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INDOOR AIR QUALITY IN HOMES AND SCHOOLS

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Abstract

Indoor air quality (IAQ) is a preventable environmental determinant of health because people spend much of their time inside homes, schools and other buildings. Inadequate ventilation, dampness and mould, combustion products, particles, and emissions from furnishings and cleaning products can contribute to respiratory irritation, allergy symptoms and exposure to infectious aerosols. This narrative review summarizes practical prevention principles for occupied rooms, with emphasis on homes and educational settings. Guidance from the World Health Organization (WHO) and the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE), together with peer-reviewed evidence cited in those guidance documents, was reviewed. The evidence supports a layered approach: reduce pollutant sources, provide and maintain adequate outdoor-air ventilation, control moisture, use appropriate filtration, and monitor conditions using more than one indicator. Carbon dioxide (CO_2) can help identify changes in ventilation relative to occupancy, but it is not a comprehensive measure of IAQ and should not be treated as a universal health-based limit. Prevention programs should combine routine building maintenance with occupant education and a response plan for persistent dampness, combustion sources, or symptoms associated with time spent indoors.

Keywords: Indoor air quality; ventilation; dampness; mould; particulate matter; prevention; schools; homes.

Introduction

Indoor environments contain a changing mixture of particles, gases, biological agents and moisture. Sources include outdoor air entering through openings,

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cooking and heating, tobacco smoke, cleaning products, building materials, furnishings, occupants and damp surfaces. Exposure depends on the pollutant source, room use, occupancy, building design, ventilation and time spent indoors. An effective prevention strategy therefore considers both the contaminant and the building conditions that allow exposure to persist.

The public-health importance of dampness and mould is well established. WHO guidance links damp or mould-affected buildings with increased respiratory symptoms, allergies and asthma, and recommends preventing or remediating moisture-related problems [1]. WHO guidance on selected indoor pollutants also identifies chemicals of concern that may arise from indoor sources, including formaldehyde, benzene, nitrogen dioxide and carbon monoxide [2]. In schools, ventilation is relevant to comfort, dilution of indoor emissions and management of airborne infection risk; it must be evaluated together with occupancy, air distribution and filtration [3,4].

Aim and Review Approach

The aim was to summarize current, actionable approaches to preventing poor indoor air quality in homes and educational rooms. This is a focused narrative review, not a systematic review or a new field study. WHO publications on indoor air quality and dampness, current ASHRAE ventilation standards and its 2025 position document on indoor CO_2 were consulted, along with scientific studies cited in these sources. The recommendations below are general principles; building-specific ventilation rates and pollutant limits must follow applicable national regulations and qualified engineering assessment.

Main Indoor Hazards and Preventive Priorities

A useful first step is to identify likely sources and pathways rather than relying on smell or a single sensor. Some hazardous pollutants, such as carbon monoxide and radon, may not be detectable by occupants. Conversely, odour or elevated CO_2 may signal a need to investigate but does not identify every pollutant. The main hazards and corresponding prevention measures are summarized in Table 1.

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Table 1. Common indoor air hazards and preventive priorities

Hazard or indicator	Typical sources	Health relevance	Practical prevention
Fine and coarse particles ($PM_{2.5}$, PM_{10})	Cooking, tobacco smoke, candles, outdoor traffic or dust, resuspended dust	Airway irritation; effects depend on particle composition, concentration and exposure duration	Avoid indoor smoking; use kitchen exhaust; reduce dust-generating activities; choose particle filtration suited to the room and maintain filters
Dampness and mould	Leaks, condensation, wet materials, persistent high moisture, inadequate exhaust	Associated with respiratory symptoms, allergy and asthma exacerbation	Repair leaks promptly; dry wet materials; exhaust moisture from kitchens and bathrooms; remove or remediate mould and address the moisture source
Combustion pollutants (e.g., CO, NO_2)	Unvented or poorly maintained fuel-burning appliances, cooking, generators, tobacco smoke	Can cause acute poisoning or respiratory harm; CO is odourless and potentially fatal	Maintain appliances; vent combustion outdoors; never operate generators indoors; install and maintain carbon-monoxide alarms where appropriate
Volatile organic compounds and formaldehyde	New furniture, pressed-wood products, paints, solvents, fragranced products, cleaning agents	May irritate eyes and airways; risks vary substantially by chemical and exposure	Select lower-emitting products where feasible; follow labels; store chemicals securely; ventilate during and after activities
Bioaerosols and infectious aerosols	Infected occupants, crowded rooms, poorly distributed or insufficient outdoor air	Transmission risk depends on pathogen, activity, duration, occupancy and controls	Combine adequate ventilation, filtration, reduced crowding where feasible, respiratory hygiene and staying home when ill
Carbon dioxide (CO_2)	Exhaled air from occupants	Primarily a ventilation/occupancy indicator in typical non-industrial settings; not a complete IAQ measure	Use calibrated sensors as a trend and diagnostic aid; interpret against occupancy, room use, outdoor baseline and ventilation design

A Layered Prevention Framework

Control Sources First

Source control prevents pollutants from entering indoor air and is often more reliable than trying to remove them after release. Keep tobacco smoke and vaping

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out of indoor spaces. Use externally vented kitchen and bathroom exhaust where available, especially during cooking or moisture-producing activities. Follow product labels for cleaning agents, paints and solvents; avoid unnecessary aerosol use and do not mix cleaning chemicals. Maintain fuel-burning appliances and keep combustion exhaust outdoors. New materials and furnishings should be allowed to air out according to manufacturer guidance when practical.

Ventilate and Maintain Systems

Ventilation should supply outdoor air and remove stale or contaminated air in a way that suits the room's occupancy and use. Natural ventilation through windows may be useful when outdoor conditions are acceptable, but it is variable and can introduce outdoor pollution, noise, heat or security concerns. Mechanical systems require routine inspection of outdoor-air intakes, fans, dampers, ducts and filters. ASHRAE Standards 62.1-2025 and 62.2-2025 set recognized ventilation and IAQ requirements for non-residential and residential building applications, respectively; local codes remain controlling [3].

In rooms affected by outdoor pollution, opening windows at peak traffic periods may worsen particle exposure. A context-aware plan can coordinate window opening with outdoor air quality, weather and room occupancy, while ensuring that ventilation is not stopped for long periods. Air cleaners can supplement ventilation when source control and outdoor-air supply are insufficient, but they do not remove all gases and do not replace ventilation.

Prevent And Correct Moisture

Moisture control requires fixing the cause, not simply covering visible mould. Inspect roofs, plumbing, window frames and damp basements; improve drainage and exhaust moisture at its source. Dry wet materials promptly and replace porous materials that remain mouldy or cannot be adequately cleaned. Where mould is extensive, recurrent, or associated with building damage, use trained remediation personnel and verify that the underlying moisture problem has been resolved. WHO emphasizes prevention or remediation of dampness and mould-related problems as a public-health measure [1].

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Use Filtration and Air Cleaning Appropriately

Particle filters can reduce airborne particle concentrations when correctly sized and operated. Building filters should match the equipment design and be installed without bypass; stronger filters may require system compatibility checks. Portable HEPA air cleaners can be considered for occupied rooms where exposure reduction is needed, provided the clean-air delivery rate is appropriate for room size and noise does not lead users to switch the device off. Avoid air-cleaning devices that intentionally produce ozone. Filtration should complement source control and adequate outdoor-air ventilation.

Monitoring And Response in Everyday Settings

A practical monitoring program begins with a room and building walkthrough: check occupant load, ventilation operation, odours, visible dampness, leaks, exhaust fans, filter condition and occupant reports. Instrument measurements should answer a defined question and be interpreted with the building context. Table 2 gives a basic framework for routine prevention and escalation.

Table 2. Indoor air quality monitoring and response framework

What to check	How to assess	When to respond	Preventive action
Ventilation and occupancy	Observe system operation and air distribution; record room use and occupancy; review CO_2 trends if sensors are available	CO_2 repeatedly rises during occupancy or complaints coincide with crowded periods	Check outdoor-air supply, schedules, dampers and sensor placement; have a competent technician verify system performance
Moisture and mould	Visual inspection for leaks, condensation, water stains and mould; check bathrooms, kitchens and window edges	Any recurring leak, persistent condensation, visible mould or musty odour	Find and repair the moisture source; dry or remediate affected materials; document completion and recheck
Combustion safety	Inspect appliance maintenance and exhaust; use certified CO alarms where required or recommended	Alarm activation, combustion malfunction, or symptoms such as headache/dizziness affecting occupants	Leave the area and contact emergency services for suspected CO exposure; arrange qualified appliance inspection
Particles and outdoor air	Review local outdoor air quality information; inspect filters and indoor particle sources	Dust or smoke episodes, poor filter condition, or symptoms temporally linked to exposure	Reduce indoor sources; adjust ventilation timing; use compatible filtration or portable particle cleaning

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What to check	How to assess	When to respond	Preventive action
Occupant symptoms and complaints	Keep a simple log of room, time, activity, symptoms, occupancy and ventilation conditions	Repeated complaints clustered by room or time, especially if symptoms improve away from the space	Investigate building conditions and likely sources; refer persistent or severe symptoms for clinical assessment

CO_2 needs particular interpretation. ASHRAE's 2025 position document explains that Standard 62.1 does not establish a universal indoor CO_2 limit and that CO_2 does not track all pollutants [4]. A sensor can help identify ventilation changes in relation to occupancy, but results depend on sensor accuracy, location, outdoor concentration, room mixing and occupant activity. It should be used as one component of an IAQ assessment, not as a pass/fail test for health or safety.

Prevention in Homes and Schools

In homes, prevention is most effective when incorporated into routine maintenance: use exhaust ventilation during cooking and bathing, keep fuel-burning appliances serviced, prevent indoor smoking, respond quickly to leaks and maintain filters according to manufacturer instructions. Families should know the signs of carbon-monoxide alarm activation and the steps to take. People with asthma or allergies may benefit from reducing specific triggers identified in their own environment, while avoiding unsupported claims that a single product can eliminate risk.

Schools and childcare settings need a documented building-level plan because room occupancy changes throughout the day. Facility managers should keep outdoor-air systems running according to design and schedules, inspect intakes and filters, and report ventilation failures promptly. Teachers can support the plan by avoiding blocked vents, reporting moisture or unusual odours, and following room-specific ventilation instructions. Cleaning routines should control dust without introducing excessive fragrances or aerosols. A cross-functional team of administrators, facilities staff, health personnel and occupants can review complaints and maintenance records periodically.

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Discussion

The central practical implication is that indoor air prevention should be managed as a building and public-health process rather than as a search for one "safe" number. A layered approach reduces reliance on any single control: source reduction limits emissions, ventilation dilutes and removes contaminants, moisture management prevents biological growth, and filtration reduces particles. Monitoring supports troubleshooting but does not replace maintenance or exposure-specific assessment.

Several limitations affect interpretation. Indoor pollutant levels vary by building, season, activity and outdoor conditions. Health responses differ by age, underlying disease and exposure duration. Available guidance documents use distinct scopes and methods, and ventilation requirements depend on occupancy category and jurisdiction. Therefore, the numerical requirements in local building and health regulations should be checked before making compliance claims. Where a serious exposure is suspected, such as carbon monoxide, qualified technical and emergency assessment takes priority over routine monitoring.

Conclusion

Healthy indoor air is best protected through a repeatable prevention cycle: identify sources, reduce emissions, ventilate appropriately, control moisture, maintain filtration and mechanical systems, and investigate recurring complaints. CO_2 monitoring can inform ventilation management when correctly interpreted, but no single sensor captures the full range of indoor pollutants. Applying these measures consistently in homes and schools can reduce avoidable exposures and support healthier indoor environments.

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