JARED

Joint Action on REspiratory Diseases

Guidance for improving indoor air quality in educational institutions and reducing asthma risks

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Key message

Maintainers and managers of nurseries, kindergartens, and schools, as well as teachers, parents, and school health staff, can significantly reduce exposure of children and staff to air pollution through informed decisions regarding both indoor and outdoor environments. Improving indoor air quality not only supports general health and cognitive performance but also plays a critical role in preventing and managing respiratory diseases such as asthma.

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1. Introduction

Children spend a significant part of their time in educational settings. Indoor air quality in these environments has a direct impact on health, well-being, and learning performance.

Recent evidence suggests that indoor air pollutants contribute to acute respiratory symptoms and exacerbate chronic respiratory diseases (EEA, 2023; WHO Europe, 2021). They may also contribute to the development of chronic respiratory, cardiovascular, immune, and neurological disorders. Chemical and biological pollutants in indoor air can act as irritants, allergens, toxicants, carcinogens, or infectious agents. Therefore, raising awareness about the health risks associated with poor indoor air quality is essential. Improving indoor air quality in classrooms can reduce adverse health effects, decrease school absenteeism, and support better cognitive performance among students.

Asthma is the most common chronic disease in children. Environmental exposures play a key role in both the development and exacerbation of asthma. Poor indoor air quality can trigger symptoms, reduce lung function, and increase the risk of exacerbations, particularly in school settings where children spend a large proportion of their time.

Improving indoor environments in educational institutions therefore represents an important opportunity to protect children's health, reduce disease burden, and support learning outcomes. This document provides practical, evidence-based recommendations to reduce environmental risks and support healthy, asthma-friendly school environments.

2. The major air pollutants in and around schools

- Particulate matter ($PM_{2.5}$, PM_{10}): Tiny airborne particles that can penetrate deep into the lungs, and the smallest ones can even enter the bloodstream. They can originate from both outdoor and indoor sources.
- Nitrogen dioxide (NO_2): Mainly produced by traffic and other combustion processes.
- Ozone (O_3): A secondary pollutant formed when sunlight reacts with other pollutants like nitrogen oxides and volatile organic compounds.
- Carbon monoxide (CO): A toxic gas produced by incomplete combustion of fuels.
- Volatile organic compounds (VOCs): The most common VOCs with significant health impacts in educational buildings include formaldehyde, acetaldehyde, benzene, ethylbenzene, toluene, xylenes, naphthalene, styrene, limonene, and α-pinene. These are emitted from multiple indoor sources such as certain furniture, floor/wall/ceiling coverings, textiles, carpets, curtains, indoor blinds, PVC materials, resins, glues, paints, varnishes. Such materials can release chemicals continuously over weeks to years. Cleaning agents, disinfectants, waxes, polishes, and air fresheners often emit hazardous chemicals intermittently. Some VOCs have outdoor sources as well.
- Semivolatile organic compounds (SVOCs) (e.g. bisphenols, phthalates, flame retardants, per- and polyfluoroalkyl substances, certain pesticides) originate from furniture, flooring, carpets, electronics, cleaning materials and other indoor sources, and can accumulate in indoor dust.
- Mould and spores: Mould grows in damp and humid environments - especially where moisture builds up and ventilation is limited - and releases spores into the air.
- Pollen is made up of tiny grains released by plants (such as trees, grasses, and weeds) as part of their reproductive process. Highly allergenic pollen can trigger allergic reactions in sensitive individuals.
- Other biological allergens: dust mites, pet dander, pest allergens.
- Human bioeffluents: airborne contaminants released by occupants (carbon dioxide (CO_2), moisture, viruses and bacteria), which are particularly important in classrooms where occupancy is high and ventilation may be limited.

3. Improving indoor air quality in school buildings

Indoor air quality is shaped by multiple factors such as outdoor air quality and infiltration rates, the presence of indoor sources, occupant activities, applied building materials, and maintenance practices. Controlling chemical and biological pollutants and providing a sufficient amount of fresh air are essential for maintaining healthy indoor air and preventing allergies, asthma, and infections common among schoolchildren.

3.1 Avoidance of environmental triggers from outdoor sources

To reduce ambient air pollution around buildings and minimize the penetration of pollutants into indoor spaces:

- Set minimum distances between pollution sources and educational buildings during planning.
- Place parking areas and drop-off zones away from classroom windows and fresh air intakes for ventilation systems.
- Where feasible, introduce speed limits, one-way traffic, road closures or limited traffic zones near schools to reduce traffic-related air pollutants.
- Promote active commuting and ensure safe routes for walking and cycling to school and provide appropriate bicycle parking.
- Optimize ventilation periods by avoiding ventilation during rush hours.
- Implement anti-idling measures.
- Ventilate classrooms and community spaces through windows facing less polluted areas.
- Encourage awareness of air pollution forecasts and health indices to support protective behaviours.
- During periods of elevated air pollution, reduce outdoor time and physical exertion for children.
- Schedule major building renovations for the summer holidays.
- Increase green buffers around school buildings to help filter air pollution.
- Establish outdoor learning spaces in shaded, protected, less polluted areas.
- Plant only low-allergenic and non-poisonous plants in school gardens/outdoor areas around schools.

- Where ambient air quality standards cannot be met through other measures, install mechanical ventilation that filters the incoming outdoor air.
- Take actions to prevent waste burning and wildfires in surrounding areas.
- Do not light barbecues or campfires.

3.2 Source control of pollutants of indoor origin to prevent adverse health effects

Alongside mitigation against pollutants from outdoor sources, chemical and biological pollutant emissions from indoor sources must also be minimized, since together, these pollutants contribute to a cumulative health risk. Risk mitigation measures:

- Ventilate rooms adequately; increase ventilation to dilute harmful indoor pollutants (e.g. chemicals, viruses, bacteria)
- Provide extra ventilation during activities that release chemical pollutants (painting, using glues, laboratory work). Use smaller quantities of chemicals.
- Use environmentally friendly (green) alternatives for paints, solvents and adhesives.
- Select certified, eco-labelled, low-emission materials (low formaldehyde, VOC/SVOC, PFAS, flame retardant emission) for floor/wall/ceiling coverings, furniture and decoration.
- Schedule refurbishment or redecoration for the beginning of the summer holidays, and increase the ventilation rate for 6-8 weeks following renovation (opened windows or exhaust ventilation system) before children return.
- Promote the conscious use of cosmetics and other hair and beauty products and ensure proper ventilation of changing rooms.
- Eliminate candles, incense, and air fresheners.
- Use mosquito netting instead of insecticide sprays, if needed.
- Use easy-to-clean surfaces, avoiding dust-collecting materials.
- Carry out daily wet cleaning (outside school hours) to reduce resuspension of dust.
- Use fragrance-free cleaning materials.
- Ventilate classrooms during, and for 15–30 minutes after cleaning.
- If possible, avoid carpets and textile-based furniture. If needed, use washable knotted or woven textile carpets instead of glued carpets with synthetic backing.
- For curtains, if needed, choose low-emitting, washable textiles, rather than textiles, that require dry cleaning.
- Prefer trees or mobile outdoor awning/sun-blinds instead of indoor shadings.
- Choose outdoor heat protection films for windows rather than indoor ones.
- Disinfect frequently touched surfaces, especially during epidemic periods, but avoid overuse of chemicals.

- Prevent and repair moisture damage and mould growth.
- Control pests (cockroaches, rodents) to reduce asthma triggers, but minimize children's exposure to chemicals. Use professional integrated pest management and non-chemical methods.
- Ensure gyms are dust-free through regular maintenance and are equipped with adequate ventilation systems to provide a sufficient supply of fresh air.
- Place photocopiers and printers in separate ventilated rooms to reduce exposure to heat, noise, and airborne pollutants.

3.3 Increasing ventilation rates to dilute harmful indoor pollutants

Effective ventilation is critical for diluting air contaminants, including viruses and bacteria, that can cause airborne respiratory infections.

3.3.1 Recommendations for naturally ventilated school buildings

Estimating the frequency of natural ventilation

The amount of fresh air to be provided per person is 25–30 m^3/hour/person, and at least 36 m^3/hour/person (EN 16798; Carrer et al., 2020; Honan et al., 2024), during epidemic periods (Morawska et al., 2024). Accordingly, if there is 30 m^3 of air space per person (e.g. 10 m^2 of floor space per person with a 3-meter ceiling height), this air volume is sufficient for one hour. Therefore, cross-ventilation of the room is necessary every hour. However, if there is less than 10 m^2 of floor space per person (typically 2–3 m^2/student in classrooms), in addition to hourly cross-ventilation, a continuous supply of fresh air should be provided (for example, by keeping windows tilted open or by using air inlets in windows or façade walls).

Required duration of natural ventilation

Conditions for efficient air exchange include:

- sufficient openable window area,
- a temperature difference to ensure adequate airflow,
- and sufficient time for air exchange.

When ventilating classrooms and community spaces:

- If the difference between the outside and inside temperature is more than 20°C, ventilation period of 5 minutes is sufficient.
- For a temperature difference of 10–20°C, ventilation should last 5–15 minutes.
- If the difference is less than 10°C, ventilation should last 15–20 minutes.

In case of a small temperature difference, the use of cross-drafts or fans, or taking advantage of wind or chimney effects, can help improve air exchange. If occupant comfort does not allow sufficient natural ventilation, additional mechanical solutions are recommended (e.g. air inlets or ducts with exhaust fans). If outdoor air is persistently polluted, HVAC (Heating, Ventilation, and Air Conditioning) systems can ensure a sufficient supply of filtered outdoor air.

Use of low-cost carbon dioxide (CO_2) monitors to control ventilation

The level of CO_2 exhaled by occupants can serve as a proxy for occupant-emitted contaminants and pathogens, as well as other pollutants from indoor sources, since higher concentrations of CO_2 are usually associated with higher levels of other indoor pollutants. A low-cost CO_2 sensor can indicate when the indoor air is exhausted and when ventilation is required to dilute contaminants with fresh outdoor air. The alarm level should be set at 900–1250 ppm to achieve acceptable air quality. During epidemic seasons (e.g. influenza, SARS, RSV, HMPV) or after refurbishing/redecorating periods, when chemical emissions are higher, the alarm level should be set lower, at 800–900 ppm.

3.3.2 Recommendations for mechanically ventilated school buildings

Optimal ventilation systems are energy-efficient HVAC systems with HEPA (High Efficiency Particulate Air) air filtration and heating/cooling of incoming air.

- Supply 29–30 m^3/hour/person of fresh air, or 36–50 m^3/hour/person during epidemic periods.
- Ensure separation of fresh and exhaust air (closed heat-exchange systems).
- Place air intake points in clean areas, away from pollution sources.
- Maintain and clean the whole system regularly and replace filters as prescribed.

3.3.3 Thermal comfort and relative humidity in classrooms

The optimal temperature range for comfort and concentration is between 20 and 27°C depending on the season. The optimal relative humidity is between 30 and 55% in classrooms to prevent both drying of mucous membranes and dampness or mould. However, in countries with cold winters, the relative humidity of indoor air often falls below 30%.

Passive, environmentally friendly means of protection against heat:

- Outdoor shading of windows and façade walls, while not limiting the view and airflow, helps reduce the temperature.
- Green walls and roofs, green shading, and large trees cool their environment through evaporation and also humidify, filter, and refresh the air.

- Limiting the use of paving stones or tarmac in schoolyards is recommended, as they can increase the heat island effect around buildings.
- Opening classroom windows in partially opened position at night (tilting, awning, and louvred windows) can help cool insulated buildings.

With the widespread use of air conditioning systems that are not powered by solar panels, electricity consumption is rising, and electricity production contributes to carbon dioxide emissions and further global warming. The large number of operating air conditioning systems also contributes to the urban heat island phenomenon, meaning that the temperature around buildings becomes even higher.

Since mobile and split air conditioners only recirculate and cool the contaminated indoor air without supplying fresh air, and there is a particular risk that natural ventilation will be limited to preserve cool indoor air, awareness is necessary to avoid poor air quality caused by increase in human effluents and other indoor air contaminants.

Please note: Most room air conditioners do not provide fresh air, they only recirculate the contaminated indoor air, while properly designed HVAC systems can provide a controllable amount of fresh air.

3.4 Pollutant removal techniques

In specific cases (e.g. construction works, windstorm, epidemics, or students with severe asthma), high-performance portable air cleaners with HEPA-filters may be useful for maintaining safe indoor air quality as an interim, complementary solution. In contrast, ionizers and ozone-generating air purifiers are not recommended for occupied indoor spaces as they can create ozone or other reactive byproducts (aldehydes, NO_2, CO, O_3).

Please note: Air cleaners do not provide fresh air; they only recirculate the air already in the room. They are not substitutes for the minimum outdoor air requirements and should not be used without fresh air intake. Mobile air cleaners can filter the air only in a single room or in a restricted area due to their limited performance. Devices with high enough fan speeds to efficiently filter the air in a classroom are usually too large and noisy.

Indoor plants and indoor green walls of sufficient size, with appropriate plant density and proper lighting can remove some VOCs, CO_2, and PM. However, their efficiency is limited, and special attention should be paid to preventing exposure to mould and fungi during installation and maintenance.

4. Asthma and respiratory health in school settings

4.1 Asthma in children

Asthma is a chronic inflammatory disease of the airways and one of the most common chronic diseases in children. It is a leading cause of school absenteeism and can significantly affect quality of life, participation in physical activities, and learning performance.

Children with asthma are particularly sensitive to environmental exposures, including air pollutants, allergens, and irritants commonly present in school environments. These exposures can trigger airway inflammation and bronchoconstriction, leading to increased respiratory symptoms, impaired lung function, and more frequent exacerbations.

4.2 Common asthma triggers in schools

Asthma symptoms in school settings may be triggered or exacerbated by multiple environmental and behavioural factors, including:

- Air pollutants: $PM_{2.5}$, NO_2, O_3, VOCs from cleaning products, disinfectants, fragrances, paints, and adhesives
- Indoor allergens: dust mites, mould and spores, pet dander, and pest allergens (e.g. cockroaches, rodents)
- Respiratory viruses and bacteria
- Physical factors: cold air, rapid temperature changes, and physical exertion

The interaction between these factors may further amplify respiratory effects, particularly in poorly ventilated environments.

4.3 Reducing asthma risks through environmental measures

Many of the measures described in Section 3 contribute directly to reducing asthma risks. In particular:

- Controlling indoor emission sources limits exposure to pollutants.
- Improving ventilation reduces the concentration of indoor air pollutants, allergens, and infectious agents.
- Minimizing the penetration of outdoor air pollutants into indoor spaces reduces exposure to harmful pollutants.
- Preventing dampness and mould growth reduces exposure to fungal spores.
- Maintaining appropriate humidity levels helps control dust mite populations.

A comprehensive approach combining these measures is essential for creating asthma-friendly school environments and reducing the frequency and severity of symptoms among affected children.

5. Supporting asthma management in schools

5.1 Awareness and communication

Effective asthma management in schools requires clear communication and awareness among all relevant stakeholders:

- Identify children diagnosed with asthma and maintain updated records.
- Inform teachers, school staff, and relevant personnel about affected students.
- Ensure awareness of individual triggers, symptoms, and required actions.
- Promote basic understanding of asthma among school staff and caregivers.

5.2 Access to medication

Timely access to medication is essential for preventing and managing asthma symptoms:

- Ensure that reliever inhalers are readily accessible at all times.
- Allow children, where appropriate, to carry and use their inhalers independently.

- Provide additional (backup) medication at school when needed.
- Ensure that staff are aware of medication location and basic use.

5.3 Asthma action plans

Each child with asthma should have an individualized asthma action plan that is:
- Developed in collaboration with healthcare providers and parents.
- Available to relevant school staff.
- Clearly describing typical symptoms, known triggers, prescribed medications, step-by-step actions in case of symptom worsening or an asthma attack.

5.4 Responding to asthma attacks

In the event of an asthma attack:
- Keep the child calm and seated in an upright position.
- Administer a reliever inhaler (typically 1 puff every 30–60 seconds, up to 10 puffs, according to guidance).
- Monitor symptoms closely.
- Seek emergency medical assistance (e.g. call 112) if symptoms do not improve, the child is unable to speak or breathe properly or medication is not available.

If symptoms persist after initial treatment and emergency services have not yet arrived, repeat the inhaler administration as recommended.

5.5 Reducing asthma triggers in daily school life

In addition to environmental measures, daily practices can help reduce asthma triggers:
- Avoid strong fragrances, scented products, and unnecessary chemical exposures.
- Maintain clean, well-ventilated classrooms.
- Ensure regular cleaning using appropriate methods to reduce dust and allergens.
- Monitor outdoor air quality and adjust outdoor activities accordingly.
- Adapt physical activity where necessary, while encouraging safe participation.
- Minimize the presence of allergens (e.g. pets, pests) in classrooms.

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