I D E A L

INDOOR AIR QUALITY HEALTH

Policy Brief

The **IDEAL Cluster** aims at **filling knowledge gaps in the understanding of the impact on our health and well-being of a series of key environmental, occupational and socio-economic risk factors**. The Cluster focuses on indoor air quality (IAQ) and its main pollution sources in indoor settings across Europe.

The Cluster comprises **seven research projects committed to advance scientific knowledge on IAQ, inform policy decisions, and promote better health through healthier indoor environments**. In pursuit of these goals, all projects are guided by the following key principles:

- **Interdisciplinary research**, enabling a holistic understanding of IAQ and its impact on health
- Emphasis on the development of **advanced monitoring systems for IAQ**
- Implementation of a **health impact assessment** approach, through rigorous research, the use of real-life data, and studies on vulnerable groups
- Oriented to **solutions and interventions** with practical use
- Priority to **stakeholder engagement and dissemination** including policymakers, educators, and the public
- Use of **advanced technologies** such as AI algorithms and multi-sensing platforms

Indoor Air Quality and health: Overarching issues

Indoor Air Quality (IAQ) encompasses the air within and surrounding buildings, focusing on the comfort, well-being, and health of occupants

Indoor air pollution has a **significant impact on health.** It is linked with life-threatening chronic conditions such as asthma, chronic obstructive pulmonary disease (COPD), cardiovascular disorders, strokes, and lung cancer. According to WHO, indoor air pollution is responsible for about 3,2 million premature deaths per year globally, with most of them resulting from ischemic heart disease, stroke and lower respiratory infections impacting children.

Elements like smoke, emissions from heating/cooking, as well as certain chemicals such as Volatile Organic Compounds (VOCs) have a proven harmful effect on health. Moreover, **allergens, endotoxins, and mould** present in indoor air are associated with compromised health in both children and adults. Typical short-term symptoms from exposure to indoor air pollution are eye irritation, coughing, wheezing, headaches, and fatigue (see here and here).

The population groups who are particularly vulnerable to indoor air pollution include children, pregnant women, the elderly, people with pre-existing respiratory and cardiovascular diseases, and people from socioeconomically disadvantaged households. Children, for instance, face higher health risks against air pollution as their immune and respiratory systems are still under development. Meanwhile, people within low-income households are more likely to live in inadequately ventilated buildings with higher concentrations of pollutants.

It is important to highlight that the **complete scope of health effects stemming from indoor air pollution remains largely unknown.** Human activities like smoking, burning solid fuels, and cleaning, along with particle emissions from building materials and biological contaminants are often happening simultaneously, leading to a harmful mix and producing synergistic effects. Despite strides in understanding, substantial knowledge gaps persist, hindering a comprehensive grasp of sources, factors, contaminants, and pollutants influencing IAQ.

Complexity is also added by the **intricate interplay between outdoor and indoor air pollution**. While the common belief is that opening a window “refreshes” or “cleans” indoor air, incoming outdoor air may carry significant pollutants. Technologies for **ventilation and infiltration** are, therefore, key to facilitate the exchange of outdoor and indoor air, without pollutants entering home environments[1].

[1] Infiltration refers to a process where outdoor air flows into buildings through openings, joints, and cracks in walls, floors, and ceilings, and around windows and doors.

Relevance for EU policies

The IDEAL Cluster as a compendium of each individual project goal, aims to inform, complement and bring added value in a number of existing EU policies and legislative frameworks that pertain to indoor air quality:

Health

- **Europe's Beating Cancer Plan (European Commission Action Plan, 2021):** Enhancing understanding of the effects of exposures to indoor pollutants that are proven to be carcinogenic, including in workplaces and educational settings.
- **Tobacco Products Directive (2014/40/EU legislation) and revision of Council's 2009 Recommendation on smoke-free environments (upcoming):** Building on existing evidence on the health effects of second-hand smoke from tobacco and novel smoking products in indoor environments, including impact on vulnerable groups such as patients living with allergy and asthma. Contributing to stricter regulation of smoke-free environments at the national level.
- **EU Healthier Together initiative (2021-2027):** Contributing to evidence-based policies and the exchange of best practices in the area of non-communicable diseases, including chronic respiratory/cardiovascular conditions, mental health and diabetes.

Climate

- **EU Climate Adaptation Strategy (European Commission strategy, 2021)**: Contributing to the advancement of mechanisms that mitigate the climate footprint of the building stock, including through pollutants removal and building management systems.
- **Horizon Europe Mission for Climate Neutral and Smart Cities (EU research initiative, 2021-2027):** Several projects addressing urban air quality through pilot studies in various European cities. Cases include industrial zones, traffic-laden urban centres, and cities where people spend long times in transport means.

Chemicals

- **EU Chemicals Strategy for Sustainability (European Commission strategy, 2020):** Several Cluster projects contributing to the overall EU strategy as they aim to identify and mitigate toxic substances, chemicals, pollutants and mixtures thereof at their source and in many different indoor settings, including educational establishments and workplaces.

Environment

- **European Green Deal (European Commission strategy, 2020):** Promoting healthier indoor environments, therefore enhancing overall air quality and public health. Using cutting edge technology for monitoring and removing indoor air pollutants, as well as data management, in line with the Green Deal's emphasis on innovation and digitalisation.
- **Zero Pollution Action Plan (European Commission Action Plan, 2021)**: Cluster projects supporting the Plan's overall vision of reducing all pollution by 2050, generating evidence that will enable defragmentation and contribute to IAQ-specific policy options in the shorter term.
- **EU Ambient Air Quality Directives (2008/50/EC and 2004/107/EC):** Generating data that take stock of the indoor-outdoor air quality interactions and can offer further clarity on the health effects of individual pollutants. Results can contribute to a more comprehensive understanding of ambient air quality, informing future legislative revisions.

Buildings

- **EU Renovations Wave initiative and revised Energy Performance of Buildings Directive (2024/1275/EU):** Cluster projects serving as enablers of energy efficiency in buildings through the development of tools and technologies that enhance the building management capabilities, and putting focus on the importance of ventilation and insulation as key enablers of good IAQ.
- **EU Construction Products Regulation (305/2011/EU):** Expanding knowledge, assessment and monitoring of chemicals and other harmful substances typically involved in construction products such as floorings, wooden panels, paints and adhesives.

Digital

- **EU Data Strategy (European Data Governance Act (2022) and EU AI Act (2024)**: Through the development of digital tools and innovative technological solutions, always in respect with an open science approach and generating data and results in line with the requirements of the EU Data Strategy.

Current situation on IAQ in Europe and beyond: Guidelines, policies, best practices

While there is no cohesive policy framework addressing IAQ at the EU level, it is important to note that the initiatives of the IDEAL Cluster projects do not come at a complete void. IAQ is recognised by the WHO as a critical health determinant of health. Through a series of publications over the last 35 years, WHO has offered guidelines and recommendations to address indoor air pollution both from a general and more specific perspectives. Although not legally binding, they equip WHO member states with evidence-driven tools to shape national legislation and policies.
Several EU Member States, including Austria, Belgium, Finland, France, Germany, Lithuania, the Netherlands and Portugal have taken varied approaches to address IAQ. These include adopted guide values, reference concentrations, and action values, aligning with WHO guidelines. Such measures typically stem from national IAQ plans and dedicated legislative acts for indoor environments. Additionally, there are initiatives for mandatory indoor air monitoring, alongside training programmes targeting technical officers, managers, and staff. Some EU Member States have also introduced specific legislations and reference ISO standards for individual pollutants.

This mosaic of efforts reflects the need and interest of EU Member States to enhance IAQ standards and health protection at national level. Moreover, several standards focusing on indoor air have been agreed at international level within the International Organization for Standardization (ISO). Most of them address standardized sampling methodologies and measurement techniques of specific pollutants, while some of them have been adopted at European level in the frame of the European Committee for Standardization (CEN).

Regarding indoor air quality management, two relevant standards have been published by ISO: Standard 16000-40 "Indoor air — Part 40: Indoor air quality management system" (2019), and Standard 16000-41 "Indoor air — Part 41: Assessment and classification" (2023). Nevertheless, these standards have not been adopted at European level. This circumstance provides each EU Member State with the decision to adopt the ISO standards as national standards, or to develop its own standard related to IAQ management and assessment.

Key policy questions in addressing indoor air pollution

With the EU seeking to develop a more consistent policy approach to address indoor air pollution and the risks associated with it, as part of its Zero Pollution ambition, a set of fundamental questions arise:

- What is the **appropriate legal basis** that would allow the EU to adopt measures for the protection of public health and to facilitate the exchange of best practices across Europe?
- What could be a **commonly acceptable legal definition for indoor air pollution**, integrating person-level activities and external factors? As IAQ is the result of multiple components at different levels, where should the limits between individual-level behaviour and the systemic level be set to define legal limits? Even more importantly, how do the two levels influence each other?
- How to ensure **cohesion with EU policies, strategies and plans currently in place**, such as the Beating Cancer Action Plan, the Zero Pollution targets, the climate goals, and the EU One Health agenda – while also **emphasising the health aspects** in policies around construction products and renovation?
- What can the EU do to **support IAQ innovation** and its strong potential to advance EU competitiveness worldwide, while safeguarding access to all without losing sight of the ultimate goal to protect health and wellbeing of people?
- How can the EU **address the current fragmentation of approaches and tools** around IAQ in the EU, including measurement, exposure assessment and analysis methods?
- How near are people in Europe, both authorities and the public, to the **development of an IAQ culture** that involves taking into consideration and acting on the challenges posed by indoor air pollution? How ready are we to **re-assess the social perception of indoor spaces**, especially in the wake of the COVID-19 pandemic experience?
- How can we ensure **close cooperation among policymakers and stakeholders relevant to IAQ**, including technical specialists, scientists, civil society organisations and public health experts at both the EU and the national level, to reflect on these questions in an inclusive, exhaustive and effective way.

POLICY RECOMMENDATIONS

The EU has a key role in responding to the open questions above. We call for swift action to address the persistent challenges posed by indoor air pollution by:

Establishing a sound legal basis for EU action against indoor air pollution. Article 168 of the Treaty for the Functioning of the EU (TFEU) would be most suitable, linking the heterogeneous and multifaceted challenges posed by indoor air pollution

Adopting a common legal definition for IAQ that considers the complex interplays among the individual level and the external factors involved.

Presenting a cohesive strategic plan for IAQ, connecting the numerous policies relating to indoor air pollution such as renovations, construction, and energy efficiency; aligning it with existing environmental and climate objectives; and integrating it in the unfolding EU Green Deal and One Health agenda.

Facilitating and supporting IAQ innovation that ensures access for all and puts human health and wellbeing at the centre.

Reinforcing the links between existing standards relevant to IAQ in the framework of the European Committee of Standardisation (CEN) and the EU regulations, while developing new standards on IAQ management, exposure assessment and analysis, to ensure a harmonised landscape across the EU.

Conducting a survey on the public perception of indoor spaces and the health impact of indoor air pollution, especially in view of the COVID-19 experience and the potential emergence of an IAQ culture.

THE IDEAL CLUSTER

Variables/data: FAIR data with toxicological characterization & hazard assessment of chemical & biological determinants
Scope:
- Where: Homes
- Who: Children under 5 years old
- What: PM, VOCs, CO2, EDs, plastic additives, PFAS, PAHs etc.

Methodology: Surveys in 8 European countries & Australia; chemical & biological screening techniques; identification of risk drivers & their sources; human biomonitoring
Health outcomes: Better indoor air quality & public health

Variables/data: Physical-chemical & microbiological properties of indoor air pollutants, toxicological data
Scope:
- Where: Residences, schools/kindergartens, offices, administrative & social care buildings
- Who: All age groups
- What: CO2, PM, CO, NO2, O3, TVOCs, PAHs, CH_2O

Methodology: Chemical sampling; evaluation of IAQ sensors; questionnaires.
Health outcomes: Better understanding of IAQ & its impact on health

Variables/data: Measurements of key pollutants & particles, self-reported health data, including respiratory & allergic symptoms, mental health & general well-being
Scope:
- Where: Residencies, workspaces, hospitals, transportation, schools
- Who: All age groups
- What: NO, NO2, CO, CO2, VOC, PM, UFPs

Methodology: Identification & characterisation of pollutants through digital twin technology; individual health measurements & questionnaires; novel health impact assessment methods
Health outcomes: Estimation of total health burden association with IAQ

Variables/data: Real-life data on the synergistic effects of biological & chemical pollutants
Scope:
- Where: Educational settings
- Who: Children, allergy & asthma patients,
- What: Chemical & biological pollutants, including allergens

Methodology: Novel sensing system for atmospheric pollutants in indoor air; establishment of a multi-pollutant realistic setting
Health outcomes: Increased awareness of the impact of IAQ in education

Variables/data: Qualitative & quantitative information concerning health risks & potential adverse effects, standardized Key Performance Indicators (KPIs)

Scope:

- Where: Hospitals, metro stations, markets, retirement homes, residences, university canteens/residences/lecture halls, schools
- Who: High-risk outpatients, workers, children, elderly people
- What: Chemical & biological indoor air pollutants

Methodology: Monitoring and characterisation of IAQ in different scenarios (settings), novel artificial intelligence algorithms and advanced data analysis, real-life scenarios, public health surveillance

Health outcomes: Correlations between IAQ characterisation and its harmful effects on physical and mental health

Variables/data: Measurement of indoor and outdoor air pollutants

Scope:

- Where: Schools
- Who: Children
- What: VOCs, UFPs

Methodology: Evaluate exposure biomarkers & their effect on children's cognition; novel sensors to detect air pollutants; novel filtration-based remediation strategies; in vitro lung & skin models

Health outcomes: Improve children's quality of life by improving IAQ in schools

Variables/data: Data on children's exposure to indoor pollutants & pollutant concentrations

Scope:

- -Where: Schools, homes, sports halls, transport
- -Who: Children at school age
- What: PM, UFPs, bioaerosols, endotoxins, mycotoxins, VOCs

Methodology: Active & passive air sampling, culture-based microbiology of bacteria & fungi, metabarcoding, qPCR, and metagenomics of bacteria and fungi, different methods for chemical analysis, cytotoxicity, novel sensors to detect air pollutants

Health outcomes: Improve IAQ & reduce disease burden

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