Environmental Lung Disease

From Exposure to Health

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2026년도

제141차 춘계학술대회

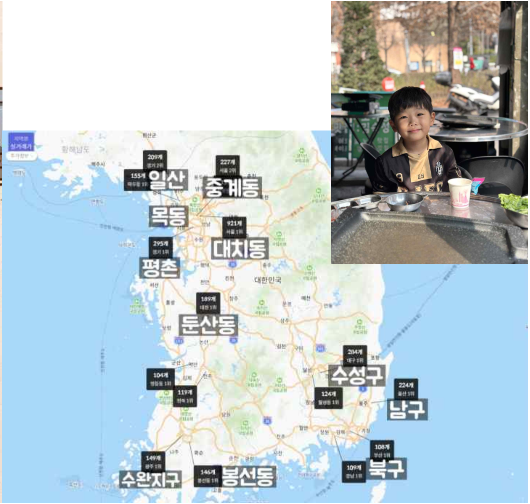
제55차 Workshop, 제21회 폐암 심포지엄

제6차 Interactive Learning

2026년 04월 17일(금) – 18일(토)

DCC 대전컨벤션센터


孟子很小的时候父亲就去世了，
母亲守节没有改嫁，
独自承担起了教育孟子的责任。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남구
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부산 1위
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경남 1위
북구
149개
광주 1위
수완지구
146개
봉선동

Rethinking Environment & Health

BASED ON World Health Organization

Environment
環境

둥글게 둘러싼 **고리(環)**처럼
우리를 에워싸고 있는 **지경(境)**

"환경이란 생물체를 둘러싸고 있으며
생명에 영향을 주는 모든 외부 조건의 총화"

ACADEMIC DEFINITION

Environmental Health

> *"...identifying, evaluating, and managing environmental exposures that influence human health..."*
>
> 인간의 건강에 영향을 미치는 **물리적·화학적·생물학적 노출**을 확인, 평가, 관리함으로써 질병을 예방하고 삶의 질을 향상시키는 과학이자 실천

CLINICAL FOCUS

Environmental Lung Disease

ENVIRONMENTAL IMPACTS ON HEALTH

WHAT IS THE BIG PICTURE?

FACT:

24% of all

global deaths are linked to the environment. (2016)

That's roughly **13.7 million deaths** a year.

WHERE IS IT HAPPENING?

4.1 million in South-East Asia Region

3.6 million in Western Pacific Region

2.5 million in Africa Region

1.4 million in European Region

1.1 million in the Region of the Americas

984 000 in Eastern Mediterranean Region

World Health Organization

#EnvironmentalHealth

Total environment

24%

of all estimated global deaths are linked to the environment

Ambient air pollution

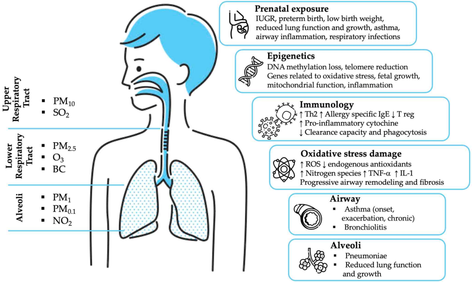
4.2 million

deaths every year as a result of exposure to fine particulate matter

Household air pollution

3.2 million

deaths every year as a result of exposure to indoor smoke from cooking fuels



Prenatal exposure
IUGR, preterm birth, low birth weight, reduced lung function and growth, asthma, airway inflammation, respiratory infections

Epigenetics
DNA methylation loss, telomere reduction
Genes related to oxidative stress, fetal growth, mitochondrial function, inflammation

Immunology
↑ Th2 ↑ Allergy specific IgE ↓ T reg
↑ Pro-inflammatory cytochine
↓ Clearance capacity and phagocytosis

Oxidative stress damage
↑ ROS ↓ endogenous antioxidants
↑ Nitrogen species ↑ TNF-α ↑ IL-1
Progressive airway remodeling and fibrosis

Airway
- Asthma (onset, exacerbation, chronic)
- Bronchiolitis

Alveoli
- Pneumoniae
- Reduced lung function and growth

Lung as the *first and continuous* interface with the environment

COP30 OUTCOME: BELÉM, BRAZIL (DEC 2025)

Global Goal on Adaptation (GGA): A New Yardstick for Health Resilience

Reference: Lancet Planet Health 2026; 10:101419

ADAPTATION FINANCE GOAL
Tripling to $120B / Year (by 2035)

GGA FRAMEWORK DECISION
59 Metrics Formally Adopted

HEALTH PRIORITY
8 Specialized Health Indicators

8 Global Health Adaptation Indicators

01
Climate-associated Mortality
Tracking mortality rates compared with counterfactuals to assess adaptation coverage.

02
Infectious Disease Incidence
Monitoring levels of climate-sensitive infectious diseases as an adaptation outcome.

03
Climate-related Morbidity
Assessing respiratory and heat-related morbidity rates against historical baselines.

04
Mental Health & Psychosocial
Proportion of vulnerable populations with access to psychosocial support systems.

05
Service Capacity Retention
Maintaining full health service capacity during and following extreme climate events.

06
Facility Climate-Resilience
Percentage of health facilities resilient to hazards under various warming scenarios.

07
Essential Service Coverage
Ensuring continuity of essential health services through targeted adaptation measures.

08
Practitioner Capacity
Proportion of health practitioners trained in climate adaptation and health response.

Lancet Planet Health 2026;10: 101419

Characteristics of Studies

Key Features of Environmental Health Research in This Lecture

01 Large-Scale Epidemiological Studies

Population-based cohort studies using national health registries and longitudinal datasets.

02 Complex Statistical Methodology

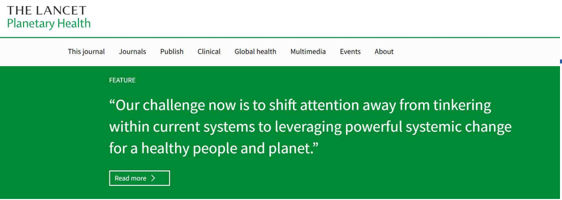
Multi-level models, mediation analysis, and survival analysis for exposure-outcome research.

03 Multidisciplinary Collaboration

Partnerships with environmental scientists integrating exposure monitoring and health data.

04 AI & Machine Learning Approaches

ML algorithms for exposure prediction, pattern recognition, and data modeling.



THE LANCET
Planetary Health

FEATURE

"Our challenge now is to shift attention away from tinkering within current systems to leveraging powerful systemic change for a healthy people and planet."

Aims and Scope

- *The Lancet Planetary Health* is the pre-eminent journal for enquiry into sustainable human civilisations in the Anthropocene.
- Particularly favour work contributing to **a safe and just space for humanity**, respecting planetary boundaries and the social and economic foundations of a healthy life.
- Interested in all aspects of **societal development and its interaction with the environment** — including drivers of change, implications for people, and policies for a healthier planetary future.

Environmental Research

Supports open access • Open archive

14.7	7.7
CiteScore	Impact Factor

Aim and Scope

•Covers **human health and wellbeing effects of environmental factors**, mainly **based on observational or experimental epidemiological studies** on human participants.

•Ambient and indoor air, water, soil, noise, light at night, and radiation pollution

•Organic and inorganic chemicals (e.g. endocrine disruptors, pesticides, metals etc.)

•Natural environments (e.g. green, blue, and brown spaces), biodiversity, and urban design/planning

•Climate change and associated conditions (e.g. extreme weather), occupational exposures

•Also of interest: novel methods for the assessment of human exposure to environmental factors

Key Domains of Exposure

Categories, Concepts, and Specific Examples

01 Climate Change & Extreme Events (Climate related Hazards)

Amplifiers of exposure intensity, frequency, and biological risks

Wildfire Smoke • Heatwaves • Asian Dust • Flood-related Microbials

02 Physical & Chemical Pollutants (Air Pollution)

Traditional indicators of anthropogenic environmental pollution

PM2.5 / PM10 • SO_2 / NO_x • Heavy Metals • Ozone (O_3)

03 Occupational & Build Environment

Micro-environments and specific workplace settings

Silica / Asbestos • Indoor Air Quality • Radon / VOCs

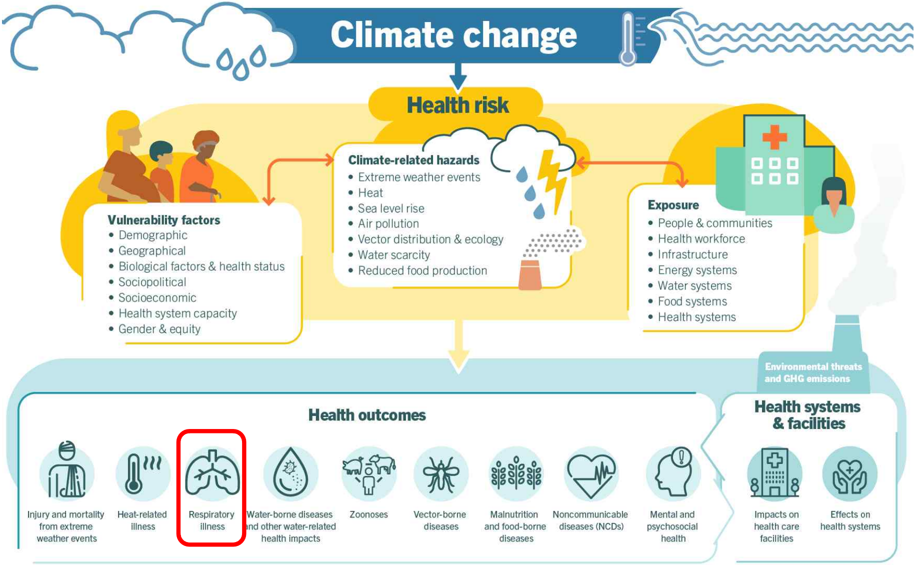
04 Natural Environment & Ecosystems

Protective factors and biogenic respiratory stressors

Green Spaces • Pollen • Mold / Fungi

Climate Change

and Environmental Lung Disease



Climate change

Health risk

Vulnerability factors

- Demographic
- Geographical
- Biological factors & health status
- Sociopolitical
- Socioeconomic
- Health system capacity
- Gender & equity

Climate-related hazards

- Extreme weather events
- Heat
- Sea level rise
- Air pollution
- Vector distribution & ecology
- Water scarcity
- Reduced food production

Exposure

- People & communities
- Health workforce
- Infrastructure
- Energy systems
- Water systems
- Food systems
- Health systems

Environmental threats and GHG emissions

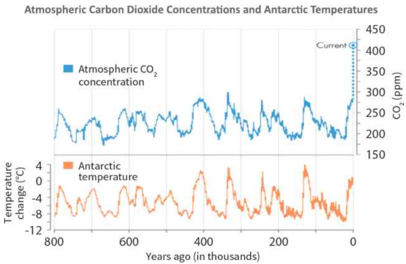
Health outcomes

- Injury and mortality from extreme weather events
- Heat-related illness
- Respiratory illness
- Water-borne diseases and other water-related health impacts
- Zoonoses
- Vector-borne diseases
- Malnutrition and food-borne diseases
- Noncommunicable diseases (NCDs)
- Mental and psychosocial health

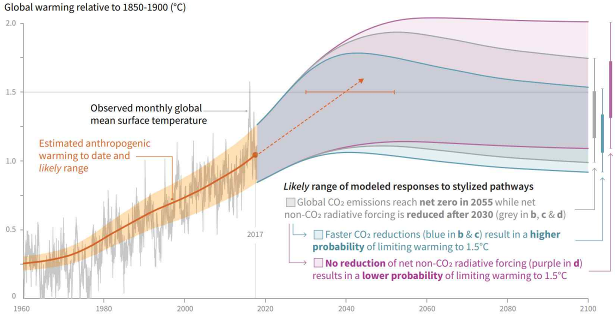
Health systems & facilities

- Impacts on health care facilities
- Effects on health systems

Cause of Climate Change



- Changes in the Earth's Orbit and Rotation
- Variations in Solar Activity
- Changes in the Earth's Reflectivity
- Volcanic Activity
- **Changes in Carbon Dioxide Concentrations**

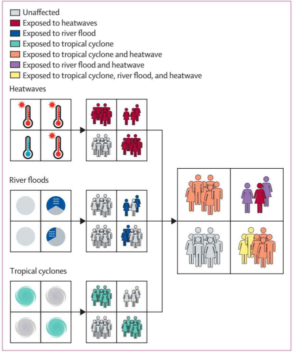


National Academy of Sciences (2020)

Leung et al., 2023, Fifth National Climate Assessment, authoritative for Earth system processes.

Global assessment of population exposure to multiple climate-related hazards from 2003 to 2021: a retrospective analysis

Zélie Stalhandske, Marleen C de Ruiter, Jonathan Chambers, Sandra Zimmermann, Felipe J Colón-González, Nivedita Sairam, David N Bresch, Chahan M Kropf

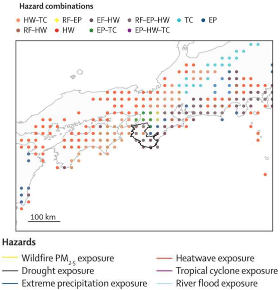


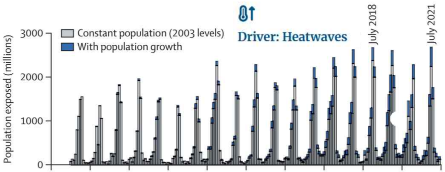
- **Study Population**

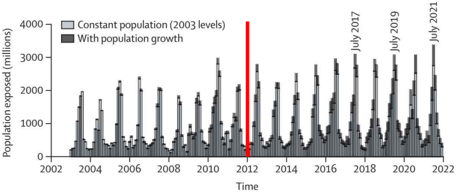
Global gridded population data (WorldPop, **2003–2021**)
Vulnerable age groups (<5 and >65 years).

- **Exposure**

Monthly co-occurrence of 6 climate hazards







+69% Increase in per-person exposure to **3+ simultaneous hazards** between 2003–12 and 2012–21.

Lancet Planet Health 2025; 9: 101295

Climate Change and Wildfire

Climate Change (Global Warming)

- **Strong winds ↑**
- **Relative humidity ↓**
- **Ambient temperature ↑**
- **Fuel Aridity ↑**
- **Fuel Load (Biomass) ↑**

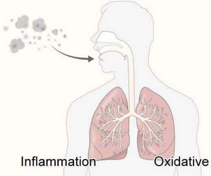
Large-scale wildfire ↑
(e.g. 2025 Los Angeles)

Wildfire Smoke ↑

Air Pollutants Released During Wildfires

- Particulate Matter ($PM_{2.5}$, PM_{10})
- Carbon Monoxide (CO)
- Nitric Oxides (NOx)
- Ozone (O_3)
- Volatile Organic Compounds (VOCs)
- Carcinogenic Substances (Benzene, Formaldehyde)
- Trace metals (Lead, Mercury)

Ambient air pollution ↑



Respiratory health impacts

Short term

- Acute Exacerbations of …
  COPD, Asthma, Pneumonia
- Mortality ↑
- Healthcare Utilization ↑

Long term

- Development & progression of COPD
- Lung cancer risk & mortality ↑

Morbidity, Mortality,
Socio-economic costs ↑

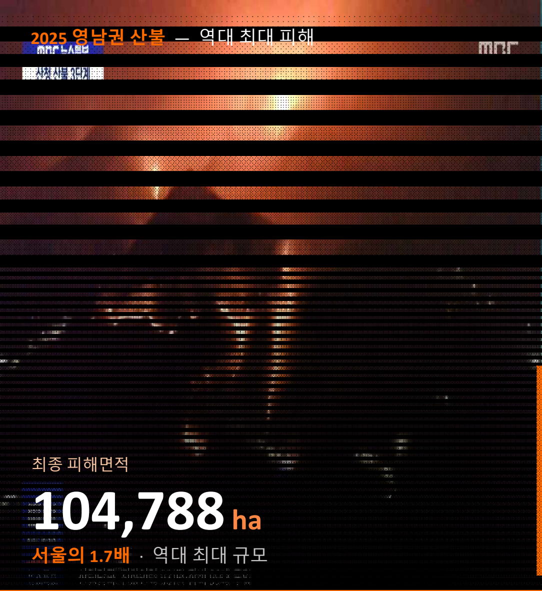
Wildfire Exposure and Respiratory Health: A Comprehensive Review of Emerging Evidence, TRD, 2025
N Engl J Med, 2020;383:2173-2181

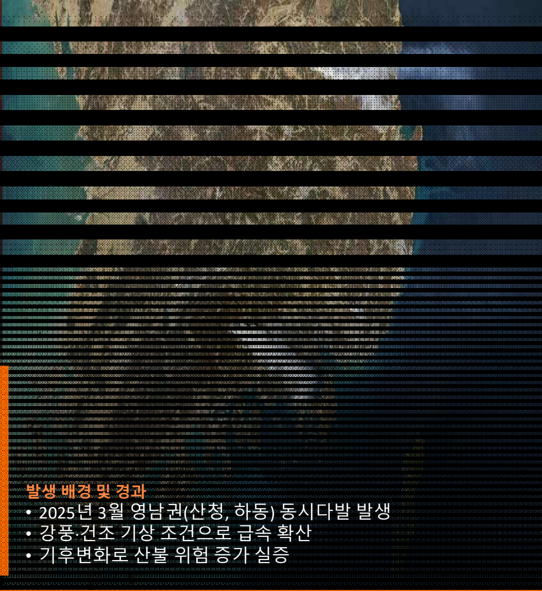
2025, Southern California Wildfires

Ignited on January 7, 2025, and were fully contained after 24 days, on January 31, 2025

Category	Palisades Fire	Eaton Fire	Total Impact
Total Area (km²)	94.89	56.74	151.63 = 52.3Yeouido
Structures Destroyed	6,837	9,418	16,255
Fatalities	12	17	29
Estimated Cost	$28 - $275 billion	Included in total	$28 - $275 billion

2025 영남권 산불 — 역대 최대 피해





최종 피해면적

104,788 ha

서울의 1.7배 · 역대 최대 규모

발생 배경 및 경과

- 2025년 3월 영남권(산청, 하동) 동시다발 발생
- 강풍·건조 기상 조건으로 급속 확산
- 기후변화로 산불 위험 증가 실증

Research Assessing the Impact of Wildfire Smoke Exposure on Asthma-Related Healthcare Utilization

Author	Year	Wildfire Location	Study Participants	Main Result (OR/RR, 95%CI) for each outcome
Asthma related Emergency Department Visit (EDV)				
Rappold et al.	2011	North Carolina, USA	Records of 111 of 114 North Carolina EDs	1.65 (1.25–2.10) (RR)
Resnick et al.	2015	New Mexico, USA	0.55 million population	1.08 (0.91–1.29) (RR)
Haikerwal et al.	2015	Victoria, Australia	5.1 million population	1.02 (1.00–1.04) (RR)
Alman et al.	2016	Colorado, USA	10,699 ED records	1.04 (1.02–1.06) (OR)
Reid et al.	2016	California, USA	12.7 million population	1.06 (1.05–1.07) (RR)
Parthum et al.	2017	Virginia, USA	2 million population	1.65 (1.25–2.17) (RR)
Hutchinson et al.	2018	California, USA	176,851 healthcare utilized population	2.12 (1.57–2.86) (RR)
Borchers Arriagada et al.	2019	Meta-analysis	20 Studies (Meta-analysis)	1.07 (1.04–1.09) (RR)
Malig et al.	2021	California, USA	Bay Area population	1.56 (1.49–1.64) (RR)
Tornevi et al.	2021	Jämtland Härjedalen Region, Sweden	130,000 population	1.68 (1.09–2.57) (RR)
Heaney et al.	2022	California, USA	Total population of California	1.10 (1.02–1.19) (RR)
Duncan et al.	2023	North Carolina, USA	12,483 ED records	1.10 (1.06–1.14) (OR)
Chen et al.	2023	California, USA	17,847,917 population	1.57 (1.45–1.71) (RR)
Schweizer et al.	2023	California, USA	Total population of California	1.38 (1.21–1.57) (OR)
Doubleday et al.	2023	Washington, USA	1,864,470 non-traumatic ED visits	1.13 (1.10–1.17) (OR)
Asthma related Hospital admission				
Morgan et al.	2010	Sydney, Australia	3.5 million population of Sydney	1.05 (1.02–1.08) (RR)
Kollanus et al.	2016	Helsinki, Finland	1 million population of Helsinki	1.16 (0.98-1.37) (RR)
Reid et al.	2016	California, USA	12.7 million population of California	1.07 (1.05–1.10) (RR)
Gan et al.	2017	Washington, USA	26,835 admissions	1.07 (1.02–1.14) (OR)
Borchers Arriagada et al.	2019	Meta-analysis	20 Studies (Meta-analysis)	1.06 (1.02–1.09) (RR)
Malig et al.	2021	California, USA	Bay Area population of San Francisco	1.22 (1.06–1.40) (RR)
Magzamen et al.	2021	Colorado, USA	46,585 admissions of Colorado	1.46 (1.09–1.94) (OR)

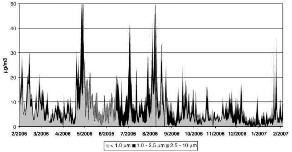
Wildfire Exposure and Respiratory Health: A Comprehensive Review of Emerging Evidence, TRD, 2025

Research Assessing the Impact of Wildfire Smoke Exposure on COPD-Related Healthcare Utilization

Author	Year	Wildfire Location	Study Participants	Main Result (OR/RR, 95%CI) for each outcome
COPD related Emergency Department Visit (EDV)				
Rappold et al.	2011	North Carolina, USA	Records of 111 of 114 civilian North Carolina EDs	1.73 (1.06–2.83) (RR)
Alman et al.	2016	Colorado, USA	10,699 ED records	1.05 (1.02–1.08) (OR)
Reid et al.	2016	California, USA	12.7 million population	1.02 (1.01–1.04) (RR)
Parthum et al.	2017	Virginia, USA	2 million population	1.73 (1.06–2.83) (RR)
Duncan et al.	2023	North Carolina, USA	12,483 ED records	2.93 (1.59–5.41) (OR)
COPD related Hospital admission				
Morgan et al.	2010	Sydney, Australia	3.5 million population	1.04 (1.01–1.06) (RR)
Gan et al.	2017	Washington, USA	26,835 cardiopulmonary hospital admissions	1.08 (1.03–1.15) (OR)
Magzamen et al.	2021	Colorado, USA	46,585 hospital admissions	1.15 (1.00–1.31) (OR)

Characteristics of Wildfire PM

Source	Wildfire PM results from **combustion of biomass**
Particle Size	**Smaller than PM from urban sources** →Higher proportion of Fine/Ultrafine PM ($PM_{2.5}$ and PM_1 in PM_{10})
Exposure Pattern	•Contributing factor on **20% of the days $PM_{2.5}$ exceeded standard** (35 μg/m³) •2019–2020 Australian wildfire: daily **$PM_{2.5}$ reached 600 μg/m³** •**Episodic exposure** — high-intensity peaks with low background levels
Toxic Effects	•**More oxidative components** (oxygenated PAHs, quinones, heavy metals) •**More proinflammatory components** (aldehydes, oxides of nitrogen) •**Greater oxidative potential** •Wildfire PM in urban areas: toxic effects **5X greater than urban PM** •**High temperatures and oxidant gases amplify health risks**



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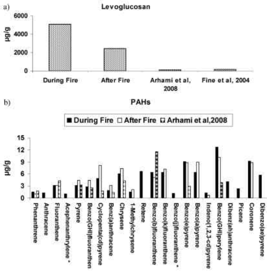


Sci Total Environ 2010;408:644-651
Sci Total Environ 2017;603-604:268-278

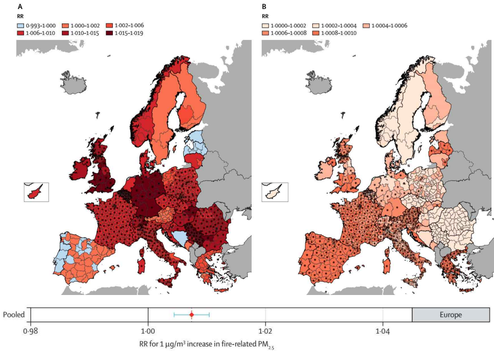
Quantifying the short-term mortality effects of wildfire smoke in Europe: a multicountry epidemiological study in 654 contiguous regions

Anna Alari, Joan Ballester, Carles Milà, Tarik Benmarhnia, Mikhail Sofiev, Andreas Uppstu, Risto Hänninen, Cathryn Tonne

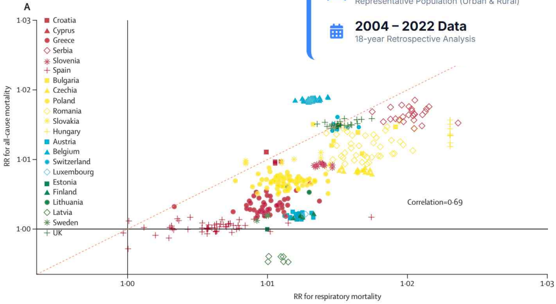
32 European Countries
654 Contiguous Subnational Regions

541 Million People
Representative Population (Urban & Rural)

2004 – 2022 Data
18-year Retrospective Analysis


Mortality associated Fire-related $PM_{2.5}$

Non-fire-related $PM_{2.5}$



Pooled Cumulative Relative Risks (RRs) per 1 μg/m³ increase in fire-related PM2.5

ALL-CAUSE MORTALITY	CARDIOVASCULAR	RESPIRATORY
1.007	**1.009**	**1.013**
95% CI: 1.004 – 1.010	95% CI: 1.006 – 1.013	95% CI: 1.008 – 1.019

Lancet Planet Health 2025;9: 101296

중앙대학교병원
CHUNG-ANG UNIVERSITY HOSPITAL

ORIGINAL ARTICLE

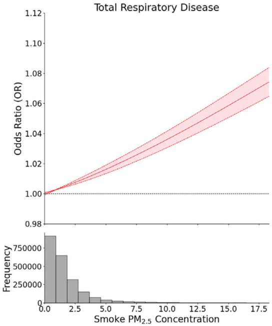
Differential Effects of Wildfire Smoke Fine Particulate Matter Exposure on Respiratory Disease Emergency Department Visits in the Western United States

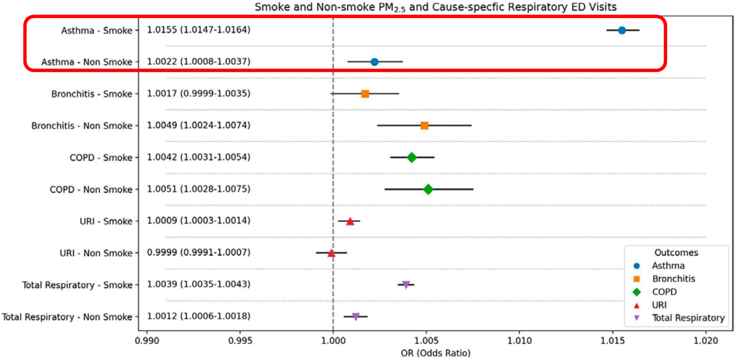
Wenhao Wang[1], Linzi Li[2], Qingyang Zhu[1], Rohan Richard D'Souza[3], Danlu Zhang[3], Haisu Zhang[1], Stefanie Ebelt[1,2], Howard H. Chang[3], Alvaro Alonso[2], and Yang Liu[1]

[1]Gangarosa Department of Environmental Health, [2]Department of Epidemiology, and [3]Department of Biostatistics and Bioinformatics, Rollins School of Public Health, Emory University, Atlanta, Georgia

ORCID IDs: 0000-0002-6228-7516 (W.W.); 0000-0003-3835-5598 (L.L.); 0000-0001-7205-5199 (Q.Z.); 0009-0001-9233-2162 (D.Z.); 0000-0002-7171-6167 (H.Z.); 0000-0003-4713-2337 (S.E.); 0000-0002-6316-1640 (H.H.C.); 0000-0002-2225-8323 (A.A.); 0000-0001-5477-2186 (Y.L.).

- **Study Design**: Time-stratified case-crossover design.
- **Study Population: 6 million respiratory ED visits 5 Western US states (2007–2018).**
- **Exposure**: Daily wildfire-specific vs. non-smoke PM2.5, machine learning at a 1-km resolution.
- **Outcome**: ED visits for asthma, bronchitis, COPD, URI, and total respiratory diseases.
- **Statistics**: Conditional logistic regression estimating ORs, adjusting for meteorology and holidays





Am J Respir Crit Care Med. 2025 Nov;211(11):2086–2095

ORIGINAL ARTICLE

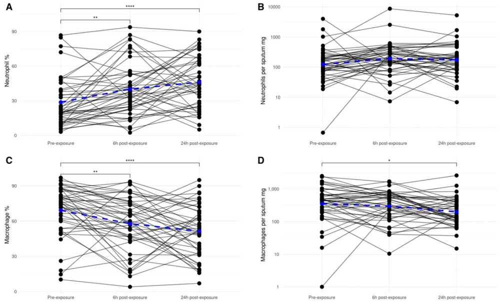
Human Sputum Microbiome Composition and Sputum Inflammatory Cell Profiles Are Altered with Controlled Wood Smoke Exposure as a Model for Wildfire Smoke

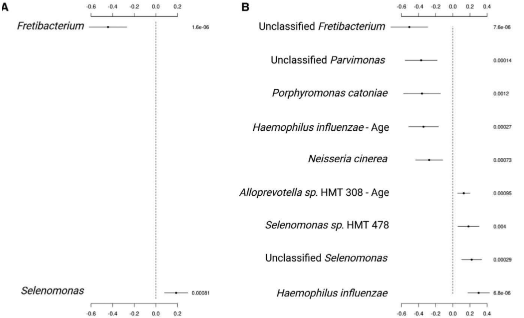
Catalina Cobos-Uribe[1], Radhika Dhingra[2], Martha A. Almond[3,4], Neil E. Alexis[3,4], David B. Peden[3,4], Jeffrey Roach[5], and Meghan E. Rebuli[1,3,4]

[1]Curriculum in Toxicology & Environmental Medicine, [2]Environmental Sciences and Engineering Department, Gillings School of Global Public Health, [3]Center for Environmental Medicine, Asthma, and Lung Biology, [4]Department of Pediatrics, and [5]UNC Microbiome Core, University of North Carolina at Chapel Hill, Chapel Hill, North Carolina

ORCID IDs: 0000-0002-6671-0780 (C.C.-U.); 0000-0003-0202-1860 (R.D.); 0000-0002-9417-8269 (N.E.A.); 0000-0003-4526-4627 (D.B.P.); 0000-0001-9817-5877 (J.R.); 0000-0003-1918-2257 (M.E.R.).

- **Study Design**: Controlled human exposure study with longitudinal sampling.
- **Study Population**: **54 healthy, non-smoking adult volunteers.**
- **Exposure: 2hr exposure to wood smoke (500*μg*/*m*3) with exercise.**
- **Outcome**
  - Sputum microbiome composition (16S rRNA sequencing) and inflammatory cell profiles (macrophages, neutrophils) at baseline, 6h, and 24h post-exposure.





Am J Respir Crit Care Med. 2025 Nov;211(11):2060-2071

GeoHealth

RESEARCH ARTICLE

10.1029/2025GH001332

Min-Taek Lee and Hoyoung Cha contributed equally to this work.

Key Points:

- Even short-term exposure to small wildfires significantly increase the risk of healthcare utilization for respiratory diseases
- Exposure to wildfire smoke had immediate and delayed effects on the respiratory diseases healthcare utilization

Impact of Wildfire Smoke on Respiratory Disease Associated Healthcare Utilization in Gang-Won Province, South Korea, in 2017

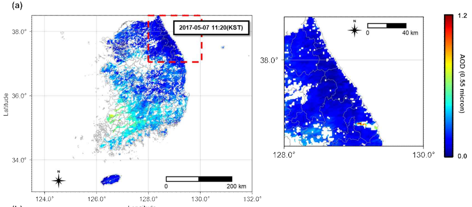
Min-Taek Lee[1,2], Hoyoung Cha[3], Ju Won Lee[1,2], Jongjin Baik[4], Hae In Jung[5,6], Kyoung Min Moon[5,6], Changhyun Jun[4], Sun-Young Jung[1,2], and Kang-Mo Gu[5,6,7]

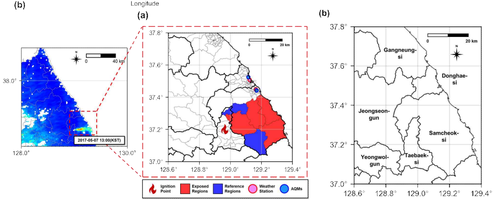
[1]College of Pharmacy, Chung-Ang University, Seoul, Korea, [2]Department of Global Innovative Drugs, The Graduate School of Chung-Ang University, Seoul, Korea, [3]Department of Civil, Environmental and Architectural Engineering, Korea University, Seoul, Korea, [4]School of Civil, Environmental and Architectural Engineering, Korea University, Seoul, Korea, [5]Department of Internal Medicine, College of Medicine, Chung-Ang University, Seoul, South Korea, [6]Department of Internal Medicine, Division of Pulmonary and Allergy Medicine, Chung-Ang University Hospital, Seoul, Korea, [7]Biomedical Research Institute, Chung-Ang University Hospital, Seoul, South Korea

Methods - Study Area & Period

- Gangwon Province Overview
  - 81.5% forest coverage
  - Structure vulnerable to wildfires
- Wildfire Incident area (A.O.D.)
  - May 6-9, 2017 in Samcheok and Donghae (764Ha)
- Study Period
  - Pre-wildfire: April 22 – May 5, 2017
  - Wildfire: May 6 – 9, 2017
  - Post-wildfire: Immediate and extended (2-week)

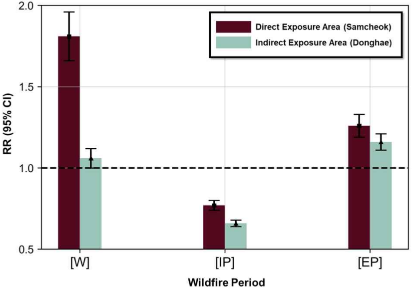
4.22.~5.5. (14 days)	5.6.~5.9	5.10.~5.23. (14 days)	5.24.~6.6. (14 days)
Pre-wildfire Period (Control)	**During Wildfire**	**Immediate Post-wildfire Period**	**Extended Post-wildfire Period**





Wildfire-exposed areas
(a) Locations of ignition of AQMs, Weather Station, and Affected Areas from the May 6, 2017, wildfire
(b) Administrative divisions of Gangwon-do (Samcheok (directly-exposed area), Donghae (indirectly-exposed area)

Relative Risk of Respiratory Disease healthcare utilization by Region



(a) Samcheok (Direct exposed area)

Age Group (year)	2017 [W] RR (95% CI)	2017 [IP] RR (95% CI)	2017 [EP] RR (95% CI)
All age	**1.81(1.67–1.96)**	0.77(0.75–0.80)	**1.26(1.20–1.33)**
≥ 20	**1.83(1.68–1.98)**	0.76(0.74–0.79)	**1.23(1.17–1.29)**
0-9	**2.20(2.04–2.38)**	0.83(0.80–0.86)	**1.44(1.37–1.52)**
10-19	**1.23(1.13–1.33)**	0.71(0.69–0.74)	**1.09(1.03–1.15)**
20-65	**1.90(1.76–2.06)**	0.80(0.77–0.82)	**1.19(1.13–1.25)**
>65	**1.76(1.61–1.93)**	0.71(0.68–0.73)	**1.24(1.17–1.31)**

(b) Donghae (Indirect exposed area)

Age Group (year)	2017 [W] RR (95% CI)	2017 [IP] RR (95% CI)	2017 [EP] RR (95% CI)
All age	**1.06(1.01–1.12)**	0.66(0.64–0.68)	**1.16(1.11–1.21)**
≥ 20	**1.21(1.14–1.27)**	0.64(0.62–0.66)	**1.08(1.03–1.12)**
0-9	0.71(0.67–0.75)	0.71(0.69–0.74)	**1.57(1.51–1.64)**
10-19	**1.08(1.02–1.13)**	0.66(0.64–0.68)	0.96(0.92–1.00)
20-65	**1.13(1.08–1.19)**	0.67(0.66–0.69)	**1.07(1.03–1.11)**
>65	**1.40(1.31–1.49)**	0.59(0.57–0.61)	**1.07(1.02–1.12)**

- **During the wildfire period - the direct-exposure area 81% increase RR (RR = 1.81, 95% CI 1.67–1.96) vs 6%**
- **During the extended post-wildfire period, the direct-exposure area an 26% increase in the RR vs. 16%**

Relative Risk Ratio of Respiratory Disease healthcare utilization by Region

(a) Samcheok (Direct exposed area)

Age Group (year)	2017 [W] RR (95% CI)	2017 [IP] RR (95% CI)	2017 [EP] RR (95% CI)	2017/2018 [W] RRR (95% CI)	2017/2018 [IP] RRR (95% CI)	2017/2018 [EP] RRR (95% CI)
All age	**1.81(1.67–1.96)**	0.77(0.75–0.80)	**1.26(1.20–1.33)**	**1.30(1.15–1.45)**	0.97(0.91–1.04)	**1.75(1.61–1.91)**
≥ 20	**1.83(1.68–1.98)**	0.76(0.74–0.79)	**1.23(1.17–1.29)**	**1.49(1.32–1.67)**	1.04(0.97–1.11)	**1.84(1.69–2.00)**
0-9	**2.20(2.04–2.38)**	0.83(0.80–0.86)	**1.44(1.37–1.52)**	**1.37(1.22–1.54)**	0.94(0.87–1.00)	**1.83(1.67–2.01)**
10-19	**1.23(1.13–1.33)**	0.71(0.69–0.74)	**1.09(1.03–1.15)**	**1.39(1.24–1.55)**	1.20(1.12–1.28)	**1.99(1.83–2.17)**
20-65	**1.90(1.76–2.06)**	0.80(0.77–0.82)	**1.19(1.13–1.25)**	**1.44(1.29–1.61)**	0.98(0.92–1.04)	**1.72(1.58–1.86)**
>65	**1.76(1.61–1.93)**	0.71(0.68–0.73)	**1.24(1.17–1.31)**	**1.22(1.07–1.39)**	0.94(0.87–1.01)	**1.67(1.52–1.83)**

(b) Donghae (Indirect exposed area)

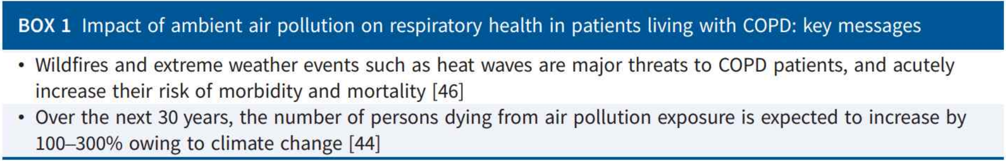
Age Group (year)	2017 [W] RR (95% CI)	2017 [IP] RR (95% CI)	2017 [EP] RR (95% CI)	2017/2018 [W] RRR (95% CI)	2017/2018 [IP] RRR (95% CI)	2017/2018 [EP] RRR (95% CI)
All age	**1.06(1.01–1.12)**	0.66(0.64–0.68)	**1.16(1.11–1.21)**	0.48(0.45–0.52)	0.51(0.48–0.53)	0.81(0.77–0.86)
≥ 20	**1.21(1.14–1.27)**	0.64(0.62–0.66)	**1.08(1.03–1.12)**	0.53(0.50–0.58)	0.48(0.45–0.50)	0.74(0.70–0.78)
0-9	0.71(0.67–0.75)	0.71(0.69–0.74)	**1.57(1.51–1.64)**	0.31(0.29–0.33)	0.55(0.52–0.58)	1.09(1.03–1.16)
10-19	1.08(1.02–1.13)	0.66(0.64–0.68)	0.96(0.92–1.00)	0.75(0.70–0.80)	0.59(0.57–0.62)	0.90(0.85–0.96)
20-65	1.13(1.08–1.19)	0.67(0.66–0.69)	**1.07(1.03–1.11)**	0.55(0.51–0.59)	0.53(0.50–0.55)	0.80(0.76–0.85)
>65	1.40(1.31–1.49)	0.59(0.57–0.61)	**1.07(1.02–1.12)**	0.52(0.48–0.57)	0.42(0.40–0.44)	0.63(0.59–0.68)

- In the **direct-exposure area**, the **RRRs during the wildfire (RRR = 1.30, 95% CI 1.15–1.45)** and **extended post-wildfire (RRR = 1.75, 95% CI 1.61–1.91) periods** were significantly elevated.

EUROPEAN RESPIRATORY JOURNAL
PERSPECTIVE
D.D. SIN ET AL.

Air pollution and COPD: GOLD 2023 committee report

Don D. Sin[1], Dany Doiron[2], Alvar Agusti[3], Antonio Anzueto[4], Peter J. Barnes[5], Bartolome R. Celli[6], Gerard J. Criner[7], David Halpin[8], MeiLan K. Han[9], Fernando J. Martinez[10], Maria Montes de Oca[11], Alberto Papi[12], Ian Pavord[13], Nicolas Roche[14], Dave Singh[15], Robert Stockley[16], M. Victorina Lopez Varlera[17], Jadwiga Wedzicha[5], Claus Vogelmeier[18] and Jean Bourbeau[2] on behalf of the GOLD Scientific Committee



BOX 1 Impact of ambient air pollution on respiratory health in patients living with COPD: key messages

- Wildfires and extreme weather events such as heat waves are major threats to COPD patients, and acutely increase their risk of morbidity and mortality [46]
- Over the next 30 years, the number of persons dying from air pollution exposure is expected to increase by 100–300% owing to climate change [44]

European Respiratory Journal 2023 61(5): 2202469

Climate Change and Floods

Hawaii, US, 2026.3.

Respiratory Impacts of Flooding

DIRECT EXPOSURE & INDIRECT SYSTEMIC RISKS

Direct Respiratory Effects

Contaminated Exposure

- **Toxicants:** Exposure to pesticides and drug-resistant pathogens in floodwater.
- **Aerosolization:** Drying sediments turn into **toxic dust** that residents inhale.
- **Cleanup Risk:** High intensity exposure during cleaning and sediment removal.

Clinical Link: Urban flooding is directly associated with increased ARIs.

Indirect Systemic Effects

Infrastructure & Housing

- **Care Disruption:** Damaged clinics and interrupted vaccination/chronic care programs.
- **Housing Compromise:** Overcrowding and poor ventilation in water-damaged homes.
- **Transmission:** Facilitated spread of viral infections due to displacement.

Management vulnerability persists months after water recedes.

Lancet Respir Med 2023; 11: 963–64

Post-Flood Mould Exposure

A CRITICAL BUT UNDERSTUDIED RESPIRATORY THREAT

Stage 1

Floodwaters subside, leaving saturated materials.

Stage 2

Persistent damp indoor micro-environments.

Stage 3

Rapid and massive proliferation of fungal spores.

→ **Duration: Few weeks to months**

Associated Respiratory Spectrum

- Asthma Onset/Exacerbation
- Bronchitis & Chronic Cough
- Aspergillosis (Infectious)
- Allergic Rhinitis
- ⚠ Hypersensitivity Pneumonitis (Severe/Rare)

HIGH-RISK GROUPS

Children & Immunocompromised

Research Gap: *Strong biological plausibility exists, but longitudinal post-flood research is currently limited.*

Lancet Respir Med 2023; 11: 963–64

Severe flooding and cause-specific hospitalisation among older adults in the USA: a retrospective matched cohort analysis

Sarika Aggarwal, Jie K Hu, Jonathan A Sullivan, Robbie M Parks, Rachel C Nethery

- **Study Design**: Retrospective matched cohort analysis

- **Study Population**
  - **4.5 million hospitalizations** of Medicare **≥65 US (2000–2016)**

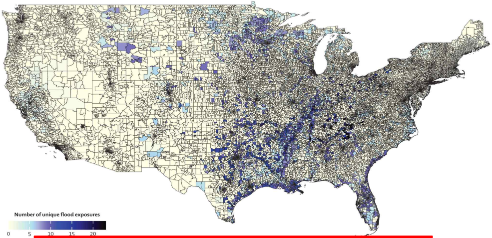
- **Exposure**
  - **72 major floods, Flood map(Satellite), Lag 4 week (12wk Extended)**
  - **같은 ZIP code를 flood 시기와 non-flood 시기로 비교하는 self-matched design**
- **Outcome**
  - Hospitalization rates in 13 exclusive disease categories **(Including Respiratory)**

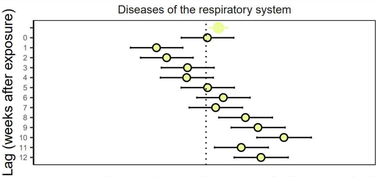
- **Statistics**
  - Conditional quasi-Poisson distributed lag models **comparing flooded days (+4 weeks lag)** to self-matched, non-flooded control days.

Significant Hospitalization Rate Increases (Mean % Change)

+3.1%	+2.5%	+1.3%	+1.1%
SKIN DISEASES	NERVOUS SYSTEM	MUSCULOSKELETAL	INJURIES

*Peak musculoskeletal risk (+5.6%) observed at 4-week lag, likely due to cleanup-related strain or delayed care.



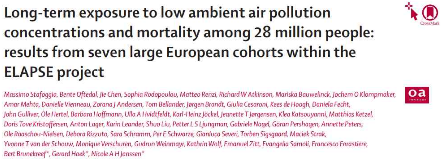


In our secondary analysis with an extended lag period of 12 weeks, we observed increased rates of hospitalisation for respiratory system diseases during the later lag weeks (ie, weeks 8–12) with a peak increase during lag week 10 (4·1% [95% CI 2·7–5·5]). Other causes of hospitalisation exhibited patterns consistent with the primary analysis

Lancet Planet Health 2025; 9: 101268

Air Pollution

Outdoor & Indoor Air Quality



Long-term exposure to low ambient air pollution concentrations and mortality among 28 million people: results from seven large European cohorts within the ELAPSE project

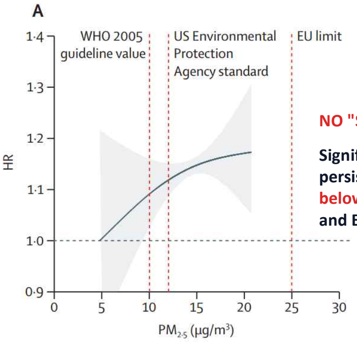
Massimo Stafoggia, Bente Oftedal, Jie Chen, Sophia Rodopoulou, Matteo Renzi, Richard W Atkinson, Mariska Bauwelinck, Jochem O Klompmaker,
Amar Mehta, Danielle Vienneau, Zorana J Andersen, Tom Bellander, Jørgen Brandt, Giulia Cesaroni, Kees de Hoogh, Daniela Fecht,
John Gulliver, Ole Hertel, Barbara Hoffmann, Ulla A Hvidtfeldt, Karl-Heinz Jöckel, Jeanette T Jørgensen, Klea Katsouyanni, Matthias Ketzel,
Doris Tove Kristoffersen, Anton Lager, Karin Leander, Shuo Liu, Petter L S Ljungman, Gabriele Nagel, Göran Pershagen, Annette Peters,
Ole Raaschou-Nielsen, Debora Rizzuto, Sara Schramm, Per E Schwarze, Gianluca Severi, Torben Sigsgaard, Maciek Strak,
Yvonne T van der Schouw, Monique Verschuren, Gudrun Weinmayr, Kathrin Wolf, Emanuel Zitt, Evangelia Samoli, Francesco Forastiere,
Bert Brunekreef, Gerard Hoek*, Nicole A H Janssen**

28,153,138
TOTAL PARTICIPANTS

258 Million
PERSON-YEARS

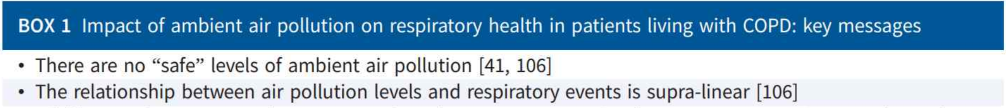
100m²
SPATIAL RESOLUTION

07
INTEGRATED COHORTS



NO "SAFE" LEVEL EXISTS

Significant mortality associations persist at concentrations well below current WHO (5 μg/m³) and EU (25 μg/m³) limits for $PM_{2.5}$



BOX 1 Impact of ambient air pollution on respiratory health in patients living with COPD: key messages

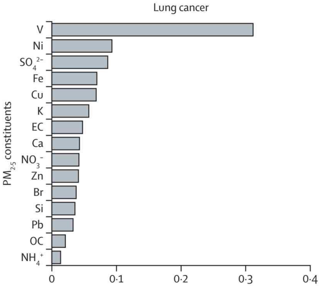
- There are no “safe” levels of ambient air pollution [41, 106]
- The relationship between air pollution levels and respiratory events is supra-linear [106]

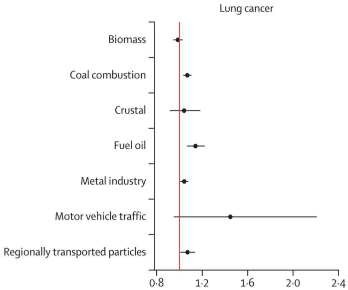
Lancet Planet Health 2022; 6: e9–18
European Respiratory Journal 2023 61(5): 2202469

Long-term exposure to $PM_{2\cdot5}$ constituents and incident cancer among Medicare beneficiaries in the USA: a national cohort study

Yijing Feng, Tingfan Jin, Yaguang Wei, Kyle Steenland, Joel Schwartz

- **Study Design**: National cohort study.
- **Study Population**: 15M (aged ≥65 years), 2000 and 2018.
- **Exposure:** 3-year average 15 PM2.5, ZIP code (machine learning models)
- **Outcome:** Incident lung, colorectal, prostate, breast, and endometrial cancers.





Public Health Impact

> *"Reducing $PM_{2.5}$ by just **1 μg/m³** across the USA can prevent **2,300** new lung cancer cases annually."*

Health Disparities

- Higher risk in individuals **aged 75+**
- Pronounced vulnerability in **Males**
- Socioeconomic gap (**Medicaid-eligible**)

CONCLUSION

Regulatory standards must transition from Total Mass to Constituent-Based control.

The Primary Driver: Vanadium (V)

Vanadium contributes 31.3% of the total mixture effect, followed by Nickel (9.3%).

Highest Risk Sources

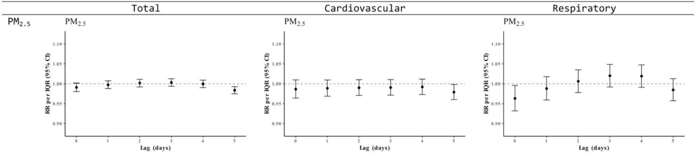
FUEL OIL
1.141 HR

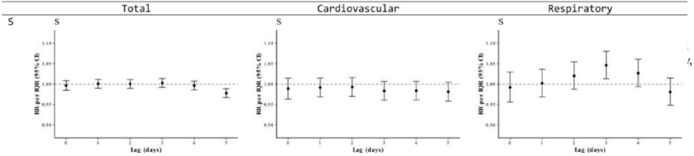
COAL
1.069 HR

Lancet Planet Health 2025; 9: 101334

Effects of $PM_{2.5}$ and particle constituents on overall, cardiovascular, and respiratory mortality in Seoul

Oh Beom Kwon[1], Eun Ju Lee[1], Myoung Nam Lim[2], Young Ji Han[3], Jun Young Ahn[4], Hye Jung Shin[4], Jung Min Park[4], Jeeyoung Kim[1] & Woo Jin Kim[1,5]





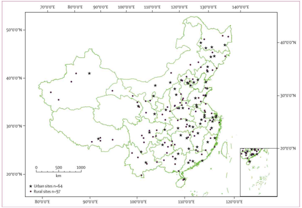
	Mass of components		
	Mean ± SD	Minimum-maximum	IQR
PM2.5 ($\mu g/m^3$)	26.02 ± 16.32	1.07–142.0	17.77
Ions ($\mu g/m^3$)			
SO_4^{2-}	4.02 ± 3.34	0–27.48	3.83
NO_3^-	5.03 ± 5.66	0–51.91	5.79
Cl^-	0.28 ± 0.31	0–2.57	0.35
Na^+	0.07 ± 0.09	0–0.62	0.10
NH_4^+	3.09 ± 2.81	0–25.19	3.00
K^+	0.12 ± 0.13	0–1.05	0.15
Mg^{2+}	0.01 ± 0.02	0–0.21	0.004
Ca^{2+}	0.06 ± 0.08	0–0.58	0.09
Carbon			
OC	3.58 ± 1.91	0.20–12.55	2.40
EC	1.06 ± 0.58	0.03–4.04	0.70
Metal (ng/m^3)			
S	2711.71 ± 2057.66	45.74–16032.50	2325.72
K	239.65 ± 195.24	7.68–2287.96	212.04
Ca	68.78 ± 75.72	0–1104.97	48.08
Ti	10.63 ± 0.08	0.08–137.87	7.08
V	3.30 ± 4.25	0–31.60	4.20
Cr	1.26 ± 0.90	0–7.19	1.05
Mn	11.05 ± 7.84	0.03–56.10	8.71
Fe	199.73 ± 129.29	9.64–1642.18	125.33
Ni	1.26 ± 1.39	0–10.14	1.47
Cu	7.90 ± 4.89	0.33–29.21	6.23
Zn	53.33 ± 34.88	0.84–258.70	41.00
As	3.79 ± 3.45	0–45.23	3.63
Se	1.06 ± 1.06	0–6.42	1.15
Br	7.38 ± 5.88	0.02–63.13	6.22
Pb	18.28 ± 12.23	0.03–89.32	15.51

Scientific Reports. 2026;16:2984.

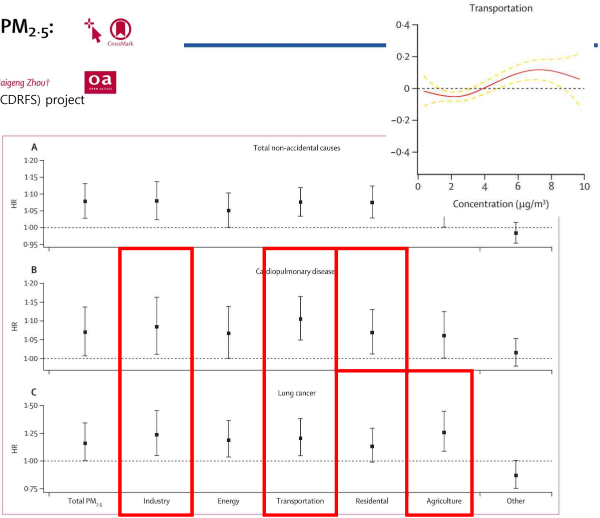
Mortality and long-term exposure to source-specific $PM_{2\cdot5}$: evidence from a national cohort study in China

Xia Meng, Yuchang Zhou*, Su Shi*, Shuxiao Wang, Maryam Zaid, Hongliang Zhang†, Jianlin Hu†, Gang Li, Haidong Kan, Maigeng Zhou†*

2010–11 of the China Chronic Disease and Risk Factors Surveillance (CCDRFS) project



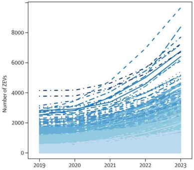
- **N=96,955 (>18yr, ~2020.12.31.)**
- **High-resolution machine-learning–based (Random Forest) and CMAQ-derived source-specific PM2.5**
- **Outcome Definitions**
    - Total non-accidental mortality ICD-10: A00–R99
    - **Respiratory Disease Mortality: J00–J99**
    - **Lung cancer mortality: C34**
- **Model**: Cox proportional hazards model



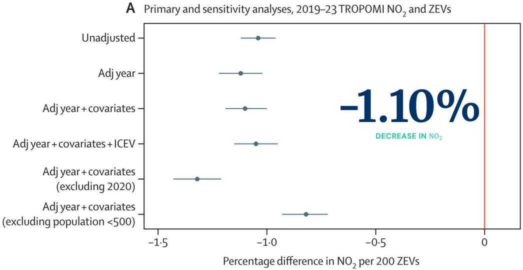
Lancet Planet Health 2026; 10: 101400

Zero-emissions vehicle adoption and satellite-measured NO_2 air pollution in California, USA, from 2019 to 2023: a longitudinal observational study

Sandrah P Eckel, Futu Chen, Sam J Silva, Daniel L Goldberg, Jill Johnston, Lawrence A Palinkas, Alberto Campos, Wilma Franco, Erika Garcia

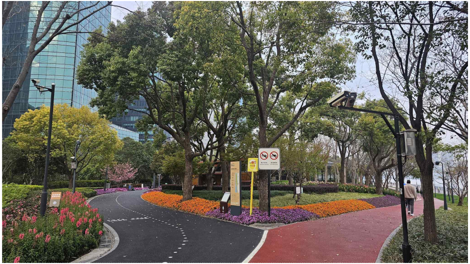


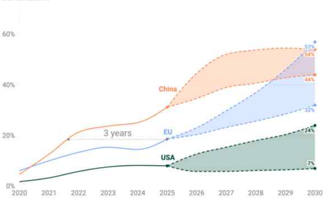
- **Study Design**
  - Longitudinal observational study
  - Natural experiment of the electric vehicle transition
- **Study Population**
  - 1,687 ZIP code tabulation areas (ZCTAs), California (2019-2023)
- **Exposure**
  - Within-ZCTA changes in the annual number of registered light-duty zero-emissions vehicles (ZEVs)
- **Outcome**
  - Annual mean tropospheric NO2 measured by the TROPOMI satellite instrument
- **Statistics**
  - Longitudinal linear mixed-effects models with ZCTA-level random intercepts (population size, socioeconomic status, fuel prices, telecommuting patterns)
  - ZEV counts were group-mean centered to isolate within-ZCTA effects



- **ZEV Adoption and NO_2 Reduction**
  - From 2019 to 2023 in California increases in registered light-duty zero-emissions vehicles
  - **An increase of 200 zero-emissions vehicles corresponded to an approximately 1.1% decrease in NO_2**

Lancet Planet Health 2026;10: 101379





Europe can regain global EV leadership, if it maintains 2035 ambition

BEV sales share

Source: GlobalData (China and USA, historical data), ACEA (Europe, historical data), BloombergNEF (China, forecast), Rhodium (USA, forecast) • Europe is EU + Norway

T&E

Built Environment
& Indoor Air Pollution Exposure

Urban Design · Indoor Air · Workplace Hazards

International Journal of
Environmental Research
and Public Health

MDPI

Article

Residential Radon Exposure and Cigarette Smoking in Association with Lung Cancer: A Matched Case-Control Study in Korea

Eung Joo Park [1,2,†], Hokyou Lee [3,4,†], Hyeon Chang Kim [3,5], Seung Soo Sheen [6], Sang Baek Koh [7], Ki Soo Park [8], Nam Han Cho [9], Cheol-Min Lee [10] and Dae Ryong Kang [1,2,*]

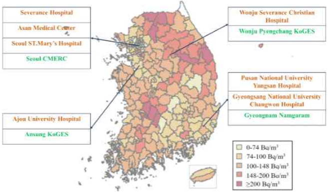
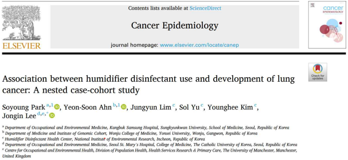


Figure 2. Map of the study area and research sites. Regional indoor radon levels were obtained from the National Institute of Environmental Research (2011–2016). Fill colors correspond to radon levels in five categories. Stars designate the locations of study sites.



Contents lists available at ScienceDirect

Cancer Epidemiology

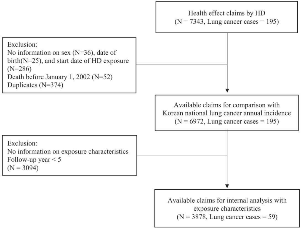
journal homepage: www.elsevier.com/locate/canep

ELSEVIER

Association between humidifier disinfectant use and development of lung cancer: A nested case-cohort study

Soyoung Park [a,1], Yeon-Soon Ahn [b,1], Jungyun Lim [c], Sol Yu [c], Younghee Kim [c], Jongin Lee [d,e,*]

[a] *Department of Occupational and Environmental Medicine, Kangbuk Samsung Hospital, Sungkyunkwan University, School of Medicine, Seoul, Republic of Korea*
[b] *Department of Medicine and Institute of Genomic Cohort, Wonju College of Medicine, Yonsei University, Wonju, Gangwon, Republic of Korea*
[c] *Humidifier Disinfectant Health Center, National Institute of Environmental Research, Incheon, Republic of Korea*
[d] *Department of Occupational and Environmental Medicine, Seoul St. Mary's Hospital, College of Medicine, The Catholic University of Korea, Seoul, Republic of Korea*
[e] *Centre for Occupational and Environmental Health, Division of Population Health, Health Services Research & Primary Care, The University of Manchester, Manchester, United Kingdom*



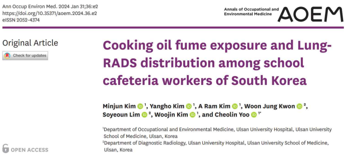
Health effect claims by HD
(N = 7343, Lung cancer cases = 195)

Exclusion:
No information on sex (N=36), date of birth(N=25), and start date of HD exposure (N=286)
Death before January 1, 2002 (N=52)
Duplicates (N=374)

Available claims for comparison with Korean national lung cancer annual incidence
(N = 6972, Lung cancer cases = 195)

Exclusion:
No information on exposure characteristics
Follow-up year < 5
(N = 3094)

Available claims for internal analysis with exposure characteristics
(N = 3878, Lung cancer cases = 59)



Ann Occup Environ Med. 2024 Jan 31;36:e2
https://doi.org/10.35371/aoem.2024.36.e2
eISSN 2052-4374

Annals of Occupational and Environmental Medicine AOEM

Original Article

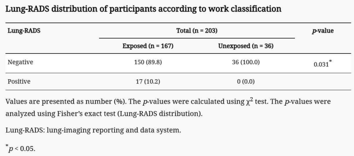
Check for updates

Cooking oil fume exposure and Lung-RADS distribution among school cafeteria workers of South Korea

Minjun Kim [1], Yangho Kim [1], A Ram Kim [1], Woon Jung Kwon [2], Soyeoun Lim [2], Woojin Kim [1], and Cheolin Yoo [1*]

[1] Department of Occupational and Environmental Medicine, Ulsan University Hospital, Ulsan University School of Medicine, Ulsan, Korea
[2] Department of Diagnostic Radiology, Ulsan University Hospital, Ulsan University School of Medicine, Ulsan, Korea

OPEN ACCESS



Lung-RADS distribution of participants according to work classification

Lung-RADS	Total (n = 203)		*p*-value
	Exposed (n = 167)	Unexposed (n = 36)	
Negative	150 (89.8)	36 (100.0)	0.031*
Positive	17 (10.2)	0 (0.0)	

Values are presented as number (%). The *p*-values were calculated using χ^2 test. The *p*-values were analyzed using Fisher's exact test (Lung-RADS distribution).

Lung-RADS: lung-imaging reporting and data system.

$^*p < 0.05$.

Contents lists available at ScienceDirect

Environmental Research

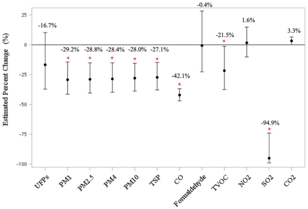
journal homepage: www.elsevier.com/locate/envres

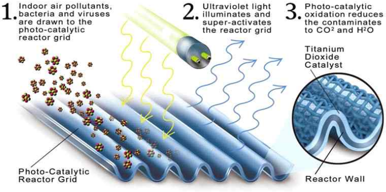
Improvement of indoor air quality and health effects in COPD patients in a heavy industrial area

Jia Lin Zhang [a,f], Yi Ting Chang [a], Ching Yu Hsiao [a], Chung-Shin Yuan [b,c], Yen-Ping Peng [b], Da Wei Wu [d], Huang-Chi Chen [d], Jia-Yu Kuo [d], Huai-Lei Juan [d], Pei-Shih Chen [a,b,e,f,*]

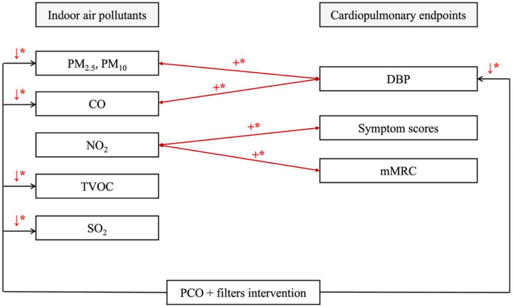
Design: Double-blind randomized crossover trial
Participants: 61 COPD patients
Interventions (2 weeks each):
PCO vs PCO + HEPA + activated carbon filters
Measurements:
Indoor pollutants (PM, CO, NO_2, SO_2, TVOCs)
Lung function, symptoms, FeNO, blood pressure
Analysis: Linear mixed-effects models

(B) PCO + filters intervention





- HEPA → **가스상 오염물질 제거에는 한계**
- **Photocatalytic oxidation (광촉매 산화)**
→ CO, VOCs, SO_2 등 **가스상 오염물질 분해 가능**

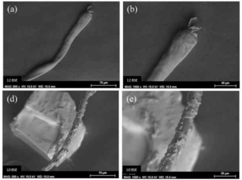


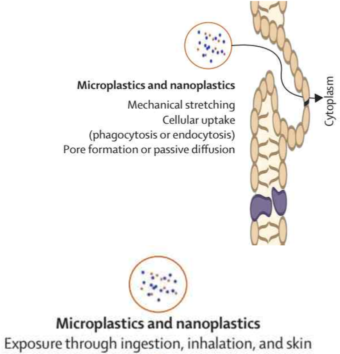
Indoor air pollutants
Cardiopulmonary endpoints
$PM_{2.5}$, PM_{10}
CO
NO_2
TVOC
SO_2
DBP
Symptom scores
mMRC
PCO + filters intervention

Environmental Research 292 (2026) 123699

Microplastic and nanoplastic pollution and associated potential disease risks

Nurshad Ali, Jenny Katsouli, Eric Auyang, Jorge Bernardino de la Serna





Microplastics and nanoplastics
Mechanical stretching
Cellular uptake
(phagocytosis or endocytosis)
Pore formation or passive diffusion

Microplastics and nanoplastics
Exposure through ingestion, inhalation, and skin

Oxidative Stress & Inflammation

MNPs strongly induce **Reactive Oxygen Species (ROS)** production, leading to cellular toxicity, tissue damage, and persistent low-level systemic inflammation.

Cellular Stress & Death

MNPs disrupt normal function by increasing **Endoplasmic Reticulum (ER) stress** and altering autophagy and **apoptosis** (programmed cell death) pathways.

The "Trojan Horse" Effect

MNPs act as vectors carrying **co-contaminants** like bisphenol A, phthalates, heavy metals, and pathogens into the body for toxic release.

Lancet Planet Health 2025;9: 101390

Contents lists available at ScienceDirect

Journal of Hazardous Materials

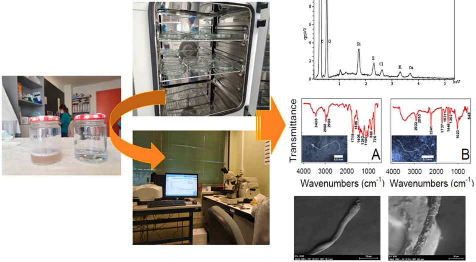
journal homepage: www.elsevier.com/locate/jhazmat

Research Paper

First evidence of microplastics isolated in European citizens' lower airway

Carlos Baeza-Martínez[a], Sonia Olmos[b], Miguel González-Pleiter[c], Joaquín López-Castellanos[b],
Eduardo García-Pachón[a], Mar Masiá-Canuto[d], Luis Hernández-Blas

[a] Pneumology Service, Hospital General Universitari d'Elx, Camí de l'Almazara, 11, E-03203 Elx, Alicante, Spain
[b] Department of Chemical and Environmental Engineering, Technical University of Cartagena, Paseo Alfonso XIII 44,
[c] Department of Biology, Faculty of Sciences, Universidad Autónoma de Madrid, Cantoblanco, E-28049 Madrid, Spai
[d] Departments of Clinical Medicine, Miguel Hernández University of Elche, E-03203 Elche, Alicante, Spain



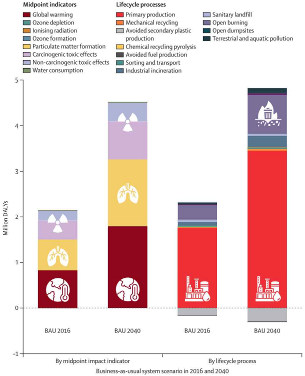
- **Microplastics detected in BALF** from lung cancer patients
    - Predominantly **microfibers (97.06%)**
    - Mean concentration: **9.18 items / 100 mL BALF**
    - Particulate microplastics: **5.88% (0.57 items / 100 mL)**
- **Clinical significance:** Confirms lower airway exposure and deposition in humans.

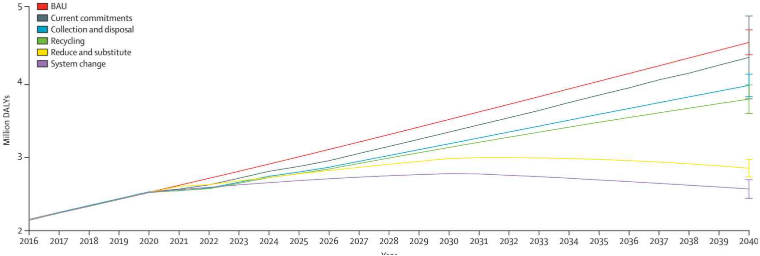
Journal of Hazardous Materials, Volume 438, 2022

Global health burdens of plastics: a lifecycle assessment model from 2016 to 2040

Megan Deeney, Lorie Hamelin, Claire Vialle, Xiaoyu Yan, Rosemary Green, Joe Yates, Suneetha Kadiyala

Disability-adjusted life-years (DALYs)
Business as usual (BAU)





- **BAU scenario (2016–2040): Cumulative 83 million DALYs, with annual health burdens rising from 2.1 million in 2016 to 4.5 million in 2040 (more than doubling)**

- **Major contributors: Primary plastics production accounts for >80% of total DALYs**

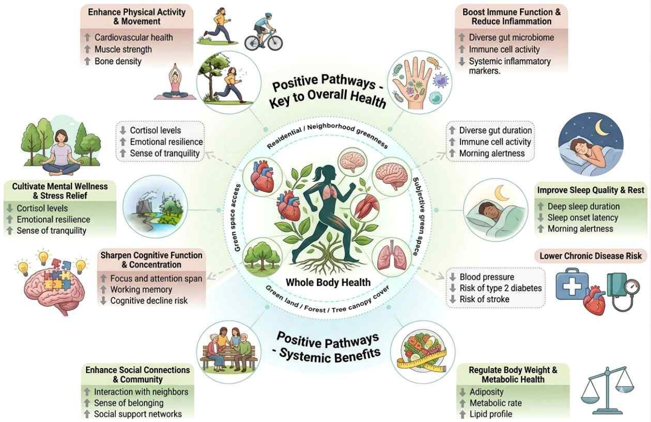
- **Policy implication: Even the “system change” scenario reduces 2040 DALYs by 43% vs BAU**
- **Deep reductions in primary plastics production are the most effective single lever**

Natural Environment & Ecosystems

Green · Blue · Gray Spaces · One Health


9
먹이금지

Why Green Space?



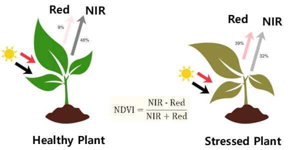
Systemic Pathways to Whole Body Health: The Impact of Green Space Exposure

Urban Forestry & Urban Greening 2015;14(4):806-816.
Environmental Research 2017;158:301-317.
The Lancet Planetary Health 2019;3(11):e469-e477

Remote Sensing & Green Space

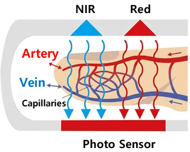
Assessing Vitality: Chlorophyll in Plants vs. Hemoglobin in Blood

Normalized Difference Vegetation Index (NDVI)



$$NDVI = \frac{NIR - Red}{NIR + Red}$$

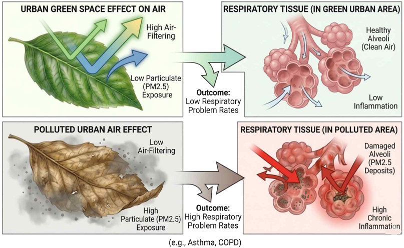
Pulse Oximeter



- **Purpose:**
  NDVI is satellite-derived metric used to quantify global **vegetation vitality and health**
- **Target**: Chlorophyll within plant leaves
- **Mechanism:**
  * **NIR**: Plant naturally reflect most NIR light
  * **Red**: Chlorophyll absorbs Red light which depends on the plant's vitality

- **Purpose:**
  Non-invasive monitoring of a patient's **oxygen saturation** to assess **respiratory function**
- **Target**: Hemoglobin(Hb) in bloodstream
- **Mechanism:**
  * Oxygenated Hb: Absorbs more **NIR**
  * Deoxygenated Hb: Absorbs more **Red**

Relation between green space and respiratory health



Green space may reduce **respiratory problems** by filtering **PM2.5** and other air pollutants, which lowers particle deposition in the alveoli and reduces inflammation and tissue damage

Association Between Green Space and COPD

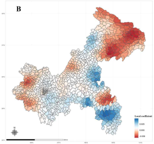
- Urban **green space** is associated with **respiratory health outcomes**, including COPD exacerbations, hospitalizations, and mortality.
- However, the **magnitude and direction** of these associations **vary across regions** and **populations**, suggesting spatial and demographic heterogeneity
- These findings suggest that **environmental context** and **population characteristics** should be considered when evaluating the health impacts of green space.

Research 1 Green space showed a positive association with COPD mortality.

RESEARCH **Open Access**

Spatial association between green space and COPD mortality: a township-level ecological study in Chongqing, China

Aiping Gou[1†], Guanzheng Tan[1†], Xianbin Ding[2*], Jiangbo Wang[3*], Yan Jiao[2], Chunyan Gou[4] and Qiang Tan[2]



Green space (NDVI) on COPD mortality, with **positive associations in 63% of regions** and negative associations in 37%

Research 2 Long-term Air Pollution and Greenness Exposure Linked to health.

Contents lists available at ScienceDirect

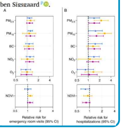
Environmental Research

journal homepage: www.elsevier.com/locate/envres

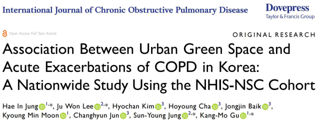
Long-term exposure to air pollution and greenness in association with respiratory emergency room visits and hospitalizations: The Life-GAP project

Shanshan Xu[a,*], Alessandro Marcon[b], Randi Jacobsen Bertelsen[c], Bryndis Benediktsdottir[d,e], Jørgen Brandt[f], Lise Marie Frohn[f], Camilla Geels[f], Thorarinn Gislason[d,e], Joachim Heinrich[g,h], Mathias Holm[i], Christer Janson[j], Iana Markevych[k,l,m], Lars Modig[n], Hans Orru[o], Vivi Schlünssen[p], Torben Sigsgaard[p], Ane Johannessen[q]

Long-term exposure to particulate air pollution ($PM_{2.5}$, PM_{10}, BC, NO_2) was associated with increased **respiratory emergency visits and hospitalizations**.



Research 3 Urban Green Space Associated with Reduced Risk of Acute COPD.



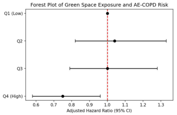
International Journal of Chronic Obstructive Pulmonary Disease
Dovepress
Taylor & Francis Group

Open Access Full Text Article

ORIGINAL RESEARCH

Association Between Urban Green Space and Acute Exacerbations of COPD in Korea: A Nationwide Study Using the NHIS-NSC Cohort

Hae In Jung[1,*], Ju Won Lee[2,*], Hyochan Kim[3], Hoyoung Cha[3], Jongjin Baik[3], Kyoung Min Moon[1], Changhyun Jun[3], Sun-Young Jung[2,*], Kang-Mo Gu[1,*]



Greater urban green space coverage was associated with a **lower risk of acute COPD** exacerbations.

BMC Pulmonary Medicine (2023) 23:89.
Environmental Research 270 (2025) 120938
International Journal of Chronic Obstructive Pulmonary Disease 2025:20 3035–3044

Association Between Green Space and Cancer

- Residential greenness was associated with **reduced incidence and mortality of certain cancers**, with the most consistent protective association observed for **lung cancer**.
- However, these associations **varied by cancer type**, with protective effects also observed for breast and prostate cancer, whereas no clear association was found for colorectal cancer.
- Additionally, increasing residential greenspace **may help reduce socioeconomic disparities** in total cancer incidence among disadvantaged populations.

Research 1 Greenness was linked to lower lung and breast cancer mortality.

Contents lists available at ScienceDirect

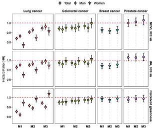
Environment International

journal homepage: www.elsevier.com/locate/envint

Full length article

Long-term exposure to residential green spaces and site-specific cancer mortality in urban Belgium: A 13-year follow-up cohort study

Lucía Rodriguez-Loureiro[a,*], Freija Verdoodt[b], Wouter Lefebvre[c], Charlotte Vanpoucke[d], Lidia Casas[c,f,1], Sylvie Gadeyne[a,1]



Residential **green-space exposure** was associated with **lower lung and breast cancer mortality**, but not colorectal cancer; prostate cancer showed possible adverse associations.

Research 2 Higher NDVI was linked to lower prostate and lung cancer incidence.

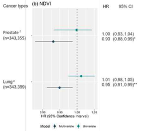
Contents lists available at ScienceDirect

Environmental Research

journal homepage: www.elsevier.com/locate/envres

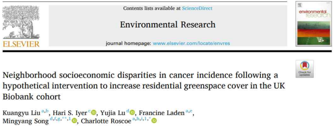
Relationships among green space, ambient fine particulate matter, and cancer incidence in Taiwan: A 16-year retrospective cohort study

Ying-Jhen Huang[a], Ping-Hsien Lee[a], Li-Chi Chen[a], Bo-Cheng Lin[b], Changqing Lin[c], Ta-Chien Chan[a,d,*]



Higher NDVI was significantly associated with **lower risks of prostate and lung cancer incidence**, suggesting that residential greenness may exert a **protective effect** on these cancer types.

Research 3 Residential greenspace may reduce cancer risk inequalities.



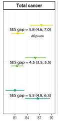
Contents lists available at ScienceDirect

Environmental Research

journal homepage: www.elsevier.com/locate/envres

Neighborhood socioeconomic disparities in cancer incidence following a hypothetical intervention to increase residential greenspace cover in the UK Biobank cohort

Kuangyu Liu[a,b], Hari S. Iyer[c], Yujia Lu[d], Francine Laden[a,e], Mingyang Song[d,f,g,**,1], Charlotte Roscoe[a,h,i,1,*]



Increasing residential greenspace, particularly within 300 m of the home, may help **reduce socioeconomic inequalities in total cancer incidence**, with the greatest benefits accruing to the most deprived populations.

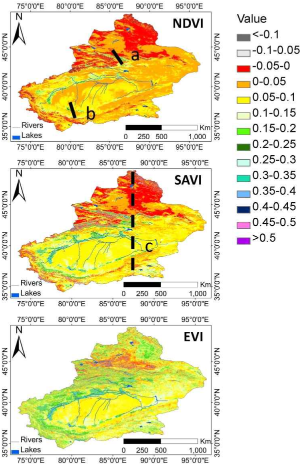
Environment International 2022;170:107571.
Environmental Research 2022;212:113416.
Environmental Research, 2025;266

Urban Green Space Indicators (Remote Sensing)

- **NDVI – Normalized Difference Vegetation Index**
  - Reflects vegetation vitality
    - High (0.6–1.0) / Moderate (0.2–0.5) /Low (0.0–0.2)

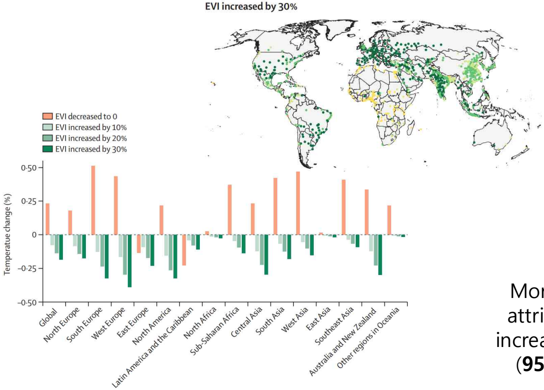
- **EVI – Enhanced Vegetation Index**
  - **Corrects soil & atmospheric noise → more accurate than NDVI**
  - **Specialized for dense vegetation & long-term monitoring**
    - **High (0.5–0.8) / Moderate (0.2–0.5) / Low (0.0–0.2)**

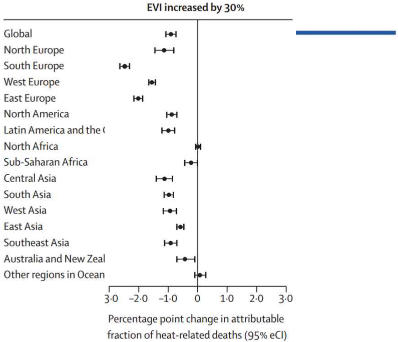
- **LAI – Leaf Area Index**
  - **Directly captures the structural characteristics of vegetation**
    - High (≥ 5.0) / Moderate (3.0–5.0) / Low (1.0–3.0)
  - **Long-term exposure modeling**
    - Annual mean, moving averages, lag structures
    - Time-varying exposure reflecting residential mobility
  - **Analytical scales**
    - Quartiles (Q1–Q4; Q1 reference)
    - Continuous increments (NDVI/EVI per +0.10, LAI per +1.0)



Estimating the urban heat-related mortality burden due to greenness: a global modelling study

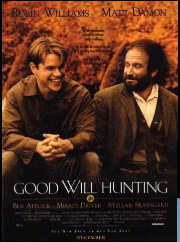
Yao Wu, Bo Wen, Tingting Ye, Wenzhong Huang, Yanming Liu, Antonio Gasparrini, Francesco Sera, Shilu Tong, Eric Lavigne, Dominic Roye, Souzana Achilleos, Niilo Ryti, Mathilde Pascal, Ariana Zeka, Francesca de'Donato, Susana das Neves Pereira da Silva, Joana Madureira, Malcolm Mistry, Ben Armstrong, Michelle L Bell, Joel Schwartz, Yuming Guo, Shanshan Li, on behalf of the MCC Collaborative Research Network*





More than **3,153,225 (2·48%)** of total deaths were attributed to heat exposure in 2000–19, and a **30%** increase in **EVI** was estimated to prevent **1·16 million** (**95% eCI 0·92–1·40**) heat-related deaths globally.

Lancet Planet Health 2025 9: 101235



환경이 얼마나 중요한데, 좋은 환경으로 가라

Examples of Good Environment



Take Home Messages

Understanding & Responding to Environmental Lung Diseases

01 Expanding Concept of Environmental Lung Diseases

Beyond pneumoconiosis — encompasses all respiratory diseases from diverse indoor/outdoor inhalation hazards.

02 Climate Change = Respiratory Health Crisis

Wildfires, heat waves, floods increase respiratory severity and mortality. PM2.5 drives acute exacerbations.

03 Complex Environmental Exposures & Health Impact

PM2.5, NO_2, and microplastics linked to airway inflammation, reduced lung function, and lung cancer risk.

04 Nature-based Solutions & Immune Resilience

Green/blue spaces mitigate pollution, reduce heat islands, enhance microbial diversity.

경청해 주셔서 감사합니다!!

구강모 올림.

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TOP 10 CAUSES OF DEATH FROM THE ENVIRONMENT

8.5 million out of **13.7 million** deaths caused by the environment are due to noncommunicable diseases

1st
ISCHAEMIC HEART DISEASE
2.4 million

2nd
CHRONIC RESPIRATORY DISEASES
1.9 million

3rd
CANCERS
1.8 million

4th
UNINTENTIONAL INJURIES
1.5 million

5th
RESPIRATORY INFECTIONS
1.5 million

6th
STROKE
1.5 million

7th
DIARRHOEAL DISEASES
829 000

8th
DIABETES
391 000

9th
MALARIA
355 000

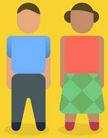
10th
NEONATAL CONDITIONS
244 000

World Health Organization
#EnvironmentalHealth

WHO IS MOST IMPACTED BY THE ENVIRONMENT

Environmental impacts on health are uneven across age and mostly affect the poor.

Low- and middle-income countries bear the greatest share of environmental disease.



Men
are slightly more affected due to occupational risks and injuries.

Women
bear higher exposures to traditional environmental risks such as smoke from cooking with solid fuels or carrying water.

Children under five and adults between 50 and 75 years old are most affected by the environment.

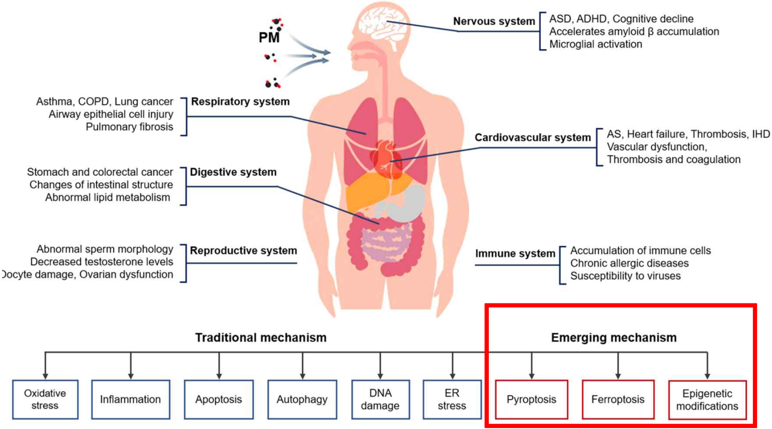
YEARLY

● **5.2 MILLION**
Deaths in adults
between 50 and 75 years. The most common causes are noncommunicable diseases and injuries.

● **1.6 MILLION**
Deaths in children
under five. The most prominent causes are lower respiratory infections and diarrhoeal diseases.

World Health Organization
#EnvironmentalHealth

Ambient PM on the adverse health effects epidemiological and laboratory evidence



PM

Nervous system
- ASD, ADHD, Cognitive decline
- Accelerates amyloid β accumulation
- Microglial activation

Respiratory system
- Asthma, COPD, Lung cancer
- Airway epithelial cell injury
- Pulmonary fibrosis

Cardiovascular system
- AS, Heart failure, Thrombosis, IHD
- Vascular dysfunction,
- Thrombosis and coagulation

Digestive system
- Stomach and colorectal cancer
- Changes of intestinal structure
- Abnormal lipid metabolism

Reproductive system
- Abnormal sperm morphology
- Decreased testosterone levels
- Oocyte damage, Ovarian dysfunction

Immune system
- Accumulation of immune cells
- Chronic allergic diseases
- Susceptibility to viruses

Traditional mechanism
- Oxidative stress
- Inflammation
- Apoptosis
- Autophagy
- DNA damage
- ER stress

Emerging mechanism
- Pyroptosis
- Ferroptosis
- Epigenetic modifications

Particle and Fibre Toxicology. 2022;19:67.

Emerging Mechanisms of PM-induced Lung Injury

Beyond Traditional Oxidative Stress & Inflammation

Pyroptosis

Inflammatory Cell Death

Trigger

PM activates NLRP3 inflammasome via ROS and lysosomal damage

Mechanism

Caspase-1 activation → Gasdermin D pore formation → cell lysis

Key Mediators

IL-1β, IL-18 release amplifies neutrophilic inflammation

Clinical Link

Drives acute airway inflammation in asthma & COPD exacerbations

Ferroptosis

Iron-dependent Cell Death

Trigger

PM-bound iron + ROS overwhelm GPX4 antioxidant defense

Mechanism

Lipid peroxidation cascade → membrane integrity loss → cell death

Key Mediators

Fe^{2+} accumulation, GSH depletion, lipid peroxide buildup

Clinical Link

Implicated in COPD progression, pulmonary fibrosis, and lung cancer

Epigenetic Modification

Heritable Gene Expression Change

Trigger

Chronic PM exposure alters DNA methylation & histone marks

Mechanism

CpG hypermethylation of tumor suppressors; global hypomethylation

Key Mediators

miRNA dysregulation, telomere shortening, histone acetylation changes

Clinical Link

Transgenerational risk: prenatal exposure → childhood asthma & reduced lung growth

Particle and Fibre Toxicology 2022;19:67 | J Clin Invest 2025;135(17):e194312

Air-Liquid Interface (ALI) Culture System

Gold Standard for Airway Epithelial Differentiation | Leach T et al. Sci Rep. 2023;13:10137

What is ALI?

Air (Apical)

Epithelial Cells + Membrane

Media (Basal)

Apical side (top)
Exposed to air, mimicking in vivo airway

Basal side (bottom)
Nutrient supply via culture media

Porous membrane
Cells cultured on Transwell insert

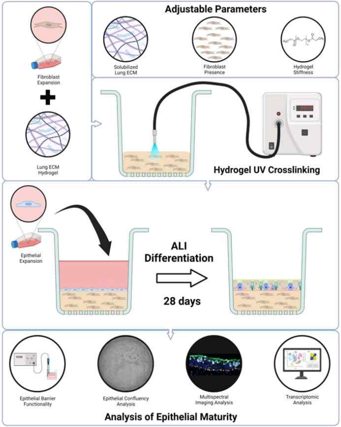
Key Principles of ALI Culture

1. **Pseudostratification**
   Recapitulates multilayered airway epithelial architecture

2. **Mucociliary Differentiation**
   Goblet, ciliated, club, and basal cell maturation

3. **Barrier Function**
   Epithelial integrity confirmed by TEER measurement

4. **Mucus Production**
   MUC5AC/MUC5B secretion and mucociliary clearance



Green Space

Parks, forests, urban vegetation

Health Impacts

▼ All-cause & CV mortality
▼ Respiratory morbidity
▼ Depression, stress & distress
▲ Physical activity & social cohesion
▼ Lung cancer & chronic disease risk

Mechanisms

- Air pollutant reduction (PM2.5, NO2)
- Heat island mitigation
- Noise attenuation
- Immune modulation (biodiversity)
- Stress reduction (cortisol)
- Physical activity promotion

Blue Space

Rivers, lakes, coastal environments

Health Impacts

▼ Psychological stress & anxiety
▲ Mental well-being & life satisfaction
▼ Cardiovascular risk markers
▼ Mortality in coastal populations
▲ Physical activity & recreation

Mechanisms

- Restorative effects (visual-auditory)
- Microclimate cooling
- Social interaction & outdoor activity
- Sleep & circadian regulation

Grey Space

Roads, buildings, concrete, high-rise areas

Health Impacts

▼ Respiratory symptoms & bronchitis
▲ Allergy risk
▼ Microbial diversity exposure
▼ Contact with nature
▲ Risk of stress-related problems

Mechanisms

- Hard-surface urban intensification
- Reduced exposure to natural space
- Separation from soil, plants
- Altered microbial communities
- Disconnection from nature

Conclusion: Green & blue spaces improve health via environmental buffering, stress pathways, immune modulation & behavioral mechanisms

Environ Res. 2024 Mar 15:245:118059.