Understanding the Exposome: Priorities for Policy and Practice
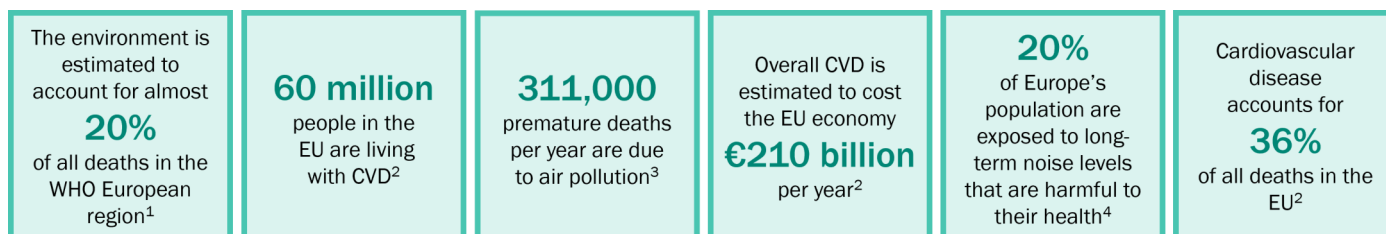
The environment is estimated to account for almost **20%** of all deaths in the WHO European region[1]	**60 million** people in the EU are living with CVD[2]	**311,000** premature deaths per year are due to air pollution[3]	Overall CVD is estimated to cost the EU economy **€210 billion** per year[2]	**20%** of Europe's population are exposed to long-term noise levels that are harmful to their health[4]	Cardiovascular disease accounts for **36%** of all deaths in the EU[2]

Figure 1. Environmental risk factors and cardiovascular disease burden in Europe

Despite medical advances, more than half a billion people around the world are affected by cardiovascular diseases[5]. Efforts continue to focus heavily on treatment, yet many of the risks come from the environment around us. Environmental factors represent a major opportunity to change the course of disease by addressing modifiable risk factors. Pollution, poor diets, limited green space, unsafe housing, and chronic stress all increase cardiovascular risk, especially for people living in difficult circumstances. The problem will not go away on its own, and due to the constant interplay between population health and the environment, the challenges for societies continue to grow. Therefore, we need to shift focus - not only treating illness but preventing it, by addressing what shapes health across our lives: the exposome.

This policy brief draws on insights from the LongITools project to inform policymakers about the exposome and its relevance for preventive, equitable, and effective health policy. It outlines key policy priorities, explains why they matter, and sets out what is needed to better address the environmental and societal factors that shape health across the life-course.

Policy call to action

1 Make the exposome central to health policy

Address factors shaping health across sectors beyond healthcare- including transport, food, housing, and urban planning

2 Apply a life-course approach to policy

Shape prevention and care strategies around key life stages and vulnerabilities

3 Make health and environment data FAIR-ER

Invest in inclusive, interoperable, and population-representative data systems

4 Accelerate research into real-world impact

Test interventions on the ground, adapt, and scale with communities, practitioners and scientists

5 Deliver timely, targeted interventions

Design local, cross-sector solutions that address everyday environmental factors to protect and promote cardiovascular health

6 Act on environmental health inequalities

Prioritise action in communities facing the greatest risks and worst outcomes

What is the exposome?

The exposome is a collective term for the physical, chemical, biological and social influences on our health. This includes the environmental factors we are exposed to throughout life, from the food we eat and the air we breathe to noise, access to green space, social interactions, and lifestyle choices.

The LongITools project used the life-course approach to build an understanding of how exposures - such as air pollution, noise, the built environment, social and economical circumstances, physical activity and diet - interplay over time, supporting better health or contributing to the development of chronic diseases such as cardiovascular diseases, obesity and type 2 diabetes.
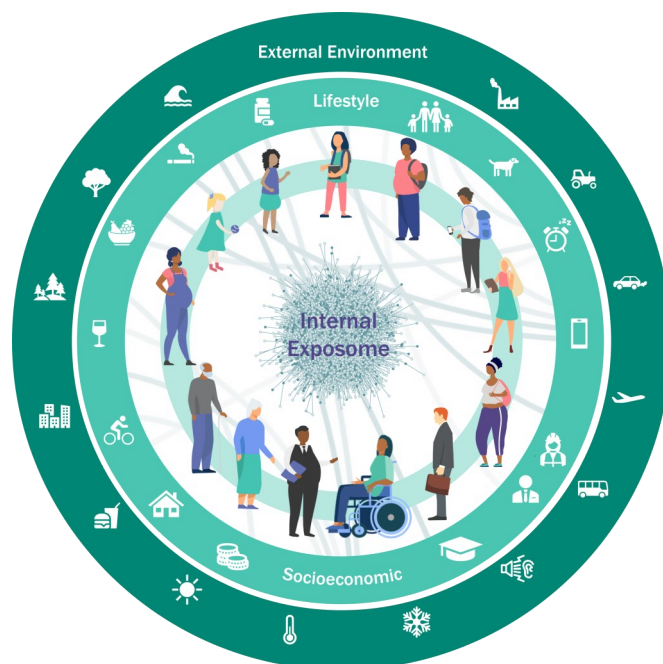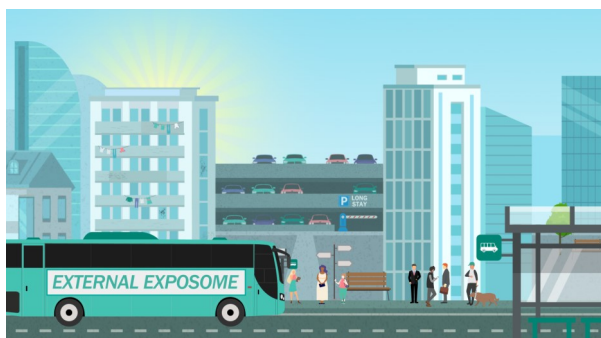

Figure 2. The LongITools exposome

> *Why treat people and send them back to the conditions that made them sick?*
>
> The Health Gap: The Challenge of an Unequal World by Sir Michael Marmott, 2015

Why does it matter for policy?

The exposome approach provides policymakers with a wider view of where and when risks accumulate, and where prevention and intervention may have the greatest impact. It supports more equitable, sustainable, and cost-effective policies that act early across the life-course, encouraging policymakers to look beyond their own sectors.

To fully utilise this approach, policies must be grounded in a broader understanding of health. A narrow biomedical focus on individual behaviour and clinical care often misses the wider context that shape health over time. This limits the scope of policy responses and misses key opportunities for prevention.

A broader understanding of health helps identify root causes, coordinate action across sectors, and design responses that are more inclusive, effective, and aligned with long-term public health goals.

By generating new evidence, LongITools contributes to the European Green Deal's ambition to protect health and wellbeing from pollution and environmental decline and helps shape better preventive strategies for healthier societies.

#1 - Integrate the life-course approach into policies and care

Why it matters?

The life-course approach helps us understand how health is shaped by environmental, social, and lifestyle exposures that accumulate and interact over time. Factors like air quality, diet, and stress can affect us differently depending on when and how we experience them. This approach highlights key windows of opportunity to act, whether by preventing illness early, reducing harm later, or tailoring support to people's needs at different stages of life. Effective policies should address how risks build up over time and provide support for vulnerable groups.

What is missing?

Current policies rarely reflect how exposures accumulate or vary across life stages. Many focus on short-term risks or specific periods only, missing key opportunities for prevention and support. There is limited use of data and tools that capture the complexity, timing, and context of exposures, such as who is most vulnerable, when, and under what conditions. Without considering both the timing of exposures and the social and environmental conditions people live in, policies risk being poorly targeted, less effective, and inequitable.

What did the LongITools project do?

- LongITools used a life-course approach to study how environmental and lifestyle exposures affect health at different stages: early life, adolescence and young adulthood, and later adulthood.

- Researchers developed three complementary exposome models to explore risk factors and potential interventions.

- LongITools created a user-friendly **Exposome Data Analysis Toolbox** to collate and add value to exposome data analysis tools and visualisation methodologies.

- The LongITools website hosts a **Life-Course Publications Map** that links project findings to different life stages, helping users understand what exposures were studied and when.

WHAT IS NEEDED?

- ✓ Design prevention and care strategies across eco-social and life-course dimensions, ensuring they reflect diverse exposures, life stages, and living conditions.

- ✓ Promote cross-sector collaboration and develop policies in synergy to avoid contradictions between public health goals and decisions in other sectors, such as transport, food, housing and urban planning.
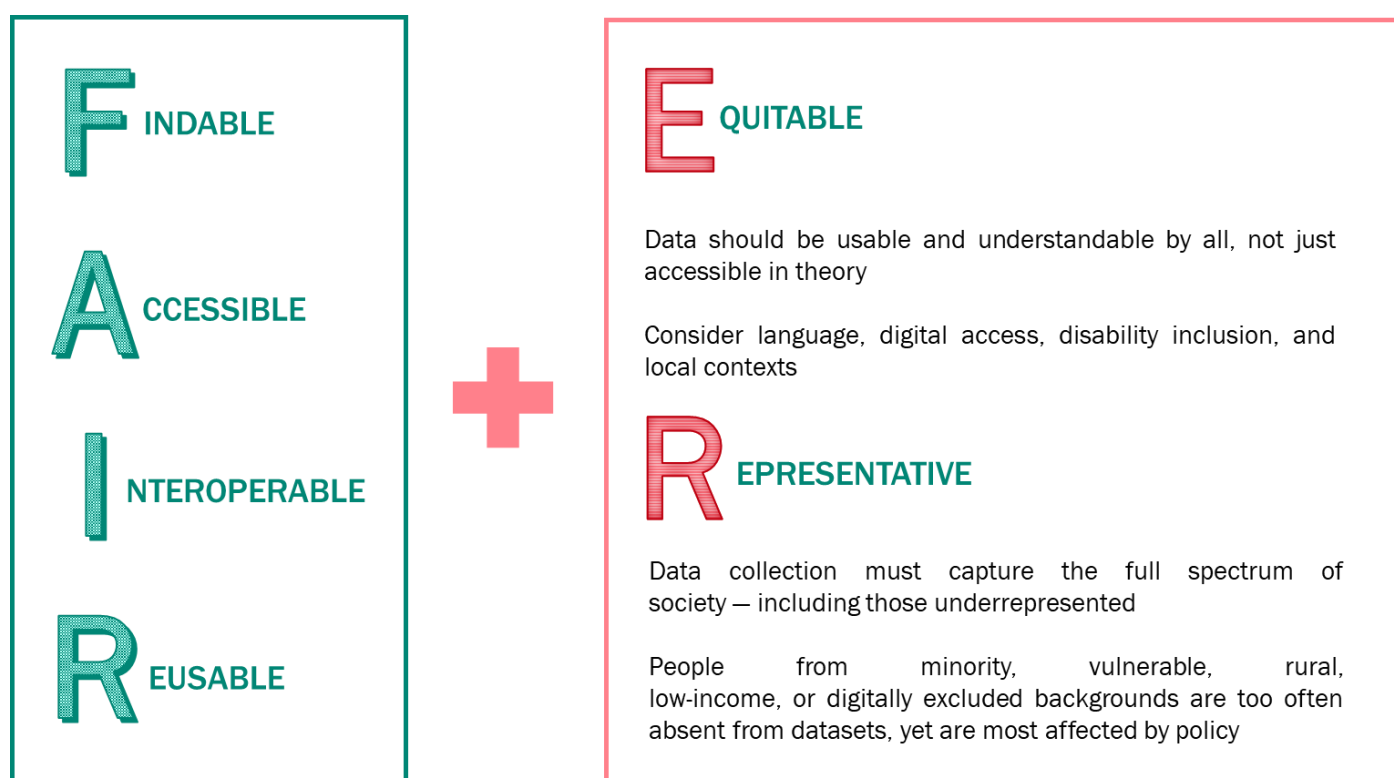
#2 Improve data systems to make them FAIR-ER

F INDABLE

A CCESSIBLE

I NTEROPERABLE

R EUSABLE

+

E QUITABLE

Data should be usable and understandable by all, not just accessible in theory

Consider language, digital access, disability inclusion, and local contexts

R EPRESENTATIVE

Data collection must capture the full spectrum of society — including those underrepresented

People from minority, vulnerable, rural, low-income, or digitally excluded backgrounds are too often absent from datasets, yet are most affected by policy

Figure 3. LongITools proposed extension of the FAIR principles

Why it matters?

Many existing health and environmental datasets have an overrepresentation of northern and western European ancestry. This results in limited representativeness, excluding groups most affected by poor health and environmental exposures, such as migrants, minority communities, and those with lower incomes or limited digital access.

Even when data exists, it often lacks the necessary level of detail to reflect individual exposure differences, lived experiences, or socioeconomic conditions, particularly in rural or underserved settings. In addition, combining data across studies, countries, or systems remains technically and legally challenging, limiting the ability to generate comprehensive, cross-sector insights that inform equitable policy.

What is missing?

- Personalised environmental data remains limited, as most data is collected at group or area level, which can miss important differences in individual exposure and daily lived experience.

- Rural areas remain underrepresented in data collection, leading to gaps in understanding and addressing the needs of non-urban populations.

- Socioeconomic conditions at both individual and neighbourhood levels are not consistently captured.

- National health surveys rarely include detailed environmental data.

- Data from different sources often cannot be easily combined, limiting comprehensive analysis across systems and sectors.

- Much of the data already collected remains unused or inaccessible due to legal, technical, or institutional barriers.

What did LongITools do?

LongITools developed a free, open-source Metadata Catalogue within the European Health Research Data and Sample Catalogue. It brings together harmonised data from diverse datasets and allows researchers to explore variables and determine the suitability of the data to answer specific research questions. The catalogue is available for reuse by other projects, and access to underlying data is managed securely through platforms such as DataSHIELD.

LongITools researchers also developed a prototype of a personalised Health Risk Assessment System to estimate individual risk of cardiovascular and metabolic diseases using smartphone data, wearables, environmental sensors, and an artificial intelligence (AI) model.
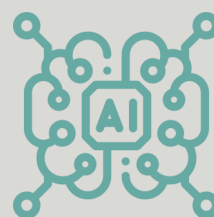
RESPONSIBLE AI STARTS WITH INCLUSIVE DATA

As AI becomes more central to health research, its effectiveness depends on the quality and inclusivity of the data it learns from. Initiatives like FUTURE-AI are setting standards for responsible AI in medicine, grounded in six core principles: Fairness, Universality, Traceability, Usability, Robustness, and Explainability. These principles align closely with efforts to make health data FAIRER. Ensuring that AI systems are designed and tested using diverse, representative datasets is crucial for advancing reliable technologies that respond to real-world needs.

WHAT IS NEEDED?

✓ Support research efforts on effective strategies to recruit, engage, and retain underrepresented populations in studies, recognising the barriers that often limit their participation.

✓ Ensure methods and measurement tools are relevant and appropriate for underrepresented groups. For example, dietary surveys should be adapted to capture foods commonly consumed in different cultural or socioeconomic contexts.

✓ Ensure digital tools and platforms are accessible across languages and literacy levels.

✓ Strengthen systems for more granular, frequent, and local environmental monitoring to improve the relevance and timeliness of data.

✓ Improve collection of personalised environmental data through questionnaires and precise tools to capture individual exposure differences, supporting tailored care while ensuring privacy is protected. Develop clear, consistent legal frameworks to enable ethical, cross-border data sharing.

✓ Invest in digital infrastructure to support secure, large-scale and inclusive data analysis.

✓ Promote trustworthy and ethical AI in health research, ensuring systems are transparent, fair, and inclusive.

#3 - Implement timely and targeted interventions

Why it matters?

Even when evidence is still evolving, we have a responsibility to share knowledge and act in ways that improve health and reduce harm. The cost of inaction is high for people and the environment. Testing interventions in real-world settings, learning from each step, and adapting policies accordingly are essential to building healthier environments and more resilient systems, while continuously strengthening the evidence base.

What is missing?

Current interventions rarely reflect the different needs people face at different life stages or in different social and environmental contexts. There is also limited integration between health and environmental sectors, and too few mechanisms to monitor what works, where, and for whom. This gap reduces the effectiveness, equity, and impact of public health interventions.
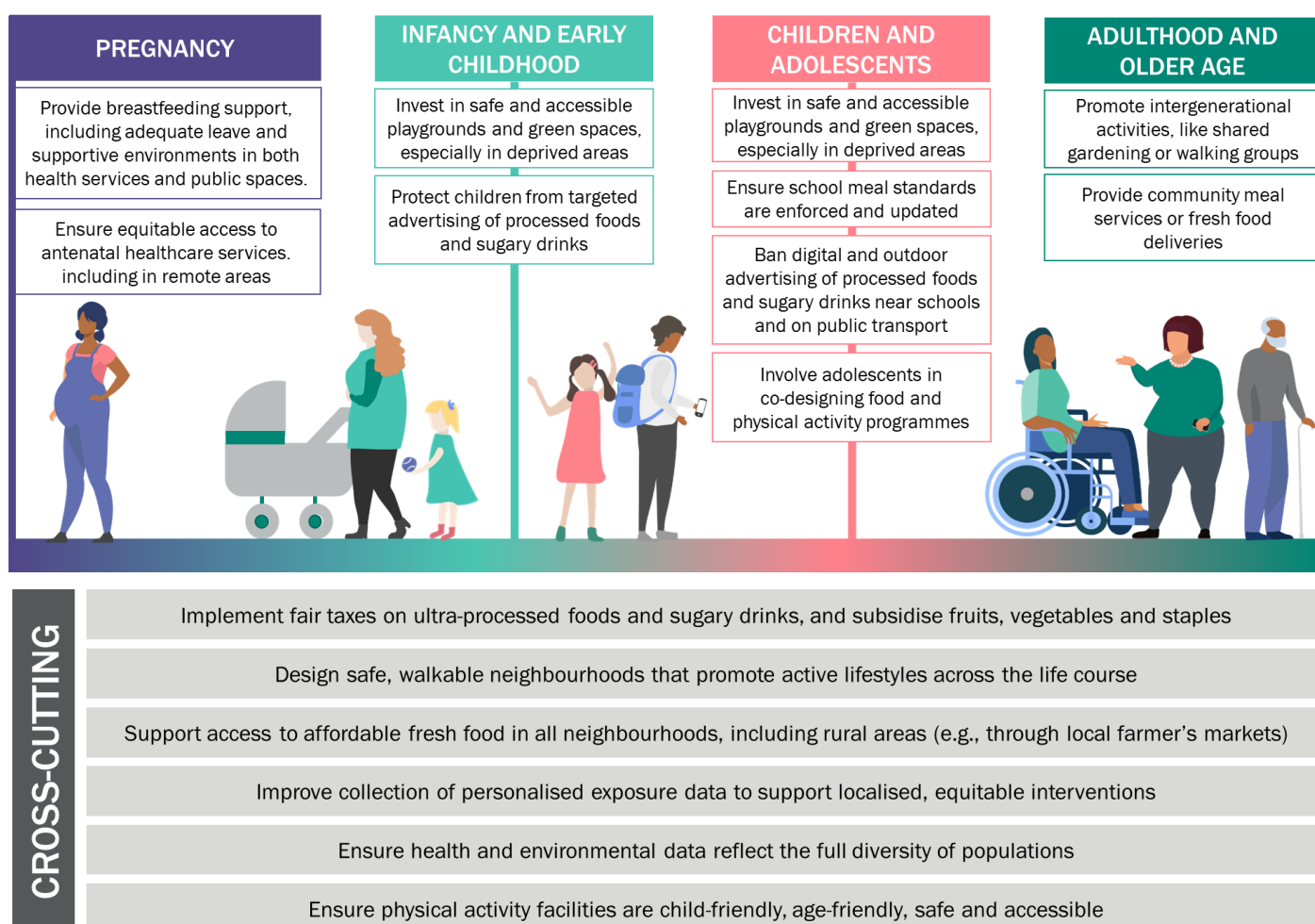
What did the LongITools project do?

Over the past five and a half years, the LongITools project generated scientific evidence, providing novel, policy-relevant insights into how various environmental exposures affect health across the life-course. Key findings include:

- **Air pollution has been linked to a range of health risks at every age**[6,7]. PM2.5 exposure was associated with higher blood pressure, changes in how the body processes energy and fat, and symptoms of depression, even at levels within legal limits – though findings vary across studies.

- **Diet could help reduce the harmful effects of pollution**[8]. Healthier eating patterns were linked to fewer negative effects from air pollution, supporting the case for integrated food and environmental policies.

- **Access to green space supports mental and respiratory health**[6,9]. Adolescents and adults living in greener areas reported fewer symptoms of depression, while children had better lung function when raised in greener neighbourhoods.

- **Noise exposure has been linked to mental health risks**[10]. Living near road traffic noise above recommended levels was associated with increased risk of depression and anxiety from adolescence into adulthood.

- **Context and inequality influence health outcomes**[11]. Cardiovascular and metabolic disease risks seem to be influenced by social and lifestyle factors. People with lower education, insecure employment, and other vulnerabilities face greater health risks, highlighting the need to address social inequality in prevention strategies.

- **Obesity risk begins early and builds over time**[12]. Adult body weight has been linked to early growth and health patterns, starting before birth. These findings support the need for early-life monitoring and action throughout childhood to reduce long-term risk.

WHAT IS NEEDED?

- ✓ Invest in local interventions that address the real conditions people live in, including air quality, green space, food access, and transport.

- ✓ Engage communities in co-designing solutions, making sure interventions are grounded in lived experience and adapted to local needs.

- ✓ Prioritise equity in interventions by designing solutions that meet the needs of different age groups and communities, especially those at greatest risk.

- ✓ Coordinate policies across sectors, such as health, environment, transport, housing, and food, to address the combined impact of environmental and social conditions on health.

- ✓ Ensure collaboration with researchers to support knowledge exchange, align research with policy priorities, and make better use of existing health surveillance data, such as routine child health monitoring.

Example: Obesity prevention across the life-course

PREGNANCY

Provide breastfeeding support, including adequate leave and supportive environments in both health services and public spaces.

Ensure equitable access to antenatal healthcare services. including in remote areas

INFANCY AND EARLY CHILDHOOD

Invest in safe and accessible playgrounds and green spaces, especially in deprived areas

Protect children from targeted advertising of processed foods and sugary drinks

CHILDREN AND ADOLESCENTS

Invest in safe and accessible playgrounds and green spaces, especially in deprived areas

Ensure school meal standards are enforced and updated

Ban digital and outdoor advertising of processed foods and sugary drinks near schools and on public transport

Involve adolescents in co-designing food and physical activity programmes

ADULTHOOD AND OLDER AGE

Promote intergenerational activities, like shared gardening or walking groups

Provide community meal services or fresh food deliveries

CROSS-CUTTING

Implement fair taxes on ultra-processed foods and sugary drinks, and subsidise fruits, vegetables and staples

Design safe, walkable neighbourhoods that promote active lifestyles across the life course

Support access to affordable fresh food in all neighbourhoods, including rural areas (e.g., through local farmer's markets)

Improve collection of personalised exposure data to support localised, equitable interventions

Ensure health and environmental data reflect the full diversity of populations

Ensure physical activity facilities are child-friendly, age-friendly, safe and accessible

The way forward

LongITools has strengthened the evidence that our physical, social, and built environments play a critical role in shaping health across the life-course. This briefing highlights the importance of acting early, focusing on prevention, and designing policies that reflect everyday realities.

To reduce the burden of cardiovascular and metabolic disease, policymakers must make the exposome central to prevention strategies, act across life stages, and address the environments in which people live, learn, work, and age.

This means moving beyond healthcare - tackling pollution, food systems, and urban design; investing in FAIR-ER data; and working with communities to co-create local solutions. Improving health requires improving the environments around us - guided by a deeper understanding of the exposome.

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