European Journal of Interdisciplinary Research and Development
Volume- 46 December- 2025
Website: www.ejird.journalspark.org ISSN (E): 2720-5746

# THE IMPACT OF INDOOR AIR QUALITY ON THE HEALTH OF CHILDREN IN SCHOOLS AND KINDERGARTENS

Fayziyeva Muxabbat
Candidate of Medical Sciences, Associate Professor
Tashkent State Medical University, Uzbekistan

Xasanova Mamura Ikramovna
Candidate of Medical Sciences, Associate Professor
Tashkent State Medical University, Uzbekistan

**Abstract**
Indoor air quality is a critical environmental determinant of child health, particularly in schools and kindergartens where children spend a substantial portion of their daily time. Due to their developing respiratory and immune systems, children are especially vulnerable to indoor air pollutants, including particulate matter, carbon dioxide, volatile organic compounds, allergens, and microbial contaminants. Inadequate ventilation, overcrowding, and poor building maintenance may exacerbate indoor air pollution and increase health risks.
This article aims to evaluate the impact of indoor air quality on the health of children in educational institutions, with a focus on schools and kindergartens. The review examines the relationship between indoor air pollutants and respiratory diseases, allergic conditions, impaired cognitive performance, and increased absenteeism among children. Particular attention is given to the role of ventilation systems, building characteristics, and environmental control measures in maintaining healthy indoor air conditions. Understanding the influence of indoor air quality on child health is essential for developing effective preventive strategies and improving the learning and well-being of children in educational settings.

**Keywords**. Indoor air quality, children's health, schools, kindergartens, respiratory diseases, ventilation, environmental health.

## Introduction

Indoor air quality has become an increasingly important public health issue, particularly in environments where children spend a large proportion of their time, such as schools and kindergartens. Children are more vulnerable to environmental exposures than adults due to their developing respiratory, immune, and nervous systems, as well as higher breathing rates relative to body weight. As a result, poor indoor air conditions may have disproportionate and long-lasting effects on child health and development.
Educational institutions often contain multiple sources of indoor air pollution, including particulate matter, carbon dioxide, volatile organic compounds, allergens, and microbial contaminants. These pollutants may originate from inadequate ventilation, building materials, cleaning products, classroom furnishings, overcrowding, and outdoor air infiltration. In many

schools and kindergartens, insufficient ventilation leads to the accumulation of carbon dioxide and airborne pollutants, which can adversely affect both health and cognitive performance.

Numerous studies have linked poor indoor air quality in educational settings to increased prevalence of respiratory symptoms, asthma exacerbations, allergic reactions, and recurrent infections among children. In addition to respiratory outcomes, emerging evidence suggests that elevated indoor pollutant levels may impair concentration, learning efficiency, and academic performance. Increased absenteeism due to illness has also been associated with suboptimal indoor air conditions, further highlighting the broader educational and social implications of indoor air quality.

The impact of indoor air quality is influenced by multiple factors, including building design, ventilation systems, maintenance practices, and environmental management policies. Kindergartens and primary schools are of particular concern because younger children spend extended periods indoors and have limited ability to recognize or communicate environmental discomfort. Seasonal variations, such as increased indoor occupancy during colder months, may further exacerbate exposure to indoor pollutants.

Despite growing awareness of the importance of indoor air quality, many educational institutions lack systematic monitoring and effective control measures. Existing regulations and guidelines are not always consistently implemented, especially in resource-limited settings. Evaluating the relationship between indoor air quality and child health outcomes is therefore essential for informing evidence-based interventions and policy development.

This article aims to examine the impact of indoor air quality on the health of children in schools and kindergartens. By analyzing key indoor pollutants, exposure pathways, and associated health effects, the study seeks to emphasize the importance of improving indoor environmental conditions as a preventive strategy to protect child health and enhance learning environments.

## Materials and Methods

This study was conducted as an environmental health assessment and narrative review focusing on the impact of indoor air quality on the health of children in schools and kindergartens. The analysis was based on peer-reviewed scientific literature, international guidelines, and environmental monitoring reports addressing indoor air conditions in educational settings. Relevant publications were identified through systematic searches of major scientific databases, including PubMed, Scopus, and Web of Science, with emphasis on studies published in English that examined indoor air pollutants, ventilation parameters, and health outcomes in children.

The selection of studies prioritized research that evaluated indoor air quality indicators such as particulate matter, carbon dioxide concentration, volatile organic compounds, allergens, and microbial contamination in classrooms and daycare facilities. Studies reporting associations between these indicators and pediatric health outcomes, including respiratory symptoms, asthma, allergic diseases, infection rates, cognitive performance, and school absenteeism, were included. Articles focusing exclusively on adult populations or non-educational environments were excluded.

Data on indoor air quality were analyzed in relation to building characteristics, ventilation systems, occupancy levels, and maintenance practices. Particular attention was given to

ventilation efficiency, as reflected by carbon dioxide concentrations, and its role as a proxy indicator for overall indoor air quality. Seasonal variations and differences between schools and kindergartens were considered in the interpretation of exposure patterns.

Health-related outcomes were evaluated based on epidemiological findings, clinical observations, and school health records reported in the literature. The analysis integrated evidence from cross-sectional, longitudinal, and intervention studies to assess both short-term and long-term health effects of indoor air pollution on children. Special consideration was given to age-related vulnerability and critical developmental periods during which exposure may have heightened impact.

As this study relied exclusively on previously published data and publicly available reports, no new environmental measurements or direct involvement of children were undertaken. Therefore, ethical approval and informed consent were not required.

**Results**

Analysis of the reviewed studies revealed that indoor air quality in schools and kindergartens frequently does not meet recommended health standards, particularly with respect to ventilation efficiency and pollutant concentration. Elevated levels of carbon dioxide were consistently reported in classrooms and daycare rooms, especially during periods of high occupancy and limited air exchange. Increased carbon dioxide concentrations were associated with insufficient ventilation and served as an indicator of overall indoor air stagnation.

Particulate matter, including fine and coarse particles, was commonly detected in indoor environments of educational institutions. Sources included outdoor air infiltration, resuspension of dust due to children's activities, and inadequate cleaning practices. Higher particulate matter concentrations were associated with increased respiratory symptoms such as coughing, wheezing, and throat irritation among children. Children attending facilities with elevated particulate levels demonstrated a higher prevalence of asthma symptoms and respiratory infections.

Volatile organic compounds were also frequently identified in indoor air, originating from building materials, furniture, cleaning products, and educational supplies. Exposure to these compounds was linked to mucosal irritation, headaches, and increased reports of discomfort among children. In younger age groups, particularly in kindergartens, exposure to volatile organic compounds was associated with increased susceptibility to allergic reactions.

Microbial contamination, including airborne bacteria and fungi, was detected in several educational settings, particularly in poorly ventilated and humid environments. Increased microbial load was associated with higher rates of allergic symptoms, recurrent respiratory infections, and absenteeism. The presence of visible dampness or mold in classrooms was consistently linked to adverse respiratory outcomes.

In addition to physical health effects, indoor air quality was found to influence cognitive performance and learning-related outcomes. Elevated carbon dioxide levels and poor ventilation were associated with reduced attention, decreased concentration, and impaired task performance in school-aged children. Several studies reported improved cognitive function and

reduced absenteeism following interventions aimed at enhancing ventilation and indoor air management.

Overall, the results indicate a clear association between suboptimal indoor air quality and adverse health outcomes in children attending schools and kindergartens. Poor ventilation and increased exposure to indoor air pollutants were consistently linked to respiratory morbidity, allergic conditions, and impaired cognitive performance. These findings emphasize the importance of maintaining adequate indoor air quality standards in educational environments to protect child health and support optimal learning conditions.

**Discussion**

The findings of this study highlight indoor air quality as a critical determinant of child health and well-being in schools and kindergartens. Consistent evidence demonstrates that inadequate ventilation and elevated concentrations of indoor air pollutants are common in educational settings and are strongly associated with adverse respiratory, allergic, and cognitive outcomes in children. These results reinforce the growing recognition that indoor environments play a substantial role in shaping health during early and middle childhood.

One of the most significant findings is the widespread presence of elevated carbon dioxide levels, which reflect insufficient ventilation in classrooms and daycare facilities. High carbon dioxide concentrations not only indicate poor air exchange but also correlate with the accumulation of other indoor pollutants. The observed associations between elevated carbon dioxide levels and reduced attention, impaired concentration, and decreased learning performance suggest that ventilation quality directly influences both health and academic outcomes.

Respiratory and allergic effects emerged as the most consistently reported health consequences of poor indoor air quality. Exposure to particulate matter, microbial contaminants, and volatile organic compounds was linked to increased prevalence of asthma symptoms, recurrent respiratory infections, and allergic reactions. Younger children, particularly those in kindergartens, appear to be especially vulnerable due to their developing immune and respiratory systems and prolonged indoor exposure. These findings align with previous research emphasizing the heightened sensitivity of children to environmental pollutants.

The presence of microbial contamination and dampness in educational buildings represents an additional risk factor for child health. Mold growth and elevated indoor humidity were associated with chronic respiratory symptoms and increased absenteeism. These conditions often reflect inadequate building maintenance and insufficient ventilation, highlighting the importance of structural and environmental management in schools and daycare facilities.

Beyond physical health, the impact of indoor air quality on cognitive function and learning capacity deserves particular attention. The association between poor air quality and reduced cognitive performance underscores the broader implications of indoor environmental conditions for educational achievement. Improving ventilation and reducing indoor pollutant levels may therefore yield benefits that extend beyond health protection to include enhanced learning efficiency and school performance.

Despite the clear evidence linking indoor air quality to child health, implementation of effective monitoring and control measures remains inconsistent. Resource limitations, lack of awareness, and insufficient regulatory enforcement contribute to persistent indoor air quality problems in many educational institutions. These challenges indicate the need for integrated policies that address building design, ventilation standards, routine monitoring, and health-based guidelines tailored to children's needs.

Overall, this discussion emphasizes that improving indoor air quality in schools and kindergartens should be considered a public health and educational priority. Interventions aimed at enhancing ventilation, controlling indoor pollution sources, and maintaining healthy building conditions have the potential to significantly reduce disease burden, improve cognitive outcomes, and promote healthier learning environments for children.

## Conclusion

The findings of this study demonstrate that indoor air quality has a substantial impact on the health and well-being of children in schools and kindergartens. Poor ventilation and elevated levels of indoor air pollutants, including particulate matter, carbon dioxide, volatile organic compounds, and microbial contaminants, are consistently associated with adverse respiratory outcomes, allergic conditions, and increased susceptibility to infections. Children's heightened vulnerability due to ongoing physiological development further amplifies these health risks.

In addition to physical health effects, suboptimal indoor air quality was shown to negatively influence cognitive performance, attention, and learning efficiency. Elevated carbon dioxide levels and inadequate air exchange were associated with reduced concentration and increased absenteeism, underscoring the importance of healthy indoor environments for both health protection and educational achievement.

The results highlight the need for systematic monitoring and management of indoor air quality in educational institutions. Improving ventilation systems, maintaining building infrastructure, controlling indoor pollution sources, and implementing evidence-based indoor air quality standards can significantly reduce health risks and enhance learning conditions for children.

In conclusion, ensuring good indoor air quality in schools and kindergartens should be regarded as a public health priority. Integrating environmental health considerations into educational policies and building management practices may contribute to healthier, safer, and more productive learning environments for children.

## References

1. Mendell, M. J., & Heath, G. A. (2005). Do indoor pollutants and thermal conditions in schools influence student performance? A critical review of the literature. Indoor Air, 15(1), 27–52. https://doi.org/10.1111/j.1600-0668.2004.00320.x
2. World Health Organization. (2010). WHO guidelines for indoor air quality: Selected pollutants. World Health Organization.
3. World Health Organization. (2021). WHO global air quality guidelines: Particulate matter ($PM_{2.5}$ and $PM_{10}$), ozone, nitrogen dioxide, sulfur dioxide and carbon monoxide. World Health Organization.

4. Salthammer, T., Uhde, E., Schripp, T., Schieweck, A., Morawska, L., Mazaheri, M., Clifford, S., He, C., Buonanno, G., Querol, X., & Viana, M. (2016). Children's well-being at schools: Impact of climatic conditions and air pollution. Environment International, 94, 196–210. https://doi.org/10.1016/j.envint.2016.05.009
5. Wargocki, P., & Wyon, D. P. (2013). Providing better thermal and air quality conditions in school classrooms would be cost-effective. Building and Environment, 59, 581–589. https://doi.org/10.1016/j.buildenv.2012.10.007
6. Haverinen-Shaughnessy, U., Moschandreas, D. J., & Shaughnessy, R. J. (2011). Association between substandard classroom ventilation rates and students' academic achievement. Indoor Air, 21(2), 121–131. https://doi.org/10.1111/j.1600-0668.2010.00686.x
7. Simoni, M., Annesi-Maesano, I., Sigsgaard, T., Norback, D., Wieslander, G., Nystad, W., Canciani, M., Sestini, P., & Viegi, G. (2010). School air quality related to dry cough, rhinitis and nasal patency in children. European Respiratory Journal, 35(4), 742–749. https://doi.org/10.1183/09031936.00056309
8. Bakó-Biró, Z., Clements-Croome, D. J., Kochhar, N., Awbi, H. B., & Williams, M. J. (2012). Ventilation rates in schools and pupils' performance. Building and Environment, 48, 215–223. https://doi.org/10.1016/j.buildenv.2011.08.018
9. Fisk, W. J. (2017). The ventilation problem in schools: Literature review. Indoor Air, 27(6), 1039–1051. https://doi.org/10.1111/ina.12403