INDOOR AIR QUALITY IN OUR SCHOOLS – WHY IT IS SO IMPORTANT FOR CHILD HEALTH?

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ABSTRACT

Introduction. It has been reported that the disease-initiated and disease-mediated effects of aerosol pollutants can be related to concentration, site of deposition, duration of exposure, as well as the specific chemical composition of pollutants.

Objective: to monitor the indoor aerosol pollution in primary schools with subsequent analysis of the concentration, size, and micro-elemental composition of pollutants and determine the indoor aerosol pollutant-related respiratory morbidity in younger school-age children.

Material and methods. 11 primary schools of Vilnius were included, and indoor aerosol pollution was regularly measured in these schools from 2016 to 2020 [1]. The total number of children participating in the study was 3638. Mean indoor air pollution based on measurements in classrooms during the lessons was calculated for each school. The total aerosol particle number concentration (PNC) in the size range of 0.01 to >1 µm was evaluated using a condensation particle counter (CPC, TSI model 3007). Particle number (PN) and particle mass (PM) concentrations in the size range of 0.3-10 µm were measured using an Optical Particle Sizer (OPS, TSI Model 3330). A micro-elemental analysis of aerosol pollutants was carried out using dust samples collected in places of natural dust sedimentation behind central heating radiators and from the surface of high cupboards. Samples were analyzed using a Spektro Xepos (XEPOS HE) and ED-XRF spectrometer. The concentrations of heavy metals Pb, W, Sb, Sn, Zr, Zn, Cu, Ni, Mn, Cr, V, and As were detected in dust samples. The samples of the surface material of the facades of old schools and other public buildings were analyzed for 137Cs content using a CANBERRA gamma-spectrometric system with the HPGe detector (model GC2520, 26.2% relative efficiency, resolution — 1.76 keV/1.33 MeV) according to the gamma line at 661.62 keV of 137mBa (a daughter product of 137Cs). Heavy metal concentrations were measured using an X-ray fluorescence spectrometer Niton XL2 Analyzer. The morbidity data of children aged 6-11 years from the same Vilnius schools were collected by the State Institute of Hygiene. It included doctor-recorded cases only. 505 pupils additionally filled in the PedsQLTM Multidimensional Fatigue Scale questionnaire

containing three domains: General Fatigue, Sleep/Rest Fatigue, and Cognitive Fatigue. Fatigue scores ranged from 0 to 100, higher scores meant less fatigue [4].

Results. It was found, that levels of PNC and PMC in study schools ranged between 33.0 and 168.0 particles/cm^3 and 1.7–6.8 µg/m^3, respectively [1]. Looking at the possible sources of elevated levels of air pollution in some schools, we found that due to the sandblasting of old facades of the buildings, the surface of the school sport yards was covered with a thin layer of scraped particles transported by gusts of wind into the school premises. Sandblasting of walls and facades can also be a source of aerosols with 137Cs activity concentrations reaching 40 Bq/kg and Pb up to 98 ppm [2]. It was found a statistically significant correlation between the incidence of asthma and PNC as well as asthma and PMC in the particle size range of 0.3–1 µm (r=0.66, p=0.028) and (r=0.71, p=0.017) respectively [1, 3]. The incidence of doctor-diagnosed asthma per school ranged from 1.8 to 6.0%. No significant correlation was found between asthma incidence and indoor air pollution in the particle size range of 0.3–2.5 and 0.3–10 µm. During the micro-elemental analysis of dust samples (natural sedimentation of aerosol pollutants), a correlation was found between vanadium concentration and acute infections of the upper respiratory tract (J00-J06), where the lowest correlation coefficient was r=0.67 (p=0.024), the highest r=0.82 (p=0.002). The concentration of vanadium in the samples of dust aggregates varied from 12.7 to 52.1 parts per million (ppm) [5]. No significant correlations between the other trace elements and the incidence of upper respiratory infections were found, which could be caused by a small number of study schools and relatively low concentrations of other heavy metals found in the samples of natural dust aggregates. The total fatigue scale score for all children was 67±3.4, with scale scores for General Fatigue at 74.9±3.9, Sleep/Rest Fatigue at 60±3.5, and Cognitive Fatigue at 66.2±3.3 points. A significant correlation was found between $PM_{2.5}$ concentration in the classroom and self-reported fatigue within the category Sleep/Rest Fatigue in response to the question “I feel tired” (r=-0.797; p=0.031).

Conclusions. The indoor aerosol pollution in the particle size range of 0.3-1.0 µm, in contrast to the particles of a larger size range, is associated with bronchial asthma morbidity in younger school-age children. Increased fatigue and learning retardation in younger school-age children are related to indoor concentration of particulate matter. Heavy metals, first of all, vanadium, in the school environment can be responsible for the increased susceptibility to acute upper respiratory infections in children. Monitoring the concentration of aerosol pollution in the indoor school environment should be an important tool for the prevention and control of respiratory morbidity in children.

References.

1. Juskiene I, Prokopciuk N, Franck U, Valiulis A. Indoor air pollution effects on pediatric asthma are submicron aerosol particle-dependent. European Journal of Pediatrics. 2022;181:2469-80. DOI: 10.1007/s00431-022-04443-6

2. Prokopciuk N, Juskiene I, Tarasiuk N, Valiulis A. On the additional risk for human health in the use of sandblasting of building walls. Environmental Science and Pollution Research. 2023;30(19):56558-68. DOI: 10.1007/s11356-023-26382-x

3. Sauliene I, Valiulis A, Keriene I, Damialis A. Airborne pollen and fungi indoors: evidence from primary schools in Lithuania. Heliyon. 2023;9(1):e12668. DOI: 10.1016/j.heliyon.2022.e12668

4. Taminskiene V, Vaitkaitienene E, Turner S, Valiulis A. Parents underestimate fatigue in younger children aged 5-7 years with asthma but not in older children. Acta Paediatrica. 2024;113(2):303-308; DOI: 10.1111/apa.17005

5. Prokopciuk N, Taminskiene V, Vaideliene L, Valiulis A. Vanadium in indoor dust aggregates is related to the incidence of respiratory infections in children. Frontiers in Pediatrics. 2024, *in press*