Global Alliance against Chronic Respiratory Diseases demonstration project: aerosol pollution and its seasonal peculiarities in primary schools of Vilnius

Nina Prokopciuk1,2, Ulrich Franck3, Vadimas Dudoitis1, Nikolaj Tarasiuk1, Izabele Juskiene2, Daiva Cepuraite4, Kestutis Staras5, Algirdas Valiulis6, Vidmantas Ulevicius1, Arunas Valiulis2

1Department of Environmental Research, SRI Center for Physical Sciences and Technology, Vilnius, LT-02300, Lithuania; 2Department of Public Health, Institute of Health Sciences, and Department of Children’s Diseases, Institute of Clinical Medicine, Vilnius University Faculty of Medicine, Vilnius, LT-03101, Lithuania; 3Department of Environmental Immunology, Helmholtz Centre for Environmental Research–UFZ, Leipzig, GE-04318, Germany; 4Department of Public Administration, Mykolas Romeris University, Vilnius Centro Outpatient Clinic, Vilnius, LT-01117, Lithuania; 5Department of Public Health, Vilnius University Faculty of Medicine, Vilnius Centro Outpatient Clinic, Vilnius, LT-01117, Lithuania; 6Department of Rehabilitation, Physical and Sports Medicine, Vilnius University Medical Faculty, Institute of Health Sciences, Vilnius, LT-03101, Lithuania.

Abstract
Background: The growing public health concern caused by non-communicable diseases in urban surroundings cannot be solved by health care alone; therefore a multidisciplinary approach is mandatory. This study aimed to evaluate the airborne aerosol pollution level in primary schools as possible factor influencing origin and course of the diseases in children.

Methods: Seasonal aerosol particle number concentration (PNC) and mass concentration (PMC) were studied in the randomly selected eleven primary schools in the Lithuanian capital, Vilnius, as model of a middle-size Eastern European city. Total PNC in the size range from 0.01 to >1.0 μm in diameter was measured using a condensation particle counter. Using an optical particle sizer, PNC was measured and PMC estimated for particles from 0.3 to 10.0 μm. A descriptive statistics was used to estimate the aerosol pollution levels.

Results: During all seasons, local cafeterias in the absence of ventilation were the main sources of the elevated levels of indoor PMC and PNC (up to 97,500 particles/cm3). The other sources of airborne particulates were the children’s activity during the lesson breaks with PMC up to 586 μg/m3. Soft furniture, carpets in the classrooms and corridors were responsible for PMC up to 200 μg/m3. Outdoor aerosol pollution (up to 18,170 particles/cm3) was higher for schools in city center. Elevated air pollution in classrooms also resulted from intermittent sources, such as construction work during classes (200–1000 μg/m3) and petrol-powered lawn trimmers (up to 66,400 particles/cm3).

Conclusion: The results of our survey show that even in a relatively low polluted region of Eastern Europe there are big differences in aerosol pollution within middle-sized city. Additional efforts are needed to improve air quality in schools: more frequent wet cleaning, monitoring the operation of ventilation systems, a ban on construction works during school year, on a use of sandblasting mechanisms in the neighborhood of schools.

Keywords: Children; Indoor aerosol; Pollution levels; Primary school; Systematic and occasional sources; Ventilation

Introduction
Health promotion and prevention should start at conception and be continued across the life cycle for healthy lungs and active and healthy aging. They form the basis of the goals of the Europe 2020 strategy of healthy and active aging, the United Nations’ Sustainable Development Goals for 2030, and the World Health Organization (WHO) strategy on non-communicable diseases (NCDs).[1,2] The growing public health concern caused by NCDs in urban surroundings must be solved in the frame of the multidisciplinary study, paying special attention to the air pollution levels.[3]

According to WHO, ambient particulate matter is responsible for an increased number of respiratory and...
cardiovascular diseases and deaths. \cite{1,4,5} For each 10 μg/m³ increase in particle mass concentrations (PMC) of particles less than or equal to 10 μm (PM10), respiratory mortality increases by 3.4% and cardiovascular mortality increases by 1.4%. \cite{6}

Taminskiene et al \cite{7} emphasize that clinicians should be mindful not only of the impact of asthma on the child and the family, but also consider exploring factors not directly related to childhood asthma, including increased tension and anxiety in family, financial hardships, and the impaired balance of personal and professional life.

Children are more susceptible to air pollution than adults. \cite{8,9} Franck et al \cite{10} and Breitner et al \cite{11} have shown that in assessing the impact on human health and respiratory diseases, sub-micron aerosol fraction (<1 μm) becomes more important, and both the mass and number concentrations should be considered. However, parallel studies of both aerosol number and mass concentrations in schools are scarce, especially those evaluating the influence of outdoor aerosol pollution affecting indoor air. Reports presenting the results of measurements of particle concentra- tions in schools have been recently published. \cite{12,13,14,15,16} Blondeau et al \cite{12} studying indoor to outdoor ratios of nitrogen oxides, ozone and particle number (0.3–15.0 μm) concentrations in eight schools of La Rochelle, France, found that one of the main sources of indoor air pollution by coarse particles (size range from 2.5–10.0 μm in diameter) was their re-suspension due to the pupil activity.

The schools indoor pollution and health observatory network in Europe project showed that in many European countries air quality in schools is an urgent problem. \cite{15} Fromme et al \cite{11} also found a high exposure of pupils in schools to particulate matter and a correlation between carbon dioxide concentrations and indoor aerosol pollution in schools. Main outdoor sources of air pollution, such as traffic emissions and residential heating, also affect the air quality in schools. \cite{16}

The aim of our survey was to evaluate the main seasonal aerosol pollution levels and its sources in primary schools of Lithuanian capital, Vilnius, with about 570,000 inhabitants, as model of middle-size Eastern European city. Seasonal indoor and outdoor aerosol particle number and mass concentrations were measured and estimated in Lithuania as a Global Alliance against Chronic Respiratory Diseases demonstration project. \cite{11}

**Methods**

**Sampling sites and school description**

Vilnius, situated at 54°41’17” N, 25°15’58” E, is located between two rivers, the Neris and the Vilnia, in a heavily hilly area. We sent invitations to all 107 Vilnius schools to participate in the study, 25 of them agreed and agreed on second of the list we included in the study. However, one of the selected schools did not have primary classes and was rejected. In this way, 11 schools were randomly selected to participate in the study. Selected schools were located in areas of different outdoor air pollution levels. Schools numbered 1, 5, 7, 10 were located in the downtown area; schools numbered 2, 3, 4, 6, and 8 were located in the peripheral part of the city and those numbered 9 and 11 were located in the suburbs (Figure 1).

**Methodology**

A condensation particle counter (CPC; TSI model 3007, total aerosol particle number concentration (PNC) in the range of 0.01 to >1.0 μm) and an optical particle sizer (OPS; TSI model 3330, aerosol PNC and its distribution by sizes in the range of 0.3–10.0 μm) were used. PNC (CPC) is total PNC measured by CPC. PNC (OPS) and PMC (OPS) are PNC and PMC measured and evaluated by OPS, respectively.

The PNC was calculated by OPS software, with the pre-defined particle density of 1 g/cm³. Before measurements, the instruments were checked for contamination by using high efficiency particulate airworstance filters.

The indoor aerosol pollution in the classrooms, corridors, and nearby cafeterias of the primary schools was measured. Because of the technical requirements of the CPC (air temperature – higher than 10°C and air humidity – below 70%), outdoor aerosol concentrations were measured in late autumn and winter usually for some (6–7) min in rooms in an induced draught. In spring, outdoor measurements were carried out near schools for 10 min. In the schools, indoor measurements were carried out during lessons from 9 until 14 h in four or five classrooms on different floors for 10 min each. The devices were placed on the last desk of the classroom. Indoor measurements were also carried out near the cafeterias and in the corridors during the lesson breaks. The data collection period lasted from the start of the heating season in October 2017 until May 2018. In autumn and winter, in each school, measurements were repeated twice, while in spring measurements were repeated up to three times.

**Results**

**Systematic sources of indoor pollution**

Typical data on aerosol pollution in school No. 3

A typical situation can be shown using measurements in autumn in school No. 3 located in the peripheral part of the city (Figures 2 and 3). At this time, total PNC (CPC) and PMC (OPS) near the cafeteria (first floor) varied from 40,000 to 78,000 particles/cm³ and from 100 to 140 μg/m³, respectively. The cafeteria appeared to be responsible for high PNC values (up to 24,000 particles/cm³) in the classrooms on the second and third floors of the building because of the air circulation. Low PNC values in the classrooms on the first floor were related to low outdoor PNC (about 9000 particles/cm³). Apparently, in the classroom nearby the cafeteria, due to coarse aerosol settling after the lesson break, high PMC (OPS) values decreased during measurements from about 270 μg/m³ after the lesson beginning down to about 150 μg/m³. Main determinants of PMC were the pupils’ activity during lesson breaks and ventilation in the classroom.
during the lesson when all windows were closed, rather elevated PMC values in the classroom on the first floor were estimated between 90 and 120 mg/m³ [Figure 2A–D].

In winter, near the cafeteria, very high PNC (CPC) and PMC (OPS) values were measured and estimated. A peak of PMC (about 500 μg/m³) was estimated when the door to the cafeteria was opened and a group of pupils left the cafeteria. PNC (CPC) in the corridor on the third floor decreased with time down to values of outdoor air when the windows were opened. In the second-floor corridor, PNC stayed nearly constant during the lessons (squares) and lesson break interval (circles) when the cafeteria ventilation was switched on. PMC on the third floor showed a peak during a lesson break up to 560 μg/m³ [Figure 3A and 3B].
A use of carpets and soft furniture in schools

Classrooms, corridors, and lounges in many schools are furnished with soft furniture (chairs, cushions) and carpets. In primary schools, wardrobe coat racks are often organized in classrooms, as well. Soft articles may be a source of particles. In school No. 6 in a corridor with a large carpet (3 m × 5 m), a significant rise in PMCs occurred with pupil activity at the beginning of the lesson break [Figure 4].

Summary of seasonal data on PNC (CPC) and (OPS) in the schools participating in the research project

Seasonal data on PNC (CPC) and (OPS) in the schools participating in the research are presented in Tables 1 and 2 (autumn), Tables 3 and 4 (winter), and Tables 5 and 6 (spring). It can easily be seen that the highest PNC (CPC) values in classrooms were measured in schools No. 3 and No. 4 due to the respective high PNC values measured in cafeterias [Table 1]. Elevated outdoor PNC (OPS), which exceeded their maximum indoor values in the classrooms, were only measured near school No. 1 [Table 2]. Maximum PMC (OPS) estimated by OPS software in all classrooms in the studied schools varied in the range of 70 to 275 μg/m³ and exceeded the outdoor values. It means that in autumn, the cafeterias were the main source of fine (sizes up to 2.5 μm, PM2.5) and coarse particles in all studied schools.

During winter of 2017 to 2018, the highest PNC (CPC) values in classrooms were determined in schools No. 1, 3, 4, 5, 6. It was not only due to high PNC values measured in their cafeterias. Thus, in schools No. 4 and No. 5, it was likely, due to high outdoor PNC values. In the absence of ventilation, high PNC maximum values were measured in the cafeterias of schools No. 10 and No. 11. In school No. 10, during the measurements in the classrooms, the ventilation was switched on and low PNC values were obtained [Table 3]. In school No. 11, the cafeteria was located far from the classrooms and had insignificant impact on the situation in the other school lodgements. It explains low PNC values measured in the classrooms [Table 3].

In the winter of 2017 to 2018, outdoor data on PNC (OPS) exceeded the maximum values in classrooms in schools No. 1, 2, 4, 6, 7 [Table 4] and possibly, partially influenced the indoor situation. The respective outdoor data on PMC estimated by OPS software were low and varied in the range of 7 to 25 μg/m³. Due to the cafeterias, elevated maximum PMC values were estimated in classrooms in schools No. 1, 2, 3, 8, 10, and No. 11 in the range of 74 to 1348 μg/m³. In the classroom in school No. 5, maximum PMC value (about 564 μg/m³) was related to the influence of construction works carried out on the unpopulated third floor. Also, the pupil activity during the lesson breaks in
Table 1: Autumn 2017 data on total particle number concentration (PNC [CPC]) (particles/cm³) in the schools participating in the research.

| School | Classroom Median | Max | Min | 95th | 5th | Outdoor Median | Max | Min | 95th | 5th | Extreme value |
|--------|------------------|-----|-----|------|-----|----------------|-----|-----|------|-----|--------------|
| 1      | 6036             | 14,507 | 4642 | 12,972 | 4981 | 47,019 | 52,705 | 39,274 | 50,604 | 39,274 | 16,833      |
| 2      | 4511             | 11,225 | 4149 | 9965  | 4331 | 11,177 | 14,273 | 9723  | 13,477 | 9823  | 13,577      |
| 3      | 10,194           | 24,158 | 6080 | 23,414 | 7286 | 58,578 | 76,739 | 41,759 | 75,278 | 41,759 | 9595        |
| 4      | 11,878           | 17,697 | 9160 | 16,963 | 9431 | 20,292 | 71,929 | 14,994 | 70,674 | 15,609 | 7911        |
| 5      | 6408             | 9052  | 3592 | 8890  | 3720 | 35,951 | 39,372 | 19,808 | 39,350 | 19,808 | 5463        |
| 6      | 5254             | 8142  | 3896 | 7454  | 4017 | 35,987 | 37,157 | 34,653 | 37,157 | 34,653 | 5371        |
| 7      | 2389             | 2832  | 2034 | 2752  | 2051 | 19,128 | 22,272 | 17,516 | 22,272 | 17,516 | 4939        |
| 8      | 6641             | 7718  | 4417 | 7525  | 4640 | 34,200 | 40,696 | 32,307 | 40,485 | 32,307 | 4304        |
| 9      | 2262             | 5131  | 1784 | 5087  | 1821 | 4400  | 5088  | 4175  | 4937  | 4175  | 4454        |
| 10     | 2879             | 3310  | 1895 | 3240  | 2027 | 4563  | 5393  | 3518  | 5393  | 3518  | 3595        |
| 11     | 1965             | 4042  | 1742 | 2319  | 1831 | 6439  | 8361  | 5901  | 8361  | 5901  | 2664        |

CPC: Condensation particle counter.

Table 2: Autumn 2017 data on particle number concentration (PNC [OPS]) (particles/cm³) in the schools participating in the research.

| School | Classroom Median | Max | Min | 95th | 5th | Outdoor Median | Max | Min | 95th | 5th | Extreme value |
|--------|------------------|-----|-----|------|-----|----------------|-----|-----|------|-----|--------------|
| 1      | 151              | 248  | 119 | 230  | 122 | 492            | 833 | 451 | 833  | 451 | 287          |
| 2      | 32               | 101  | 19  | 50   | 20  | 52             | 311 | 46  | 146  | 46  | 74           |
| 3      | 72               | 110  | 68  | 83   | 68  | 182            | 216 | 216 | 160  | 160 | 89           |
| 4      | 26               | 48   | 23  | 47   | 23  | 37             | 252 | 33  | 252  | 33  | 36           |
| 5      | 97               | 284  | 64  | 152  | 66  | 288            | 366 | 366 | 197  | 197 | 100          |
| 6      | 41               | 118  | 25  | 83   | 26  | 161            | 180 | 157 | 180  | 157 | 32           |
| 7      | 94               | 123  | 87  | 114  | 87  | 142            | 149 | 136 | 149  | 136 | 104          |
| 8      | 20               | 669  | 12  | 230  | 12  | 35             | 37  | 37  | 37   | 37  | 9            |
| 9      | 19               | 163  | 11  | 28   | 12  | 27             | 43  | 25  | 43   | 25  | 15           |
| 10     | 57               | 648  | 34  | 381  | 34  | 105            | 123 | 96  | 123  | 96  | 89           |
| 11     | 36               | 350  | 29  | 114  | 30  | 104            | 233 | 92  | 233  | 92  | 85           |

OPS: Optical particle sizer.

Table 3: Data on total particle number concentration (PNC [CPC]) (particles/cm³) in the schools participating in the research in the winter of 2017–2018.

| School | Classroom Median | Max | Min | 95th | 5th | Outdoor Median | Max | Min | 95th | 5th | Extreme value |
|--------|------------------|-----|-----|------|-----|----------------|-----|-----|------|-----|--------------|
| 1      | 47,934           | 53,000 | 38,900 | 50,701 | 38,900 | 13,679          |
| 2      | 12,371           | 19,324 | 7481  | 17,856 | 7481  | 10,047          |
| 3      | 67,751           | 84,584 | 42,475 | 84,584 | 42,475 | 7137           |
| 4      | 13,880           | 18,716 | 12,192 | 17,111 | 12,192 | 16,909          |
| 5      | 6868             | 7262  | 6374  | 7238  | 6374  | 18,170          |
| 6      | 83,895           | 97,563 | 71,348 | 96,038 | 71,348 | 7431           |
| 7      | 97,577           | 28,113 | 8840  | 28,113 | 8840  | 9949           |
| 8      | 4427             | 4973  | 3206  | 4669  | 3273 | 6092           |
| 9      | 4004             | 6853  | 1880  | 6630  | 1962 | 5163           |
| 10     | 2728             | 3289  | 2143  | 3215  | 2269 | 5091           |
| 11     | 2881             | 3536  | 2633  | 3477  | 2641 | 3091           |

CPC: Condensation particle counter.
In spring of 2018, rather low outdoor PNC (CPC) values were measured in all studied schools [Table 5]. In schools without adequate ventilation, maximum PNC values in their cafeterias in the range of 20,849 to 95,535 particles/cm³ were determined. However, elevated PNC median values (7,107–9,146 particles/cm³) were calculated only in the classrooms in schools No. 1 and No. 4. Compulsory ventilation systems were switched on in schools No. 2, 3, and No. 9 (low PNC values in the cafeterias). In school No. 2, ventilation was switched on and off during our measurements in the classrooms, which resulted in a rather high range of PNC (CPC) variations (2,957–17,205 particles/cm³).

In spring, data on the outdoor PNC (OPS) values showed that they were significantly elevated in schools No. 1 and No. 10 and possibly, influenced the maximum respective values in their classrooms. School No. 1 is located in the downtown and possibly, the intensive traffic emissions were responsible for maximum PNC (OPS) value in the classroom (about 1338 particles/cm³). In school No. 10, high maximum PNC value (about 502 particles/cm³) in the classroom was related to the outdoor source—a basketball game. In the other schools, cafeterias and the pupil activity during the lesson breaks were responsible for the elevated PNC values in the classrooms [Table 6].

In spring of 2018, estimated PMC (OPS) maximum values in the classrooms in studied schools varied in the range of 99 to 1037 mg/m³. The latter high value was caused by construction works, which were performed on the second floor in school No. 3. A significant indoor PMC value (about 227 µg/m³) was also estimated in the classroom in school No. 10 during a basketball game on the sport yard (outdoor median PMC value was about 272 µg/m³). In the absence of ventilation, cafeterias influenced elevated PMC values in the classrooms in schools No. 2 and No. 5. Resuspension of deposited particles due to the interior activity of pupils during lesson breaks was responsible for the maximum PMC values in schools No. 1 and No. 6 (236–261 µg/m³) when the ventilation systems in the cafeterias were switched on. In schools No. 7 and No. 8, outdoor pollution may be responsible for rather high maximum

### Table 4: Winter (2017–2018) data on particle number concentration (PNC [OPS]) (particles/cm³) in schools participating in the research.

| School | Classroom | Cafeteria | Outdoor | Extreme value |
|--------|-----------|-----------|---------|---------------|
| 1      | 151       | 176       | 128     | 170           | 131           |
| 2      | 128       | 148       | 100     | 146           | 101           |
| 3      | 156       | 329       | 100     | 263           | 101           |
| 4      | 128       | 142       | 97      | 140           | 98            |
| 5      | 198       | 315       | 162     | 276           | 163           |
| 6      | 211       | 272       | 156     | 260           | 158           |
| 7      | 154       | 221       | 95      | 219           | 95            |
| 8      | 42        | 57        | 37      | 47            | 37            |
| 9      | 90        | 190       | 55      | 134           | 56            |
| 10     | 102       | 216       | 68      | 184           | 68            |
| 11     | 214       | 289       | 158     | 277           | 158           |

OPS: Optical particle sizer.

### Table 5: Spring 2018 data on total particle number concentration (PNC [CPC]) (particles/cm³) in the schools participating in the research.

| School | Classroom | Cafeteria | Outdoor | Median | 95th | 5th |
|--------|-----------|-----------|---------|--------|------|-----|
| 1      | 7,107     | 11,808    | 4,527   | 10,579 | 4552 |
| 2      | 3,974     | 17,205    | 2,957   | 15,391 | 3,052 |
| 3      | 3,520     | 5,212     | 2,723   | 5,011  | 2,832 |
| 4      | 9,146     | 16,149    | 9,600   | 15,901 | 5,047 |
| 5      | 5,113     | 6,729     | 4,363   | 6,613  | 4,377 |
| 6      | 6,549     | 9,056     | 4,275   | 8,738  | 4,448 |
| 7      | 5,708     | 8,335     | 4,024   | 8,107  | 4,535 |
| 8      | 6,451     | 8,638     | 3,627   | 7,091  | 3,684 |
| 9      | 2,717     | 3,187     | 2,158   | 2,866  | 2,177 |
| 10     | 3,609     | 30,999    | 1,734   | 25,983 | 1,895 |
| 11     | 2,064     | 30,995    | 1,105   | 29,232 | 1,126 |

∗In this case, data were estimated without an influence of an occasional pollution source related to the use of a petrol-powered engine in the schoolyard.

CPC: Condensation particle counter.
PMC values (152 and 158 μg/m³, respectively) in the classrooms. Thus, 95th of the outdoor PMC values were equal to 243 and 251 μg/m³, respectively.

**Occasional pollution sources**

In addition to the already mentioned sources of indoor aerosol pollution (cafeterias, lesson break activity, soft furniture, and carpets), other occasional pollution sources may be present.

A use of a petrol-powered engine in schoolyard works

In spring, the use of petrol-powered brush cutters or trimmers in the schoolyard during lessons induced a significant increase in fine particle number and coarse PMCs in some classrooms. In school No. 8, a maximum PNC (CPC) value (66,439 particles/cm³) and PMC of 140 μg/m³ measured in the classroom on the first floor, were associated with the use of a petrol grass trimmer in the schoolyard.

First and second floor classrooms on the other side of the building had low PNC values. Elevated PMC values of about 158 to 122 μg/m³ in the classroom on the second floor appear to be related to activity related to the lesson break [Figure 5A and 5B].

Construction works during lessons

In spring, PMC increased in some classrooms on the first floor because of construction work on the second floor for almost a week. The PMC in the classroom, where construction waste was dumped under the windows, reached about 1000 μg/m³. Other classrooms had PNC (CPC) similar to the outdoor air (3000–5000 particles/cm³).
PNC in the corridors on the second and the third floors were similar to those in the classrooms. PMC values in the classroom on the second floor, where the construction work was taking place, were elevated (up to 200 \( \mu g/m^3 \)). Coarse particles due to construction works affected also the situation in the corridor on the second floor where at the beginning of the measurements during the lesson break, PMC (OPS) amounted to about 420 \( \mu g/m^3 \). On the third minute, lessons began and PMC decreased with time down to about 130 \( \mu g/m^3 \) [Figure 6A–D].

A use of sandblasting mechanisms for wall scraping near schools

The use of sandblasting mechanisms for wall scraping near schools poses a serious hazard to pupils. The outdoor PNC and PMC values near the entrance of school No. 10 during a basketball game on the schoolyard are presented in Figure 7. Scraping the walls of a neighboring building with a sandblasting mechanism caused the surface of the schoolyard to be covered with a thin layer of scraped particles. An analysis of indoor pollution showed that there were particles in the size range of 0.3 to 3.5 \( \mu m \) diameter.\[^{18}\] During a basketball game, the particles were lifted off the ground by the children playing and due to wind gusts transferred indoors. To confirm this hypothesis, outdoor measurements were repeated near the schoolyard several times within a month.

**Discussion**

Pupils of the primary schools spend much time in school premises. Therefore, it is very urgent to determine the air pollution levels and identify its sources indoors for the aim to have more opportunities to control and minimize the pupil exposure. This study found that the main source of aerosol pollution in these schools was related to cafeterias. It is the matter of fact that in the schools, hot meal is always freshly prepared in the local cafeterias. Given the spoilt or inadequate ventilation, school cafeterias turn into a source of high fine and coarse PNC and PMC in the classrooms. Daisey et al\[^{19}\] designated that inadequate ventilation and high CO\(_2\) concentrations in the US schools are related to the elevated health risks for pupils. The importance of cafeterias as a source of indoor ultrafine particle (less than 0.1 \( \mu m \) in diameter) concentrations in classrooms has been found in the other studies.\[^{20,21}\] Cooking and eating time was responsible for 83% of the total ultrafine particle exposure in schools in Italy.\[^{22}\] The effects of petrol-powered tools should be expected with the well-known association of traffic-related particle matter generation. Thus, it was determined in the study of Rivas et al\[^{23}\] that elevated mineral contents of indoor PM\(_{2.5}\) measured in Barcelona schools were due to the additional component of microelements of traffic emissions previously deposited on the sand-filled school sport yards. Being scraped from the sand particles and lifted off the ground during games, those microelements were easily transferring indoors.

Soft furniture, carpets, wardrobes in the classrooms, dusty wear and cleaning without wetting surfaces appear to be the cause of increased coarse particle concentrations probably by re-suspension from the surfaces. The PNC and PMC increase from the beginning of the lesson break could relate not only with the soft furniture and carpets, but also with the pupil clothes. Textile fragmentation due to friction may be also a source of coarse aerosol particles. The influence of pupil clothes fibers on the formation of PMCs was observed in schools in Barcelona.\[^{12,13}\] Repeated wet cleaning of school premises may help reduce the recirculation of particle matter in schools.

This study also showed that construction work during school hours and sandblasting mechanisms in the
neighborhood of schools are important hazards. It is known that construction works are always followed by emissions of airborne substances, which induce harmful effects on health. Thus, volatile organic compounds released in the gas form from building materials can irritate respiratory system, eyes and skin. Disturbing dirty areas during construction works, particulate matter may consist from debris of paint materials toxic to nervous system, heavy metals and carcinogenic asbestos. Particulate matter may also consist of biological materials, such as mold and fungi, which can induce infection and allergic diseases.

Conclusions

The results of our survey show that even in relatively low polluted region of Eastern Europe there are big differences in aerosol pollution within a city. Only in two suburban Vilnius schools could the situation be considered satisfactory with respect to indoor particle matter concentrations. In the other schools, in different seasons, maximum values of the aerosol number and mass concentrations in classrooms varied in the range of 2800 to 31,000 particles/cm³ and of 70 to 590 µg/m³, respectively. Aerosol mass concentrations in classrooms associated with construction works reached almost 1000 µg/m³. Outdoor aerosol mass concentrations during casual events such as the use of sandblasting mechanisms near the schools may reach several mg/m³. Therefore, carrying out of such works should be restricted.

During all seasons, cafeterias were the main source of indoor air pollution in these schools due to the spoiled or inadequate ventilation. In winter, pupils spend most time indoors and soft furniture, carpets, and pupil clothes could be an additional source of elevated PMC in classrooms and corridors. Therefore, frequent wet cleaning of the premises and monitor of the ventilation systems will help improving air quality in school lodgements. Considering that indoor aerosol sources are mainly responsible for the pollution levels in school premises, the proposed method for assessing aerosol air pollution in schools, conducted in the frame of a pilot study, can be further used to collect statistics on air pollution and establish correlation with data on respiratory diseases of pupils.

Acknowledgements

The authors are very thankful to the Helmholtz Centre for Environmental Research GmbH - UFZ in Leipzig (Germany), Agreement on Cooperation No. RA-236/17, for the technical support and valuable advice.

Conflicts of interest

None.

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Acknowledgements

The authors are very thankful to the Helmholtz Centre for Environmental Research GmbH - UFZ in Leipzig (Germany), Agreement on Cooperation No. RA-236/17, for the technical support and valuable advice.

Conflicts of interest

None.

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How to cite this article: Prokopciuk N, Franck U, Dudotis V, Tarasiuk N, Jusksiene I, Cepuraite D, Staras K, Valulius A, Ulevicius V, Valulius A. Global Alliance against Chronic Respiratory Diseases demonstration project: aerosol pollution and its seasonal peculiarities in primary schools of Vilnius. Chin Med J 2020;133:1516–1525. doi: 10.1097/CM9.0000000000000913