1. Protect and improve people's health

1.1 Protect people from air pollution by maintaining healthy indoor air quality, and improve air quality at building, community and wider scale

State of health

"9 out of 10 people worldwide breathe polluted air" (World Health Organization[1])

Air pollution is considered today as the greatest environmental threat to human health, causing approximately seven million deaths each year[2]. Exposure to polluted air increases mortality risk to people from stroke, heart disease, pulmonary disease, lung cancer and respiratory infections[3]. Our buildings and cities across the world both expose people to indoor air pollution and contribute to the ambient (outdoor) pollution crisis. Both pollution sources have distinct causes across the building lifecycle and must be tackled accordingly to protect human health and wellbeing.

Indoor Air Quality

Studies suggest people spend 90% of their time indoors[4]. Therefore, exposure to pollutants within the home and other indoor environments can be highly damaging to human health and worsened in sealed or contained indoor environments with reduced air flow. The primary causes of indoor air pollution that pose risk to human health are as follows;

- Household air pollution from solid fuel combustion**:** 3.8 million premature deaths are attributed to household air pollution annually[5], primarily due to the use of solid fuels and kerosene which creates toxic particulate matter through combustion. Primarily an issue in developing nations, where alternative sources of fuel can be scarce, the World Health Organization estimates that around 3 billion people worldwide lack access to clean or modern energy services for cooking[6]. Exposure to particulate matter can cause cardiovascular and respiratory disease and strokes[7].

- Household air pollution from gas appliances: gas stoves are used by millions worldwide for heating and cooking, and often considered the 'clean and safe' upgrade from solid fuel combustion. However research shows that pollutants released from gas appliances can lead to heightened nitrogen dioxide levels, which can worsen respiratory conditions such as asthma[8]. Combustion of gas within buildings is also a cause of greenhouse gas emissions, worsening climate change.

- Release of harmful gases and chemicals from materials: Other sources of indoor pollutants include volatile organic compounds (VOCs) from building or fit-out materials including paints and varnishes, adhesives and furnishings, and household items such as electronics and cleaning materials. Exposure to these pollutants can be concentrated in an indoor environment, and consequently trigger health issues such as nausea, headaches, respiratory irritation and allergies. Organically derived gases, such as radon, can also generate a form of indoor pollution that presents major health risks. Exposure to hazardous chemicals within buildings is further detailed in Principle 6.4.

- Biological contaminants: Often linked to building quality, infiltration of air through cracks in the building façade (exterior) can cause damp, leading to mould and fungi growth within walls, releasing airborne microbial pollution within indoor air[9]. Research has shown that asthma risk increases by up to 40% when occupants live in homes with mould[10].

- Infiltration from outdoors has also been identified as a significant health risk for people within buildings, with studies showing that 65% of our exposure to outdoor air pollution occurs indoors[11].

Ambient air pollution

Ambient, or outdoor, air pollution is caused by a range of factors, including transport, agriculture and waste. The contribution of the built environment across the building and construction lifecycle is

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substantial and must be mitigated to protect human and environmental health. Causes of ambient air pollution related to the built environment include;

- Manufacturing of building materials, notably the use of highly polluting brick kilns, which contribute to up to 20% of global black carbon emissions, alongside steel and iron production[12]. 90% of global brick production is concentrated in central Asia, causing direct localised health impacts to local people. Emissions from production are further increased by transportation to global markets[11].

- Building construction: 11% of carbon emissions are attributed to emissions embodied in the construction process, which further impacts public health through dust creation[13]. The release of toxic dusts from construction sites (such as silica or hardwood, which are recognised as having carcinogenic properties) creates localised extreme health hazards to construction workers and people living nearby[14].

- Operational buildings:
  - 28% of global energy-related carbon emissions are attributed to operational buildings, predominantly from energy used for heating, cooling and lighting[12]. The release of carbon emissions is a core contributor to climate change, explained as a health risk in Principle 6.1.
  - Fine particles (PM2.5/PM10) are emitted from the combustion of fuels to power our buildings, and for heating or cooking within, as well as from transport emissions[15].
  - The use of traditional cookstoves, open fires or kerosene lamps for heating, cooking and lighting within homes in the developing world is responsible for up to 58% of black carbon emissions worldwide[16].

Outcomes

- Building provides only clean air through the mitigation of air quality risks and incorporation of health-based strategies, while maintaining energy efficiency. Air quality should be enhanced at all stages of lifecycle, including construction workers, and protecting health of people within and outside, considering both building occupants and neighbouring people.

Strategies across the lifecycle

<u>Tackling ambient air pollution:</u>

Design:

- Support the switch to more efficient building material production, particularly around traditional brick firing
- Energy efficient building design (and renovation) to improve the quality of building envelope and consequential energy load for heating and cooling.
- Passive design strategies, including energy efficient building fabric, vegetation and ventilation, can reduce heating or cooling requirement within buildings and maintain comfortable living conditions (see Principle 2.1 for more detail)
- Sustainable urban planning also has a role in the reduction of air pollution, through mitigation of emissions from transport through a low or zero carbon infrastructure network

Construction:

- Dust production should be appropriately managed with national and organisational regulation, best practice and policy adherence on site, and other dust-reduction strategies. Off-site, modular construction practices can be preferable due to lower volume and more controlled dust production.
- Support the switch to more efficient building material production, particularly around traditional brick firing

Operation:

- Reduce operational and embodied carbon emissions (see Principle 6.1 for more information)
- Commit to monitoring indoor and outdoor air quality in real-time, to increase awareness and promote data-driven action to mitigate pollution sources and improve public health. Air quality monitoring can be undertaken as part of WorldGBC's Plant a Sensor campaign.

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Improving indoor air quality:

Design:

- Lessen exposure to hazardous chemicals in the indoor environment through conscious product selection and the use of low emission materials, such as low-VOC emission paints, sealants, adhesives, fixtures, fit-outs, and flooring as well as low-formaldehyde products
- Energy efficient building design and/or renovation to reduce damp or mould build risk
- Minimisation of potentially harmful chemicals in building materials (see Principle 6.4 for information)

Construction:

- Removal of harmful materials from existing buildings
- Installing porous materials after 'wet products' (adhesives/sealants and paints/coatings) have been given a chance to off gas when possible

Operation:

- The use of appropriate ventilation to remove indoor air and toxins and exchange with fresh and clean air into buildings, including designs that maximise cross flow ventilation. Ventilation can be mechanical, mixed-mode or natural
- Minimise the use of traditional cookstoves through access to clean fuels and technology within buildings, prioritising electric alternatives rather than gas-based
- Phase-out of fossil gas as an energy source worldwide, prioritising residential buildings.
- Ensure localised extraction around gas appliances when used
- Inspection of installation, maintenance and cleaning of ventilation systems (to ensure cleanliness and reduce the potential for mould and bacteria growth)
- Commit to monitoring indoor and outdoor air quality in real-time, to increase awareness and promote data-driven action to mitigate pollution sources and improve public health. Air quality monitoring can be undertaken as part of WorldGBC's Plant a Sensor campaign.

Benchmarks

The World Health Organization (WHO) provides guidance on outdoor air quality, including information of particulate and gaseous pollutants. These outdoor values are also relevant for indoor environments due to close infiltration of pollutants between outdoors and indoors (research suggests an average of 65% of our exposure to outdoor pollution happens indoors[4]). The WHO Air Quality Guidelines (AQGs) for 24-hour mean concentration limits are[17]:

- PM2.5 less than 10 µg/m³
- PM10 less than 20 µg/m³

These figures are published as 'the lowest levels at which total, cardiopulmonary and lung cancer mortality have been shown to increase with more than 95% confidence in response to long-term exposure to PM2.5'[18]. Interim targets, which reduce mortality risk to a lesser extent than the AQGs, are also available within the WHO Air Quality Guidelines.

There is no simple measure for indoor air quality due to the broad spectrum of parameters that are influenced by external and adjoining environments as well the activities and construction of the internal space. Common factors that contribute to the assessment of IAQ are volatile organic chemicals (VOCs) such as formaldehyde, and other gases including carbon dioxide and carbon monoxide, ozone, nitrogen dioxide water vapour and radon; particulate matter; and biological components including bacteria, fungi (such as mould) and pollen; and 'odours'. Benchmarks for air quality and ventilation are embedded within country specific standards.

Examples of specific benchmarks or limit values used in international rating tools[192021] are as follows:

- Carbon dioxide (CO_2): 800ppm
- Carbon monoxide (CO): 9ppm
- Formaldehyde (CH_2O): 27 ppb
- TVOC: 500 µg/m³
- Radon (Rn): 0.148 Bq/L [4 pCi/L]

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An additional consideration for indoor air quality is humidity, which can heighten susceptibility to microbial airborne pollutants from damp or mould within a building. ASHRAE sets benchmarks for acceptable ventilation rates to control this risk.

- ASHRAE Standard 62.1-2016 recommends that relative humidity in occupied spaces be controlled to less than 65% to reduce the likelihood of conditions that can lead to microbial growth.
- Humidity levels significantly below 30% are considered less optimum for the respiratory system[22]. If the relative humidity is below 30%, the air is too dry this can cause irritation of the mucous membranes of the nose and throat, and breathing difficulties in at-risk individuals (e.g., people with asthma). Dry air is also harmful to people with skin or eye conditions.[23]

See also 'World Health Organization Guidelines for indoor air quality: dampness and mould'

More information

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1.2 Preserve water quality to minimise health risks

State of health
Access to clean and safe drinking water and sanitation facilities is a fundamental right within our buildings, for all people worldwide. Within this sub-principle we identify the specific health risks relating to water quality through the lens of built environment – water quality and sanitation and infrastructure.

Sanitation:
One-third of the world's population, 2.4 billion people, do not have access to improved sanitation. 40% of the world does not have access to basic handwashing facilities.[24] Lack of access to poor sanitation is a leading risk factor for infectious diseases, including cholera, diarrhoea, dysentery, hepatitis A, typhoid, and polio. It ranks as a very important risk factor for death globally, with approximately 5% of deaths in low-income countries resulting from unsafe sanitation.[25] According to the Global Burden of Disease study 775,000 people died prematurely in 2017 as a result of poor sanitation.[26]

Water quality:
Health risks may arise from consumption of water contaminated with infectious agents, toxic chemicals, and radiological hazards. Improving access to safe drinking-water can result in tangible improvements to health[27]. Contaminated water can transmit diseases such diarrhoea, cholera, dysentery, typhoid, and polio as well as cause the ingestion of toxic materials, causing conditions such as lead poisoning[28]. Contaminated drinking water is estimated to cause 485 000 diarrhoeal deaths each year.[29] Micro plastics have emerged as an additional source of contamination[30].

The role of a sustainable built environment must be to enhance the quality of our infrastructure, serving occupants and surrounding community with clean, safe, accessible water. An important element to address is the disparity between developed and developing countries in regard to buildings regulations and codes related to water quality. However research studies even in developed nations highlight that health risks also persist worldwide: in 2015, at least 18 million Americans were served by water systems with lead violations[31].

Outcome
- All buildings should provide occupants with adequate, safe, and sustainable access to clean water and sanitation, whilst maintaining efficient use of water and striving for circularity on-site.

Strategies across the lifecycle

Design (policy recommendations)**:**
- Implementation of universal health-based targets for water quality: locally developed standards and regulations, preventative risk management across the water supply chain (catchment to consumer) including filtration, independent testing for microbiological and chemical compliance.

Operation:
- Testing for toxins and contaminants, and roll-out of water treatment plans within the water distribution system.
  - Smart water distribution systems can provide notification of testing results from the treatment plant within the distribution network to inform buildings of their risk management options.
- Legionella management plan, controlling risk of legionella bacteria commonly found in water (mitigate risk of bacteria multiplication, particularly in temperature range of 20-45°C with available nutrients).
- Ensure regular, thorough cleaning takes place in communal areas like a shared kitchen and toilet facilities.

Benchmarks
The continuous delivery of safe water requires effective management and operation throughout the water-supply chain, from catchments to consumer taps and points of use. The WHO Guidelines for Drinking-Water Quality indicate that this is most effectively achieved through the Framework for safe drinking-water, which encompasses the following elements:
- establishing health-based targets as benchmarks for defining safety of drinking water

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- assuring safety by systematically assessing and managing risks
- establishing a system of independent surveillance to verify the meeting of health-based targets

More information

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1.3 Support and enhance mental and social health through building and community design

State of health

Good mental health is related to mental and psychological well-being[33]. The global burden of mental health illnesses is significant. In 2010, mental illnesses and substance use disorders accounted for 183.9 million disability-adjusted life years (DALYs)[34] worldwide. It is estimated that the life expectancy among those with mental illness is over 10 years shorter compared to those without mental illnesses.[35]

Considered building design can reduce stress, improve mental health, and positively impact comfort, well-being, and happiness, through the adoption of strategies such as biophilic design.

Outcomes

- The built environment is designed and operated to enhance occupant and neighbouring community mental health and wellbeing. Ensure design strategies are accessible and inclusive to support social health for people of all levels of physical, cognitive and mental ability

Strategies across the lifecycle

Design:

- Designing buildings to reduce occupants' stress, using strategies such as: incorporating biophilic design, aesthetically pleasing interiors, acoustic comfort, access to external views and integrated design, including the creation of break out and shared communal spaces
- Community and neighbourhood design to improve mental and social health, including access to nature, active space for exercise and design to facilitate social connection
- Design for social justice to reduce systemic stresses on under-represented communities, including racial justice and the suggested concept of direct mental and physical health impacts, which can be tied to under-lying conditions[36] (see Principle 5)

Design (policy recommendations**):**

- National services and programs access at a regional or national level, such as depression and mental health, suicide prevention, domestic violence and nutrition services
- Regional and national policies that advocate for increased availability and accessibility to housing, alongside tenure security, working towards increased general affordability of housing

Operation:

- Post occupancy evaluation surveys can be used to collect self-reported measures for occupant health and comfort

Benchmarks

The World Health Organization has developed an Assessment Instrument for Mental Health Systems (WHO-AIMS) which is used for collecting information on the mental health system of a country or region, with the goal of collecting this information to improve and monitor mental health systems. The indicators include the presence of a mental health policy or plan as well as mental health expenditure.

There is limited research available on benchmarks for building design for benefitting mental health. Incorporating bespoke strategies for specific projects, as well as awareness of other elements of the built environment that can impact an individual's mental and psychological wellbeing, is recommended.

More information

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1.4 Reduce infectious disease transmission within the built environment

State of health
In the eighteen month period from 2019-2020 within which this Framework was developed and under consultation, the COVID-19 pandemic changed the face of the planet, the atmospheric balance of pollutants and most substantially, human lifestyle, beyond any comparable alternative in peacetime history. As of 26 June 2020, over 645,000 people have died from the coronavirus COVID-19 outbreak worldwide.

Research has suggested the primary route of transmission of COVID-19 is directly from person to person, which is applicable to many other infectious diseases. However, viruses also settle on surfaces, which can become heavily contaminated quite quickly, and how long the virus survives on surfaces is still up for debate. UK Government advice suggests that the COVID-19 virus can survive on inanimate objects and can remain viable for up to five days at temperatures of 22-25°C and relative humidity of 40-50% (which is typical of air-conditioned indoor environments)[37]. Estimates range from a number of hours to days, depending on the material and conditions.[38] Therefore, regularly cleaning surfaces and thorough handwashing are important.[39]

Ventilation strategies can also play a role in reducing disease transmission. Increasing the amount of air flowing in from outside and the rate of air exchange can dilute virus particles indoors, however, high air flow could also stir up settled particles and put them back in the air.[40] Research has also demonstrated the importance of lessening exposure to air pollution, particularly around particulate matter (PM); the Harvard School of Public Health have identified that a small increase in long-term exposure to PM2.5 leads to a large increase in the COVID-19 death rate, approximately 8% higher[41].

Outcomes
The indoor and outdoor built environment actively mitigates risk of infectious disease transmission, including both strategic design measures and implementation of building policies to enhance health, whilst maintaining energy efficiency.

Strategies across the lifecycle

Design:

- Use of technology to minimize physical contact within the building, such as sensor type activation for lifts, fixtures and security control

Operation:

- Pandemic planning, (including planning for the reopening of buildings)
- Employ operational concepts to reduce/counter infectious disease transmission (including weekly checks of the HVAC system and filters, replacing as indicated or needed).
- Cleaning/disinfecting areas such as high touch surfaces sanitising, handwashing, social distancing provision.
- Control of microbial count and bacteria (e.g. use of UV lamps, testing of surfaces)
- Maintenance and cleaning of pipes/faucets to prevent legionella in buildings that have been unoccupied as a consequence of the COVID-19 pandemic.
- Monitor and implement health guidance from national government and other authorities
- Consider and mitigate wider sources of internal disease transmission, including fungal spores and pest control

Benchmarks

Benchmarks around infectious disease mitigation measures related to the general built environment design and operation, particularly around COVID-19, do not exist at time of writing. We therefore share some useful guidance documents that offer tools:

- AIA Re-occupancy assessment tool: http://content.aia.org/sites/default/files/2020-06/STN20_%20344901_ReOccupancyAssessmentTool-V02_sm_v09.pdf
- Arc Re-entry: https://arcskoru.com/sites/default/files/Arc%20Guide%20to%20Re-Entry.pdf

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- Guide to Pandemic Planning: http://bomacanada.ca/wp-content/uploads/2020/01/BOMA-Guide-to-Pandemics-2020.pdf
- Guidance for Reopening Buildings After Prolonged Shutdown or Reduced Operation - https://www.cdc.gov/coronavirus/2019-ncov/php/building-water-system.html

More Information

- American Society for Microbiology 2019 Novel Coronavirus (COVID-19) Pandemic: Built Environment Considerations To Reduce Transmission
- The American Institute of Architects. 2020. 'Re-occupancy assessment tool' http://content.aia.org/sites/default/files/2020-06/STN20_%20344901_ReOccupancyAssessmentTool-V02_sm_v09.pdf
- Archinect News, 2020. '"Hygiene ventilation" and the case for green stimulus' https://archinect.com/news/article/150195914/hygiene-ventilation-and-the-case-for-green-stimulus
- ASHRAE 170 (Ventilation of Health Care Facilities) - including Hospital Spaces, Outpatient Spaces, and Nursing Home Spaces.
- BREEAM International In-Use Standard 'Man 03 Maintenance policies and procedures', 'Hea 16 Indoor air quality management', 'Hea 18 Legionella risk management' 'Rsl 06 Emergency plans and climate-related physical risks':
- CDC - Guidance for Reopening Buildings After Prolonged Shutdown or Reduced Operation - https://www.cdc.gov/coronavirus/2019-ncov/php/building-water-system.html
- GOV.UK - Transmission characteristics and principles of infection prevention and control - https://www.gov.uk/government/publications/wuhan-novel-coronavirus-infection-prevention-and-control/transmission-characteristics-and-principles-of-infection-prevention-and-control#section3
- Harvard University. 2020. 'Exposure to air pollution and COVID-19 mortality in the United States: A nationwide cross-sectional study' https://projects.iq.harvard.edu/covid-pm
- How we can redesign cities to fight future pandemics https://www.fastcompany.com/90479665/how-we-can-redesign-cities-to-fight-future-pandemics
- Interact Lighting 'Re-inventing the workplace after COVID-19': https://www.interact-lighting.com/global/iot-insights/workplace-post-covid-19
- Passive House Accelerator 'Hygiene Ventilation, Heard of it?' https://passivehouseaccelerator.com/articles/hygiene-ventilation-heard-of-it
- Perkins & Will. 'Understanding antimicrobial ingredients in building materials – COVID-19 Statement' https://healthybuilding.net/reports/22-covid-19-statement-understanding-antimicrobial-ingredients-in-building-materials
- Recovery Readiness – A 'how to' guide for reopening your workplace https://www.cushmanwakefield.com/en/insights/covid-19/recovery-readiness-a-how-to-guide-for-reopening-your-workplace
- Science Daily - University of California - COVID-19 and the built environment - Examining how building design can influence disease transmission https://www.sciencedaily.com/releases/2020/04/200410162450.htm
- University of California - COVID-19 and the built environment - Examining how building design can influence disease transmission

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