PEAK Urban

Safeguarding human health during urbanisation:

The vital role for policies regulating air and noise pollution in developing countries

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Rapid global urbanisation and industrialisation are generating air and noise pollution that threatens human health. Research shows road traffic noise has been linked with cardiovascular disease and its risk factors, including high blood pressure, diabetes and obesity, while air pollutants are shown to cause and exacerbate cardiovascular and respiratory disease.

Air pollutants also drive climate change, which increases respiratory disease, both via the direct effects of global warming and the associated changing weather patterns. In turn, climate change raises levels of airborne allergens such as pollen, which interact with air pollutants in complex ways, exacerbating respiratory allergic responses and reducing lung function.

But these impacts are not inevitable. By promptly adopting effective, evidence-based policies to protect air quality and manage noise levels, governments can mitigate, or even prevent, the harmful effects of pollution, climate change and noise on human health as their countries develop.

Without policy intervention, rapid urban development causes disease

Rapid global urbanisation and industrialisation generate air and noise pollution that threatens human health. Air pollutants cause and exacerbate cardiovascular and respiratory disease, and drive climate change, which in turn harms human health. Road traffic noise has been linked with cardiovascular disease and its risk factors, including high blood pressure, diabetes and obesity.

But these impacts are not inevitable. Governments can mitigate the harmful effects of pollution and climate change on human health by timely implementation of effective, evidence-based policies to protect air quality and manage noise levels in parallel with industrial development.

Key results: regulation and monitoring to protect population health

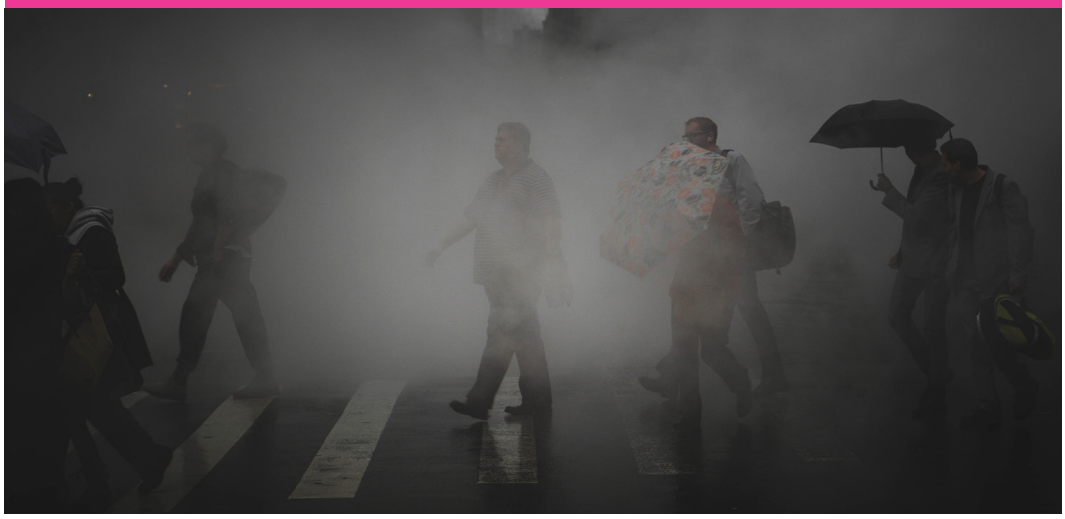
• The steep ongoing rise in global urbanisation and industrialisation means the preservation of good air quality and healthy living spaces is an important challenge for governments.

• Long-term exposure to both outdoor and indoor air pollution negatively affects human respiratory health, while exposure to road traffic noise has been linked to increased blood pressure and obesity, precursors to cardiovascular and many other diseases.

• Complex interactions between air pollutants and airborne allergens such as pollen exacerbate respiratory allergic responses and reduce lung function.

• Climate change causes or exacerbates respiratory disease, both via the direct effects of global warming and the associated changing weather patterns, and by increasing levels of airborne allergens.

• By promptly adopting effective, evidence-based policies to protect air quality and manage noise levels, governments can mitigate, or even prevent, the harmful effects of pollution, climate change and noise on human health as their countries develop.



Understanding widespread health risks as countries urbanise and industrialise

More than 90 per cent of the global population now lives with air quality below World Health Organisation (WHO) recommendations. Undergoing intense urbanisation, low- and middle-income countries (LMICs) are especially affected, accounting in 2015 for 89 per cent of deaths due to air pollution.

Substantial research shows the harmful impact of urbanisation and industrial development on respiratory health. Airborne pollutants such as toxic gases and heavy-metal particulates increase people's susceptibility to respiratory infections, allergic reactions and risk of developing chronic respiratory diseases. Children are particularly vulnerable, due to their immature lungs and immune systems.

Noise associated with increased road traffic is also thought to undermine human health, through hormone disruption which may contribute to a wide range of risk factors for many life-threatening conditions.

Given the steep ongoing rise in global urbanisation and industrialisation, the preservation of good air quality and living spaces is a significant challenge for governments. This rapid development demands focused and informed policymaking if urban environments are to sustain healthy populations. However, many LMICs currently lack adequate policy regulations and implementation systems.

This brief illustrates the harmful impact of air and noise pollution on cardiovascular and respiratory health. Drawing on several recent original and review studies, it highlights the need for robust policies in developing countries to ensure air quality and noise levels that support a healthy population:

1. A review summarising the latest research on the effects of air pollution and climate change on asthma and allergic rhinitis – conditions increasingly prevalent with growing urbanisation.

2. The first multi-country study of the relationship between particulates and coughs or acute lower respiratory infection in children under five in Sub-Saharan Africa.

3. The largest study to investigate the effect of source-specific particulates in each trimester of pregnancy, as well as in infancy and childhood, to identify potential periods of susceptibility during lung development and growth.

4. A commentary examining how interaction between urban air pollution and pollen – each independently linked to poor respiratory health – affects children's lung capacity.

5. The largest study to date examining the associations between road traffic noise and obesity and blood pressure, including a meta-analysis of previous research on noise exposure and cardiovascular mortality.

These studies indicate the need for governments to adopt strong policy responses that counter threats to air quality and the urban environment from industrialisation and urbanisation. They highlight the complexity of interaction between pollutants, allergens and climate change, and the need for further research and monitoring to ensure polices are optimally designed to protect human health.

Key findings

1. Numerous studies demonstrate that long-term exposure to outdoor air pollution negatively affects respiratory health among children, while evidence suggests exposure to traffic noise increases cardiovascular risk in the general population

Many studies have reported harmful effects of exposure to outdoor air pollution, in both short- and long-term timeframes, on respiratory health in children. A recent meta-analysis of studies published between 1999 and 2016 also showed an association between traffic pollution and childhood asthma, while other studies associated both pre-natal and post-natal exposure to traffic pollutants with reduced lung function growth throughout childhood. In LMICs, acute lower respiratory infection (ALRI) is a leading risk for mortality in children under five years old, while recent evidence in higher-income countries shows a link between air pollution, even at relatively low levels, and clinically confirmed ALRI cases among very young children.

Vulnerability in early life

The study investigating associations between particulate exposure and respiratory health in children under five across Sub-Saharan Africa found positive associations for both cough and ALRI in countries ranked medium to high on the Human Development Index. Researchers drew on satellite measurements to derive air quality, based on levels of fine particulate matter (PM2.5) for each survey area across 21 countries. Through the Demographic and Health Surveys Program, they then assessed the prevalence of cough in more than 368,000 children and acute respiratory infections in 109,000 children, finding significant variations across countries in the associations between pollution and respiratory illness.

The annual average concentration of particulate matter across the survey areas ranged from 8.5 to 79 micrograms per metre cubed (µg/m3), with West African countries having a substantially higher annual average concentration (53.4µg/m3) than the rest of Sub-Saharan Africa (16.9µg/m3). There was no overall association between children's exposure to fine particulates and either cough or respiratory infection, but in some countries, the association with cough was positive and statistically significant. This highlights the complexity of studying the health impacts of air pollution in a vast geographical region with diverse demographic and socioeconomic contexts. As the region urbanises rapidly, air quality may potentially worsen, meaning future analyses are urgently needed, using better data on particulate exposure and more accurate assessment of health outcomes.

Studying a large population-based research group in the UK, researchers also found that particulate exposures during pregnancy and early life were associated with reduced lung function by the time a child reaches the age of eight. However, this work and previous studies did not consistently identify a stage of pregnancy or early life that is particularly susceptible to the effects of road-traffic air pollution on the developing lung. This implies that it is important for public health policies to reduce exposures to road-traffic air pollution throughout pregnancy and early childhood.

Although evidence remains to be established in most LMICs, current findings support stringent policies for controlling road traffic-related air pollution to protect the respiratory health of children. This can deliver long-term benefits for lung health throughout a child's life.

New evidence for noise management

In the past decade, evidence has emerged to suggest that traffic noise pollution is an important public health problem affecting children, adults and elderly people. As a non-specific psychological and physiological stressor, exposure to long-term noise pollution has been linked to a range of non-auditory health outcomes, including cardiovascular diseases, metabolic disorders, cognitive dysfunction, poor sleep and mental health. In EU countries, at least 20 per cent of the population lives in areas where traffic noise levels are severe enough to damage health. Increasing numbers of studies also show that populations living in rapidly developing cities in LMICs are exposed to dangerously high levels of noise in daily life.

Pooling data from nearly 500,000 people in the UK, the Netherlands and Norway, researchers found varied associations between road traffic noise and obesity in the largest study to date. Traffic noise is believed to result in over-production of stress hormones linked to increased obesity. The largest group, drawn from the UK Biobank, showed positive associations between long-term exposure to road noise and obesity, although these effects were slightly diminished when data was adjusted for an area's particulate pollution or socio-economic status. In Norway, associations between noise and obesity were positive, but in the Netherlands, the study found no associations. Future studies on the relationship between traffic noise and obesity are needed, covering more geographical regions and populations, and the possible role of air pollution.

Also in the UK Biobank, researchers reported that compared to populations exposed to a road noise level within the current WHO guidelines of 55 decibels, those exposed to levels above 65 decibels – living next to a busy main road – showed small but significant increases in blood pressure, fats and glucose. Although the findings were based on comparisons of different groups at one particular time, this largest study provided important insights into the potential biological mechanisms underlying the adverse impacts of road traffic noise on heart health.

A recent review and meta-analysis has further contributed to the current knowledge base. By examining evidence from the past two decades, researchers quantified the relationships among traffic noise exposures and a range of mortality outcomes. Importantly, the review reports a 3 per cent increased risk of mortality from heart disease for every higher 10 decibels in road traffic noise, updating findings from a 2018 WHO review. It also confirmed findings in the WHO review that the noise threshold for health impacts on cardiovascular disease is around 53 decibels, according to current evidence, providing important evidence for policies that target noise management.

2. Indoor air pollutants, including chemical elements, volatile organic compounds and allergens, harm respiratory health in both residential and non-residential settings

The research into the potential effects of air pollution on allergic rhinitis and asthma identifies nitrogen dioxide, carbon monoxide and volatile organic compounds (such as formaldehyde) as among the leading indoor pollutants. Nitrogen dioxide is mainly generated by gas-fuelled cooking and heating appliances, with numerous studies reporting its harmful impact on asthma in children.

Solid fuels such as coal are widely used for cooking and heating in developing countries. Exposure to their smoke has been linked to several respiratory conditions in both adults and children, although there is little robust evidence that it causes asthma. Indoor allergens from pet fur, moulds and dust mites commonly trigger respiratory allergies, while dampness can lead to mould or cockroach

colonisation and subsequent allergic reactions or inflammation of the airways. Indoor air quality in non-residential buildings such as schools has also been shown to impact children's respiratory health, via concentrations of particulates, volatile organic compounds, carbon dioxide and mould. Air inside schools in urban or industrial areas also contains significantly higher concentrations of outdoor pollutants compared to rural areas, further undermining the quality of indoor air.

Tobacco smoke is the highest-profile indoor air pollutant, containing 4,500 toxic chemical compounds, including particulate matter, oxidative gases, heavy metals and at least 50 carcinogens. Non-smokers who inhale the fumes second-hand in households, workplaces or leisure venues face significant health risks as a result, including lung cancer, increased respiratory infection, heart disease and stroke.

3. Interaction between air pollution and pollen increases the impact of plant allergens on respiratory health, but further research is needed into the clinical effects of these interactions

Recent studies into the effect of nearby green areas on respiratory health have yielded inconsistent results, possibly due to the complex interactions between global warming, vegetation and air pollution. Some indicate a beneficial impact of nature on general health, while others suggest an increased risk of wheezing, asthma and allergic rhinitis in children exposed to green spaces, especially coniferous trees.

Air pollutants interact with plants and fungi to potentially enhance the production and allergenicity of pollen and spores. Ragweed in an urban area with high carbon dioxide levels was found to produce more pollen than ragweed in rural areas. Pollutants can also promote the release of allergens via direct cell damage. A study showed that birch trees exposed to higher concentrations of ozone produced more allergen per pollen grain, with higher potency, than ozone-free trees. Pollutants can also cause chemical changes in allergens that increase their effect on immune cells. Several studies have shown that fungal spores and pollen exposed to nitric acid provoke increased immune responses when inhaled, although the clinical significance remains unclear.

The research into whether exposure to both air pollution and pollen affects lung function in children found that those with simultaneous exposure to both had notably lower lung capacity than those with low simultaneous exposure. Drawing on daily air quality and pollen data for Paris, France, researchers grouped more than 1,000 children based on their exposure to each. Children with moderate exposure to grass pollen and low exposure to air pollution also had significantly lower lung function than children in the group with low exposure to both, while those with high pollutant exposure but low pollen exposure had higher levels of airway inflammation.

4. Climate change causes or exacerbates respiratory diseases, both via the direct effects of global warming on the airways and by increasing levels of airborne allergens

Studies show beyond doubt that climate change causes or exacerbates respiratory diseases. Higher temperatures and more frequent heatwaves make respiratory conditions more severe, usually in relation to local air pollution. Besides the direct effects of global warming on the airways, climate change alters levels of airborne allergens, affecting respiratory health. In North America, human-caused climate change is shown to

have lengthened the pollen season by 20 days and increased pollen concentrations by 21 per cent between 1990 and 2018.

Climate change also causes intensive rain and flooding, which can result in household dampness and mould, reducing indoor air quality. Extreme climate events also drive phenomena such as high numbers of people experiencing asthma symptoms during the initial 20-30 minutes of large-scale thunderstorms, due to a sudden mass release of airborne allergens.

Unlike pollutants, which alter pollen's chemical structure, climate change affects pollen and fungal spores by increasing their availability. Global warming affects local vegetation patterns, leading to increases in airborne pollen concentrations and changes in plant distribution (and probably that of fungi, although this remains to be investigated). The seasonality and severity of allergic rhinitis and asthma are affected by the growth patterns of allergenic species, which can interact with air pollutants to cause and aggravate respiratory disease.

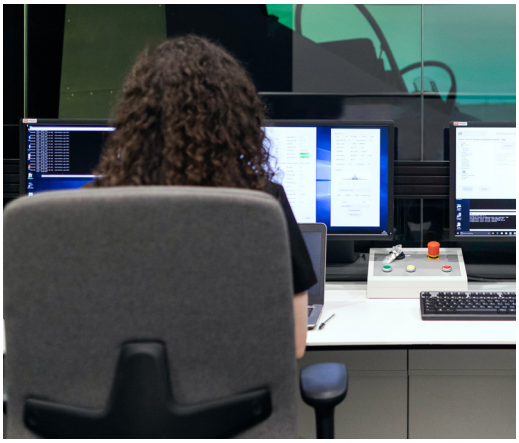
Policy insights

1. Countries should adopt and enforce robust, evidence-based policies and innovative solutions that protect air quality and ensure urbanisation and industrial development support human health

Governments can mitigate the harmful effects of pollution and climate change on human health by timely implementation of effective, evidence-based regulation. The review of studies into the effects of air pollution on respiratory health highlighted that policy changes are the most effective way to decrease air pollution. Interventions aimed at people's lifestyle behaviours are often difficult and ineffective, meaning there is need to strengthen environmental policy to promote healthy urban development. Without such policies, industrialisation and urbanisation will mean inevitable deterioration in air quality, living spaces and human health.

To safeguard public health, countries should seek to establish or continue to invest in a detailed air-quality monitoring network using innovative technologies. This is particularly important for many LMICs where such networks are still in their infancy. This would provide data vital for both policymaking and future scientific research into the concentration, distribution and toxicity of outdoor air pollution, and its impact on health.

With traffic-related air pollution becoming a major health concern in developing countries, governments should follow international guidelines, in stages, to set and enforce emissions standards. These are often either completely lacking or poorly enforced. Established evidence shows that diesel exhaust from traffic is particularly harmful for a range of childhood respiratory diseases, yet many developing countries still widely import second-hand diesel vehicles, which are often poorly maintained.



In the past decade, the evidence base has been strengthened for policymaking to control noise as a harmful public health risk factor. It is vital that governments and funders across LMICs promote multidisciplinary research into the health effects of different sources of noise, including road, air and rail transport, as well as construction, machinery and

wind turbines. Evidence from this research will be essential to inform policymaking that mitigates health impacts from noise. Using evidence readily available from higher-income countries and guidelines published by the WHO, governments in LMICs should strengthen environmental policy to promote a healthy built environment across every neighbourhood, including reduced exposure to traffic noise, in order to maximise public physical and mental health.

2. Often overlooked, indoor air pollution is a key factor in respiratory health, warranting strong regulation and awareness raising to protect air quality in residential and non-residential settings

While actions by individual citizens can mitigate air pollution only to a small extent, policy interventions can lead to larger lifestyle changes across the population. Government measures have been highly effective at decreasing levels of air pollution-related diseases – most notably, restrictions on tobacco smoking in public places. Many countries have implemented smoking bans to protect the population, particularly children, in public areas. Studies show that enforcement of smoke-free policies is significantly associated with reductions in hospital admissions among children due to asthma and lower respiratory tract infections. These associations tended to be stronger in regions with more comprehensive anti-smoking laws, indicating that more stringent policies deliver maximum health benefits.

Further policy changes could help reduce concentrations of other harmful components such as nitrogen dioxide and volatile organic compounds in air breathed indoors, and minimise their effects on respiratory health. Such policies could include building standards and regulations on insulation and ventilation. Governments should also raise awareness of indoor air quality, and encourage and support people to take measures to improve it, such as adequate ventilation, air filters and damp control.

3. City development plans should include green spaces containing diverse, non-allergenic plant species, and pollen monitoring systems to help build understanding of interactions between pollen and air pollution

In view of the Covid-19 pandemic, many cities are now considering greening projects aimed at supporting residents' mental and physical health. However, the complex interactions between plant allergens and pollutants need to be better understood as a basis for sound policymaking around respiratory health in relation to air quality. Studies show the capacity of outdoor pollutants to increase the potency of airborne plant and fungal allergens, but current evidence is inconsistent on the effect of interactions between air pollution and pollen on respiratory health. Until future research clarifies understanding of these effects, it is reasonable that city development plans include green spaces containing diverse, non-allergenic plant species.

In light of the long-term health impacts from climate change, governments should invest in urban pollen monitoring systems, to help mitigate adverse health impacts on particularly vulnerable populations such as people with asthma, and to understand the impact on health of interaction between pollen and air pollution. Most existing research is based on a daily average pollen count derived from only one monitoring station. Investment in large-scale studies of long-term exposure to pollen and pollution on public health is needed, based on accurate detail about pollen types, distribution and allergenic load – variable by season, weather conditions and precise location. In the meantime, governments can use tools such as air quality alerts and pollen calendars to help people control symptoms by planning their outdoor activities.

4. Climate change plays a vital role in air quality and requires policy interventions both for its direct effect on respiratory health and its effects on plant life and natural phenomena which provoke respiratory conditions

Governments worldwide must take firm, immediate action to prevent climate-driven trends in pollen, air pollutants and temperature from exacerbating respiratory health conditions. Policies should include the complete replacement of fossil fuels by renewable energy sources and a shift to sustainable transport, including clean public transport services, incentives for electric vehicle ownership, and cycling and walking. Policies should also seek to limit air traffic, increase the use of recyclable materials and reduce industrialised livestock farming, to cut the greenhouse gas emissions that drive climate change and its effects on health worldwide.

As countries urbanise and develop, governments can protect their people's health from associated risks by taking prompt, innovative action to limit air pollution, traffic noise and climate change.

Further reading

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About us

The PEAK Urban programme aims to aid decision-making on urban futures by:

1. Generating new research grounded in the logic of urban complexity;

2. Fostering the next generation of leaders that draw on different perspectives and backgrounds to address the greatest urban challenges of the 21st century;

3. Growing the capacity of cities to understand and plan their own futures.

In PEAK Urban, cities are recognised as complex, evolving systems that are characterised by their propensity for innovation and change. Big data and mathematical models will be combined with insights from the social sciences and humanities to analyse three key arenas of metropolitan intervention: city morphologies (built forms and infrastructures) and resilience; city flux (mobility and dynamics) and technological change; as well as health and wellbeing.

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Published by PEAK Urban

March 2022

PEAK Urban is managed by the Centre on Migration, Policy and Society (COMPAS)

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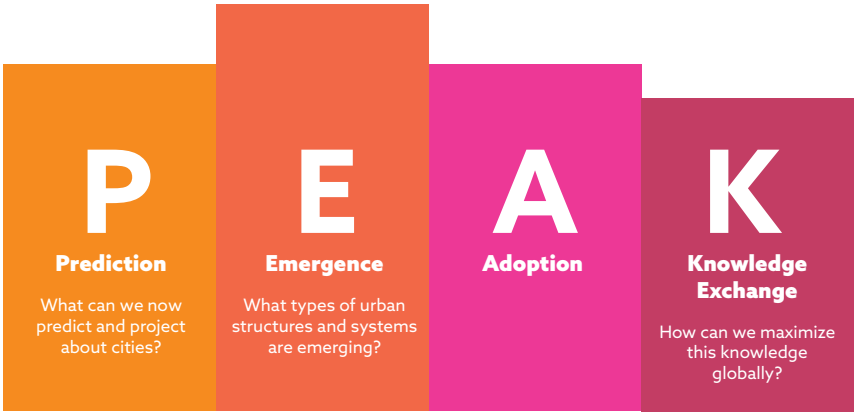
Our framework



The PEAK Urban programme uses a framework with four inter-related components to guide its work.

First, the sciences of **Prediction** are employed to understand how cities evolve using data from often unconventional sources.

Second, **Emergence** captures the essence of the outcome from the confluence of dynamics, peoples, interests and tools that characterise cities, which lead to change.

Third, **Adoption** signals to the choices made by states, citizens and companies, given the specificities of their places, their resources and the interplay of urban dynamics, resulting in changing local power and influencing dynamics.

Finally, the **Knowledge** component accounts for the way in which knowledge is exchanged or shared and how it shapes the future of the city.

PEAK Urban is funded by UK Research and Innovation as part of the Global Challenges Research Fund.

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