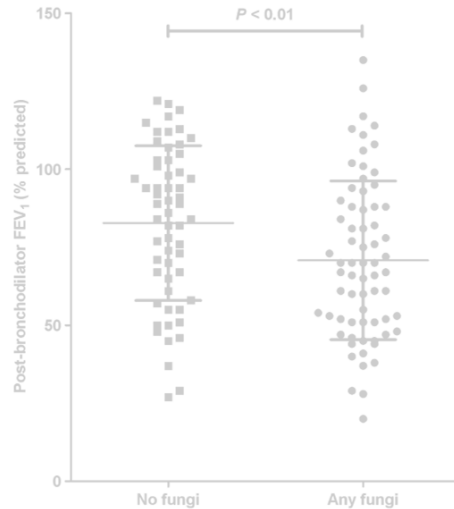


Lung function worse in asthmatics
with fungal airway colonisation

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Worst lung function in asthmatics with fungal airway colonisation and IgE sensitisation

Lung function worse in asthmatics with fungal airway colonisation

Fungal sensitization and positive fungal culture from sputum in children with asthma are associated with reduced lung function and acute asthma attacks respectively


Clin Exp Allergy 2021

Kathryn G. Welsh^{1,2} | Karl A. Holden^{1,2}  | Andrew J. Wardlaw^{1,3} | Jack Satchwell¹ | William Monteiro³ | Catherine H. Pashley¹ | Erol A. Gaillard^{1,2} 

- In a study of 186 children those with **acute asthma** had **thermotolerant filamentous fungi** in the sputum more often compared to children with chronic asthma alone

Fungal sensitization and positive fungal culture from sputum in children with asthma are associated with reduced lung function and acute asthma attacks respectively


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- In a study of 186 children those with acute asthma had higher rates of positive filamentous fungal sputum culture than children with chronic asthma and controls
- Asthmatic children sensitized to the thermotolerant fungi (*Aspergillus*, *Penicillium* or *Candida*) had a worse pre-bronchodilator FEV₁ z-score, FVC z-score and FEV₁/FVC ratio compared to non-sensitised children

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- Greater requirement for systemic corticosteroids in the previous 12 months, and a higher total serum IgE and FeNO compared to non-sensitised children

WHAT INTERVENTIONS AND POLICIES DO WE NEED TO MITIGATE AGAINST THE HEALTH AND COST IMPACT OF SEVERE FLOODING AND DAMP/MOULDY HOMES

WHAT ARE THE PRIORITIES?

- Early warning systems for extreme weather events – see Valencia
 - To warn the public – see US hurricane monitoring
 - Evacuate high risk areas safely
 - Build defences where this can be done
- River flood defences – Influence regional national sustainable policies
- Reduce indoor air pollution

WHAT CAN BE DONE TO REDUCE RIVER FLOODING?

- **Better flood defences for houses built on flood plains**
- **Major infrastructure projects**
 - Flood Walls
 - Embankments
- **Nature-based solutions**
 - Plant trees and hedges to increase water absorption, catch rainfall and slow down surface water run-off
 - Improve soil cover with plants to reduce water pollution and run- off
 - Divert high water flows and create areas to store water
 - Create leaky barriers to slow water flow in streams and ditches
 - Restore salt marshes, mudflats and peat bogs

UK Environment Agency June 2021

BENEFITS OF NATURE-BASED SOLUTIONS

- Help communities become more resilient to the effects of climate change
- Effective for low level flooding in smaller catchments
- Slow the flow of rainwater through the landscape into streams and rivers
- Reduce flooding from tidal waters on the coast

UK Environment Agency June 2021

- Additional benefits
 - Increase wildlife in rivers by restoring natural habitats
 - Improve water quality in rivers by reducing soil erosion
 - Store carbon to help reduce global warming

MITIGATE AGAINST INDOOR AIR POLLUTION – THE CASE OF AWAAB ISHAK



- Awaab, 2 years old, died in Rochdale/UK in 2020, as a result of prolonged exposure to mould in his home
- Awaab's father started legal action and repeatedly complained to council
- The housing association made no efforts to treat the mould, improve ventilation, or track the source of the damp
- The coroner ruled that duration of exposure to the toxic mould was a key factor in Awaab's death of severe granulomatous tracheobronchitis

- In 2023, 7% of **social rented homes** (council homes) had a damp problem and 4% had hazards rated at the most dangerous 'category 1' level
- From October 2025 social landlords have to address damp and mould hazards that present a significant risk of harm to tenants
- Landlords must start an investigation within 14 days of receiving a tenant's complaint about dampness or mould
- If the hazard is non-urgent, landlords have 7 days to fix it
- If it poses a real risk to tenants, landlords have just 24 hours
- If a property cannot be made safe within the prescribed timescales, landlords must provide suitable alternative accommodation for tenants
- Legal plans for **private** landlords at an early stage

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Implementation is going to be a major challenge

Will likely need risk stratification

- If a property cannot be made safe within the prescribed timescales, landlords must provide suitable alternative accommodation for tenants
- Legal plans for **private** landlords at an early stage

IN CONCLUSION

- Extreme weather events involving storms and floods appear to be increasing in frequency
- There is strong evidence to link these events to climate change
- In colder regions this results in a greater number of damp and mouldy homes
- Disproportionately affects socioeconomically deprived households
- Damp and mouldy homes affect respiratory health
- Important to work with regional and national governments to mitigate against the impact of storms, floods and increased rainfall
- Ultimately we need to slow/revert global warming/climate change
- I suspect this is not without risk either...

THANK YOU FOR LISTENING



HAPPY TO TAKE QUESTIONS