For NO_2, the average levels ranged from 12 μg/m^3 to 22 μg/m^3 with the highest average level observed in Serbia. These levels were substantially below the WHO guidelines value of 200 μg/m^3 for annual mean level and also below the short-term guideline of 40 μg/m^3 for 1-hour average level.

Average concentrations of formaldehyde varied widely among the participating countries from 1.7 μg/m^3 in Serbia to 33.1 μg/m^3 in Italy. These values are well below the WHO guideline value of 100 μg/m^3 for 30 minute average. Although concentrations were measured during one school week, variability of formaldehyde levels in time is likely to be limited as this compound is steadily emitted from certain indoor materials.

Fig. 3 presents the relationships between the indoor and outdoor concentrations of various pollutants in the surveyed schools. The low ratios for NO_2, PM_{10} and benzene show that main sources of these pollutants were located outdoor (mainly traffic), while higher ratios for VOCs and especially for formaldehyde show that these pollutants were mainly emitted from indoor sources.

The mean floor space per child in all classrooms was 2.0 m^2/child. Overcrowding (less than 1.5 m^2/child) in the classroom was associated with significant increases in concentrations of several pollutants, such as CO_2, benzene, toluene and PM_{10}. In overcrowded classrooms significantly more children suffered from respiratory tract symptoms compared to children in reference classrooms with adequate space (Fig. 4).

Based on the survey results, the following recommendations can be suggested: overcrowding in the classrooms should be avoided; ventilation should be improved by opening windows during each break or, when appropriate, during classes; sources of emissions of formaldehyde and VOCs indoors should be minimized; schools should not be built near roads with busy traffic or other sources of air pollution.

Table 9. Average levels of indoor air pollutants in schools

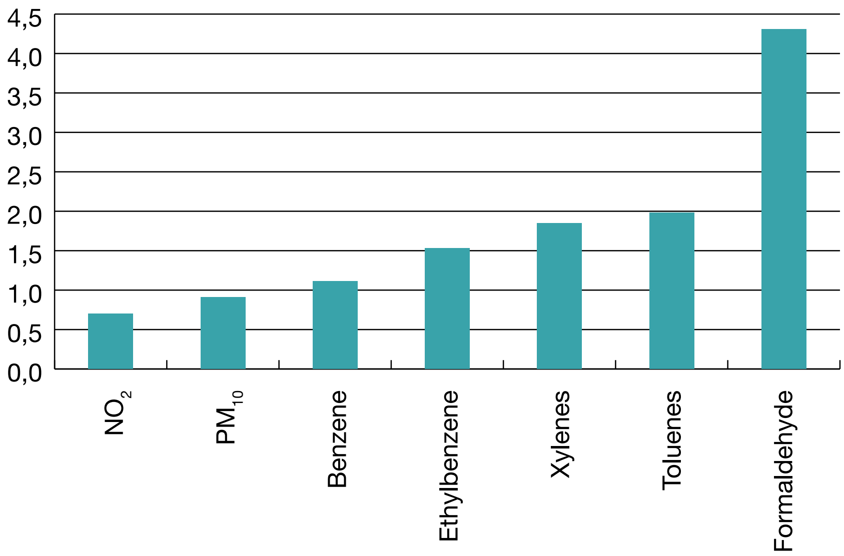
Pollutant	Albania	Belarus	Bosnia and Herzegovina	Hungary	Italy	Kazakhstan	Serbia	Slovakia	Tajikistan	Ukraine
PM_{10} (μg/m^3)	69	28	102	56	82	65	81	80	91	33
Formaldehyde (μg/m^3)	5.6	7.5	7.1	2.4	33.1	10.4	1.7	8.7	12.9	11.5
Benzene (μg/m^3)	4.1	2.0	6.3	2.2	2.0	6.3	5.9	4.8	7.4	2.5
Toluene (μg/m^3)	15.5	6.2	27.6	4.6	5.0	18.1	21.9	29.5	17.4	4.9
Ethylbenzene (μg/m^3)	1.2	0.9	1.6	1.6	1.8	1.6	1.6	1.4	1.5	0.8
Xylenes (μg/m^3)	5.0	5.9	7.7	7.0	7.1	9.1	8.0	5.1	7.0	4.3
NO_2 (μg/m^3)	12	10	21	16	19	17	22	14	13	12

Source: data from the SEARCH project (Csobod et al., 2010).

The comfort assessment was a useful tool for collecting information from children about their perceptions of the school environment. The children's subjective perceptions were well supported by objective measurements of temperature, relative humidity and CO_2 concentrations. The results show that 48% of children considered the indoor temperature in classrooms to be higher than optimal (typically, children considered the air temperature to be too high when it exceeded 22° C). Regression analysis of data also demonstrated that poor quality, stuffy air in classrooms was associated with an increase in self-reported headache symptoms in pupils.

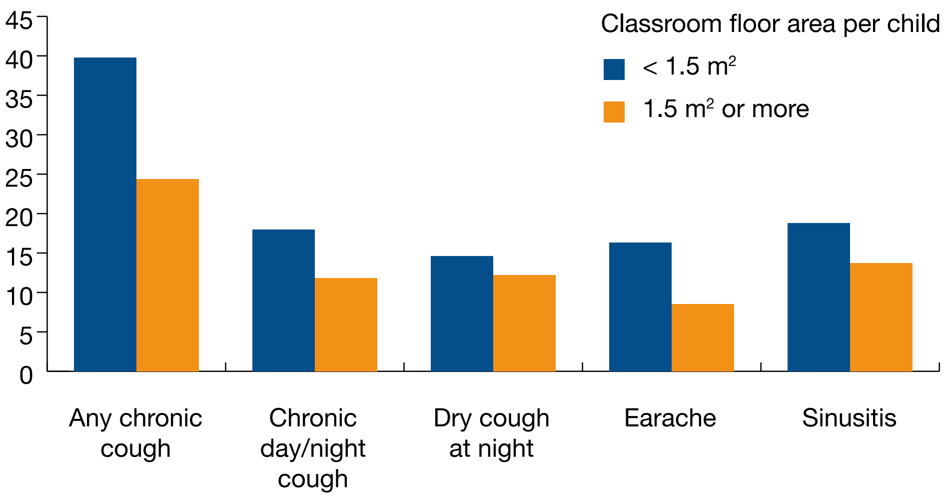
Based on the analysis of data on energy consumption in schools, it was concluded that the modernisation of the building structures and heating, ventilation, and air conditioning (HVAC) systems has a large energy-saving potential.

Fig. 3. Average ratios of indoor and outdoor concentrations of pollutants in schools



Source: combined data from ten countries which participated in the SEARCH project.

Fig. 4. Percent of children with specific symptoms by classroom occupation density



Source: data from the SEARCH project

3.2.2 SINPHONIE survey

Background and objectives

The SINPHONIE (Schools Indoor Pollution and Health: Observatory Network in Europe) project was conceived as a pilot research project to assess the quality of indoor air in schools and outdoor air in the school vicinity, and to establish a European observatory network focused on school indoor air pollution and health. This multidisciplinary project was conducted during 2010–2012. The project was initiated and funded by the European Parliament. It was carried out under a contract with DG SANCO.

SINPHONIE also aimed at improving IAQ assessments in European schools though developing methods and procedures for surveys. The project used standardized data collection procedures which were implemented by specially trained national survey staff.

The SINPHONIE project had synergies with other concurrent projects such as the European Commission's PILOT INDOOR AIR MONIT project (Kephalopoulos et al., 2013), the WHO Schools Survey (WHO Regional Office for Europe, 2011) and the SEARCH project (Csobod et al., 2010).

The project also produced recommendations on improving the quality of environment in schools which are described in section 2 of this report.

The project involved the following specific aims:

- measure physical and comfort parameters (temperature, relative humidity and ventilation rate) and chemical and biological pollutants in the indoor and outdoor air in schools and childcare facilities: formaldehyde, benzene, α-pinene and limonene, naphthalene, NO_2, carbon monoxide, CO_2, radon, trichloroethylene, tetrachloroethylene, PAH and benzo(a) pyrene (BaP), PM_{10} and $PM_{2.5}$, allergens in dust and mould, and bacteria in dust and air;
- evaluate the impact of the outdoor air surrounding the school environment, including the effects of transportation, traffic and climate change;
- assess the influence of building characteristics, cleaning products and ventilation systems on the exposure data obtained;
- assess the impacts of outdoor air pollution abatement measures on IAQ in schools;
- obtain data on the health status of children via questionnaires and clinical tests, focusing on asthma, respiratory infections, upper respiratory tract symptoms, coughing, wheezing, dyspnoea, allergic rhinitis, bronchitis and academic performance;
- evaluate the impact of the indoor air in classrooms on children's health and academic performance;
- develop recommendations and guidelines on remedial measures in school environments.

Methodology

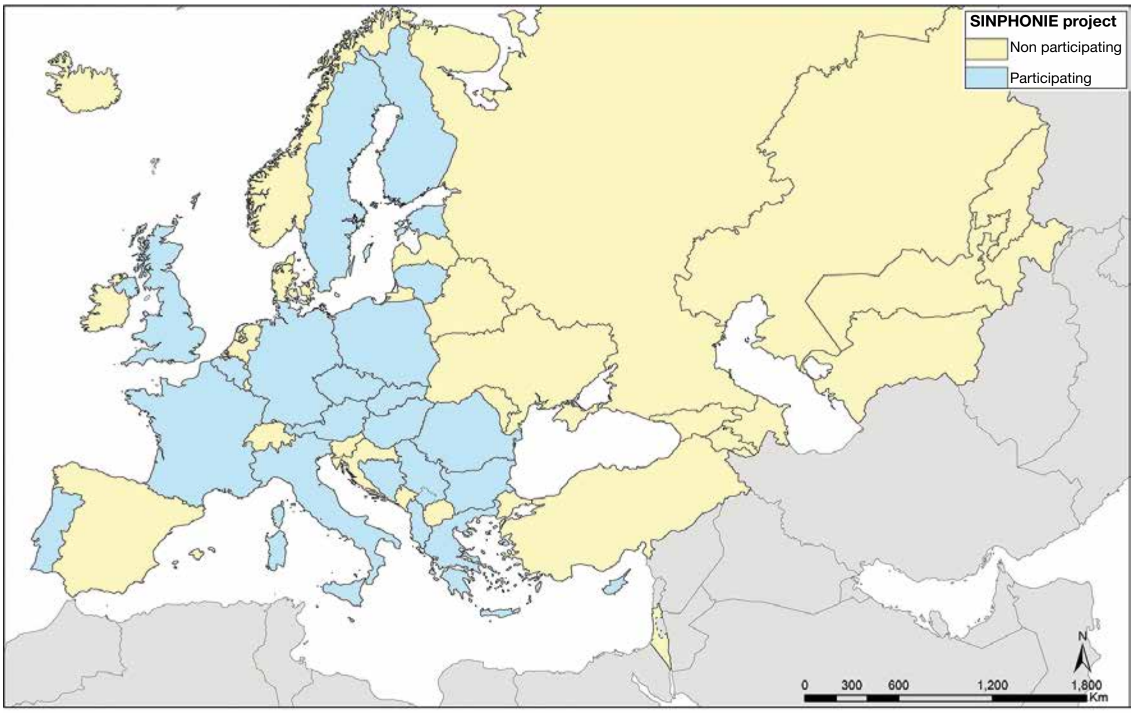
Field surveys were carried out in selected schools in each country (maximum of six schools per country). A total of 114 schools in 23 countries participated in the project (Fig. 5). In each school, three classrooms were assessed. Standardized methodological approaches that were used in all schools were developed building upon methods which were used in other international projects (Kotzias et al., 2005; Franchi et al., 2006; Geiss et al., 2011; Csobod et al., 2010; Kephalopoulos et al., 2013).

The SINPHONIE field surveys involved walkthrough inspections of school buildings, which were followed by the collection of data on school building characteristics. Data on the school environment (operations, occupants' patterns of activity etc.), and respiratory symptoms/diseases of building occupants were collected using questionnaires distributed to teachers, pupils and parents. Specific clinical tests were also administered to pupils.

IAQ characterization involved measurements of 16 chemical, physical and comfort parameters and 13 biological contaminants, including endotoxins (one analyte), fungal and bacterial DNA (seven analytes) and allergens (five analytes).

Thirty laboratories in 23 countries were involved in chemical analyses. Each national team delegated monitoring specialists to the Joint Research Centre (JRC) training in May 2011 where they learned sample collection, preparation and analysis methods. The measurements of biological contaminants were conducted at three laboratories in Finland, Hungary and Sweden.

Fig. 5. Countries that participated in the SINPHONIE project



The designations employed and the presentation of this material do not imply the expression of any opinion whatsoever on the part of the Secretariat of the World Health Organization concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers and boundaries.
Dotted and dashed lines on maps represent approximate borders for which there may be not full agreement.

Cartography by Pierpaolo Mudu (WHO)
Data Source and map production:

World Health Organization
Regional Office for Europe

Night-time ventilation rates were evaluated by analysing CO_2 decay curves after the end of the school day. While this method is well suited for estimating the intrinsic air exchange rate of the building, it only applies to periods when the building is not occupied and does not characterize ventilation during classes. Therefore, the results are not presented in this report.

Results and conclusions

The SINPHONIE results are described comprehensively in the project final report (Csobod et al., 2014). Briefly, the results of SINPHONIE project are summarized below.

1. Chemical IAQ in classrooms in schools (N = 300):

    - IAQ in classrooms varied significantly among the schools and cities in the 23 European countries that participated in the SINPHONIE survey depending on the type, location (neighbourhood environment), age and management (including cleaning practices) of the school buildings.
    - 67% of inspected schools are located near busy roads.
    - The median $PM_{2.5}$ level in all classrooms in all participating

countries was 37 μg/m^3, range from 4 to 250 μg/m^3. Approximately 65% of classrooms exceeded the WHO ambient air quality guideline. Bosnia and Herzegovina had the highest country-level median value.

- The median of average weekly levels of formaldehyde was 12 μg/m^3 (range from 1 to 66 μg/m^3). The maximum concentration and the highest country-level median value were detected in Romania, the second highest levels were measured in Poland. The WHO guideline for formaldehyde (100 μg/m^3) was not exceeded in any schools.

- The median level of benzene was 2 μg/m^3 (ranging from below the method detection limit to 38 μg/m^3). The maximum value and the highest country-level median were in Poland. Benzene is a carcinogen with no safe level.

- The median level of naphthalene was below detection limit, the maximum was 31 μg/m^3. Bulgaria had by far the highest concentrations with country-level mean and median values exceeding the WHO guideline of 10 μg/m^3. Maximum values were also above the WHO guideline in Bosnia & Herzegovina and Greece.

- The median level of NO_2 was 11 μg/m^3, range from below detection limit to 88 μg/m^3. The maximum level was observed in Italy. The maximum level is above the WHO guideline of 40 μg/m^3 for annual mean but below the WHO guideline for hourly means, 200 μg/m^3.

- For trichloroethylene and tetrachloroethylene, median levels were below the limits of detection while maximum levels were 126 μg/m^3 and 81 μg/m^3 respectively. The WHO guideline for tetrachloroethylene (250 μg/m^3) was not exceeded. Trichloroethylene is a carcinogen with no safe level.

The levels of pollutants in kindergartens (summarized separately in the SINPHONIE report) were quite similar to the levels in schools described above.

2. Dampness and moisture indicators:

   - Visible mould growth was present in 7% of classrooms, mould odour in 3%, visible damp in 9%, condensation on window frames in 17% of classrooms; roof leaks were detected in 21% of school buildings.

   - Average relative humidity in classrooms in schools was 43%, range from 6% to 98%. Albania had the highest country-level average relative humidity, followed by Malta and Portugal.

   - Exposure to biological contaminants including microbial agents and allergens varied widely among countries and schools; due to the lack of reference values classifying exposures as high or low is not straightforward.

3. Ventilation in classrooms:

   - Most schools (86%) used natural ventilation; 7% of schools used assisted ventilation and 7% of schools used mechanical ventilation.

   - Among schools with mechanical or assisted ventilation, 47% used CO_2 controlled ventilation (that is in approximately 7% of all schools).

   - Mean CO_2 level in all classrooms was 1433 ppm; mean CO_2 levels above 1500 ppm were found in different geographic regions throughout Europe. The maximum weekly average CO_2 level in a classroom was 4,960 ppm.

   - In terms of occupation density, 8% of the classrooms were found to be greatly overcrowded, providing less than 1.5 m^2/child; 20% of classrooms were mildly overcrowded, providing less than 2 m^2/child. The high occupation density is a risk factor for poor ventilation and high air stuffiness (i.e. CO_2 concentrations well above 1500 ppm), which could negatively affect children's health and learning performance.

4. Respiratory symptoms in children:

   - There was a high prevalence (3.6%) of ever having had an asthma attack; there is also a considerable proportion of pupils who have had an asthma attack in the classrooms (1.4%).

   - Children attending schools with elevated levels of air pollutants are at a greater risk of having respiratory symptoms.

5. Smoking in schools:

   - In 5% of schools, smoking is still permitted indoors for adult individuals.

Concerning the impacts of transportation and traffic, it was found that traffic-related pollutants such as $PM_{2.5}$ and NO_2, influence IAQ in schools, especially those located near busy roads. Since the issue of IAQ in school buildings cannot be properly addressed without improving the quality of the ambient air, it is essential that the local/national authorities managing maximise their efforts to ensure that the ambient air meets the WHO guidelines.

Another conclusion is that the use of low-emission materials and other measures to prevent emissions of toxic chemicals in school buildings should be promoted. Specific measures are also recommended to improve ventilation and prevent mould growth. More detailed information on SINPHONIE recommendations is presented in section 2 of this report.

3.2.3 HITEA study

Overview and methods

The objective of the Health Effects of Indoor Pollutants: Integrating Microbial, Toxicological, and Epidemiological Approaches (HITEA) study was to assess the health impacts of indoor exposures on children and adults in Europe. It involved the collection of comprehensive data on exposures to indoor dampness, and biological and chemical pollutants, which were then combined with extensive data on health outcomes from the HITEA field survey (see below) and from existing population cohorts. The focus was on microbial exposures due to dampness problems in buildings. The roles of allergens, chemicals, cleaning agents, and poor ventilation were also studied.

HITEA included a longitudinal field study in schools in three countries that represented three climatic regions in Europe: Finland, the Netherlands and Spain. The field survey was conducted in 2008–2010. Respiratory health questionnaire data were analysed from more than 9200 pupils and about 650 teachers from 66 schools that were initially inspected for moisture and dampness. Spirometric lung function measurements were conducted in approximately 3800 pupils. More than 500 pupils with asthma or asthma symptoms, and over 180 teachers, were followed in a longitudinal, detailed health survey. In parallel, extensive monitoring campaigns were conducted in the study schools assessing biological parameters (microbes and microbial agents, allergens), chemical parameters ($PM_{2.5}$, NO and NOx, CO_2) and physical parameters (temperature, relative humidity).

School buildings were dichotomized as being affected or not affected by dampness and mould. This was done using a gradient classification based on the number, location, extent and severity of dampness observations recorded during walk-through building inspections, which also involved surface moisture measurements. This dichotomous categorization was then used in subsequent health effect analyses, assuming all pupils in affected schools were exposed (Borras-Santos et al., 2013).

Results

The occurrence of moisture problems in schools was investigated using questionnaires and building inspections. The study findings indicated that, although questionnaires can be used to assess moisture problems in school buildings, they need to be validated by on-site inspection in a subsample of the surveyed buildings (Haverinen-Shaughnessy et al., 2012a). Estimates for prevalence of moisture problems in school buildings were 24% in Finland, 20% in the Netherlands, and 41% in Spain.

Similar results were produced in a national level survey in Finland, involving about 40% of all elementary schools in the country, where signs of damp or mould were reported in 27% of the schools (Haverinen-Shaughnessy et al. 2012b).

Several reports have been published on microbial and allergen exposures, and reporting of HITEA results is still on-going. One key finding is that levels of microbial agents and some allergens in schools appear to be several times higher compared to homes, indicating that the school environment may contribute considerably to the daily exposure of pupils (Jacobs et al., 2013 and 2014; Krop et al., 2014). Microbial exposure in schools varied widely. Factors associated with exposure levels include: type of ventilation system, building characteristics and the intensity of building usage, and climatic conditions. Seasonal effects (particularly in the colder climatic zone) have also been observed. Elevated microbial levels were observed in classrooms with higher occupancy (Jacobs et al., 2014; Krop et al., 2014). Moisture damage in schools has been found to be associated with increased levels of various microbial agents in the classrooms; it may also increase the immunotoxic potential of dust allergens.

Preliminary analyses indicated higher levels of indoor $PM_{2.5}$ and NO_2 in Spanish and Dutch schools, which are likely to be related to higher traffic loads in these countries, as compared to Finland. CO_2 levels were highest in Spanish classrooms (median of school-day averages: 1167 ppm; some peaks exceeded 5000 ppm). CO_2 levels were substantially lower in the Netherlands (median: 936 ppm) and Finland (median: 603 ppm). Indoor relative humidity levels, assessed during winter, were the lowest in Finnish schools (median of school-day averages: 15%), and comparable in Spain and the Netherlands (41% and 40%, respectively).

Analyses of health effects in relation to different school-based exposures are currently on-going. An initial report of Borrás-Santos et al. (2013) confirmed earlier findings of the association between exposure to moisture damage in schools and adverse respiratory health effects.

3.2.4 National IAQ monitoring programmes in France

Indoor air quality monitoring in public premises with vulnerable populations, especially in children's facilities, became a legal requirement in France in 2014. The Observatory for IAQ was created in 2001, with support from the government authorities, in order to set up a system for continuous monitoring of IAQ in indoor environments, including schools and kindergartens. France is the only country in the WHO European Region which has a policy requiring IAQ monitoring key IAQ parameters (formaldehyde, benzene, CO_2) in all schools and kindergartens. In addition, in-depth assessments of exposures to environmental factors are conducted in a representative random sample of schools and kindergartens across the country.

National pilot survey in schools and kindergartens

A national pilot survey was conducted in 101 kindergartens ("nursery schools") and 108 elementary schools, from 2009 to 2011, in order to evaluate the methodology for the full-scale national survey and to provide preliminary estimates of exposure levels for selected pollutants (Michelot et al., 2013).

Formaldehyde and benzene were measured using passive samplers during one school week (from Monday to Friday), during heating and non-heating seasons, in one to eight classrooms in each investigated school. The number of classrooms assessed depended on the size of the school. A building audit was carried out by professional technicians in order to identify sources of emissions.

CO_2 levels in classrooms were measured in 10-minute time intervals during two weeks in the heating season. The CO_2 concentration data were used to calculate an "air stuffiness index" for each classroom (Ramalho et al., 2013). The level of air stuffiness was represented by a score from zero (fresh air, 100% of CO_2 measurements below 1000 ppm) to five (extreme air stuffiness, 100% of CO_2 measurements are above 1700 ppm).

Very high (2/3 of CO_2 measurements above 1700 ppm) or extreme air stuffiness was found in 9.1% of kindergartens and 32.9% of elementary schools (Ramalho et al., 2013). It should be noted that 18% of kindergartens and 19% of elementary schools were equipped with mechanical ventilation (Michelot et al., 2013). Air exchange rates were higher, and the CO_2 concentration and air stuffiness were lower, in buildings with mechanical ventilation systems. However, the differences between mechanically and naturally ventilated schools were rather small (Ramalho et al., 2013).

The average weekly concentrations of pollutants were compared with the guidance values set by the French Committee for Public Health for formaldehyde (30 $\mu g/m^3$ for long-term exposure with remediation actions needed for levels above 100 $\mu g/m^3$) and benzene (5 $\mu g/m^3$ for long-term exposure with remediation actions needed for levels above 10 $\mu g/m^3$). Formaldehyde exceeded 30 $\mu g/m^3$ in 10.6% of establishments, while benzene exceeded 5 $\mu g/m^3$ in 2.5% of establishments (Michelot et al., 2013). No establishments had concentrations exceeding the action levels for either formaldehyde or benzene.

Examples of identified sources of formaldehyde emission included activities such as: the use of a cleaning product containing 3% of formaldehyde when the mechanical ventilation system was out of order; and the use of highly-emitting ceiling materials under warm conditions. Examples of identified sources of benzene emission included: having an air intake of a ventilation system located close to the underground car park air exhaust and having a petrol lawnmower parked inside the school building.

This pilot survey demonstrated that specific recommendations can be provided to building managers to improve the IAQ at little to no cost. Examples of recommendations include: opening windows to improve ventilation, cleaning air filters, and repairing existing mechanical ventilation systems.

Ongoing national survey in a random sample of schools

In June 2013 the Observatory launched a nationwide IAQ monitoring campaign in kindergartens and elementary schools in order to better understand indoor environment quality and comfort in French schools, and to identify building characteristics that affect these parameters.

The campaign is coordinated by the "Centre Scientifique et Technique du Bâtiment" (CSTB – Scientific and Technical Centre for Building), as the technical operator of the Observatory for IAQ. Seven trained teams are working in parallel across France. Approximately ten laboratories are analysing the samples.

The target sample size is 300 schools. The method for selecting schools is a three-stage stratified random sampling design, with the first stage stratified for climatic zone and the second for school type (nursery or elementary) and environment type (urban or rural). In each school, two classrooms are randomly selected for monitoring.

Chemical pollutants are monitored in classrooms during one school week. The list of pollutants includes $PM_{2.5}$ (mass and number), NO_2, volatile and semi-volatile organic compounds (around 60 compounds), and aldehydes. VOCs and aldehydes are also measured outdoor. SVOC, seven metals including lead, as well as dust mite and pet allergens are also measured in settled dust (vacuumed and wiped). In addition, lead is measured in wall coatings. Temperature, relative humidity and CO_2 are measured continuously during the sampling week. Light and noise levels are also measured, allowing for a complete assessment of the indoor environment. Detailed inspection checklists, characterizing the building, the classrooms, and the outdoor environment, are filled out by trained survey technicians. Time-activity diaries, as well as a questionnaire on perceived comfort, are completed by teachers. Approximately 70 schools are monitored each year; the survey will be completed in 2016.

Compulsory IAQ monitoring in schools

Under the French law, all schools have to conduct monitoring of IAQ. Formaldehyde and benzene are monitored for one week during the cold season in two classrooms in each school using passive diffusion samplers. CO_2 is monitored using automatic monitors with data loggers in order to estimate the air stuffiness index. In the administrative regions, there are commercial service providers that organize sampling, conduct laboratory analysis and prepare data for submission to the programme database at the national Observatory. The first round of monitoring is currently ongoing.

3.2.5 Municipal-level surveys in Germany

Overview of municipal surveys in schools in Germany

While Germany does not have a national-level monitoring programme in schools, many large German cities have their own monitoring programmes. A Google search using the German key words, *Schadstoffe* (English: pollutants) and *Schulen* (English: schools), produced the results shown in Table 10, without any claim or warranty of completeness. It appears that many large cities have systematic monitoring programmes. More detailed information on one of the most comprehensive programmes in the city of Cologne is presented below as an example.

Example of a school survey in Germany – municipal school and kindergarten surveillance programme in the city of Cologne

The municipal government of the city of Cologne conducts systematic inspections (active surveillance) of all public buildings and also investigates complaints (reactive inspections) about indoor conditions.

Table 10. Results of a non-systematic internet search for school building monitoring programmes in municipalities in Germany

City / Municipality	Indoor air pollutants, PCB, asbestos	Ventilation (CO_2 conc.)	Reverbe-ration time	Dampness/ mold	Electro-magnetic fields
Bielefeld	X			X	
Bonn	X				
Borken	X			X	
Bornheim	X				
Bremen	X	X	X	X	X
Bremerhaven	X				
Cologne	X	X	X	X	X
Darmstadt	X				
Duisburg	X				
Düsseldorf	X				

Table 10 (concluded)

City / Municipality	Indoor air pollutants, PCB, asbestos	Ventilation (CO_2 conc.)	Reverbe-ration time	Dampness/ mold	Electro-magnetic fields
Frankfurt	X	X			
Gelsenkirchen	X				
Gießen	X				
Hamburg		X			
Hamm	X			X	
Hannover		X			
Horb	X				
Karlsruhe		X		X	
Kevelaer	X				
Kiel	X	X			
Lünen	X				
Marburg Region	X				
Minden	X			X	
Munich (rural district)	X				
Neuss	X				
Nuremberg	X			X	
Salzgitter	X	X		X	
Trier (rural district)	X				
Wermelskirchen	X				

The Cologne programme "Classical Pollutants" was implemented from 1989 to 2003 (Gesundheistsamt Köln, 2000, 2002). Examples of monitored classical pollutants include: asbestos, polychlorinated biphenyls (PCB), pentachlorophenol (PCP), lindane, formaldehyde, VOCs, and mold. Monitoring was conducted in 554 public school buildings, including 299 primary/secondary schools and 255 kindergartens. Active sampling was conducted in each school in a representative number of classrooms to monitor levels of air pollutants.

An elevated concentration of at least one pollutant was detected in 25% of the buildings. As shown in Table 11, 9% of buildings had polychlorinated biphenyl (PCB) levels in excess of the German limit value 1 of 300 ng/m^3, and 2.3% of buildings had levels in excess of the limit value 2 of 3,000 ng/m^3. Other findings included: 5.2% of buildings had pentachlorophenol (PCP) and lindane levels in excess of the German reference values; 4.9% of buildings had VOC levels in excess of the German guidance values; and 4% of buildings had formaldehyde levels in excess of the German guidance value. In almost one-third (30%) of buildings hygienic and constructional deficiencies were observed. In all cases when elevated exposure levels or other deficiencies were detected, remediation measures were reported to have been conducted.

Based on the experiences in the aforementioned monitoring programme which identified multiple IAQ problems, a

Table 11. Elevated pollutant concentrations in public buildings: data from the "Classical Pollutants" monitoring programme in Cologne, Germany (1989–2003)

Indoor air pollutant	Limit value / reference value / guidance value	Number (percent) of buildings with exceedance of limit value / reference value / guidance value
PCB	Limit value 1: 300 ng/m³ Limit value 2: 3 000 ng/m³	50 (9.0%) 13 (2.3%)
PCP, lindane	100 ng/m³	29 (5.2%)
VOC	300 µg/m³	27 (4.9%)
Formaldehyde	0.1 ppm (125 µg/m³)	22 (4.0%)

new programme called "Active Health Care" was started in Cologne in 2004. In addition to the above pollutants, it included data collection on the following environmental factors: mold and dampness, ventilation (CO_2 concentration), quality of air conditioning systems, room acoustics (reverberation time, speech intelligibility), lighting, drinking water (cold and hot water), kitchen hygiene, and WASH conditions (Barth et al., 2011; Kaesler et al., 2014). The survey methodology and assessment criteria are summarized in Table 12. The results of the Cologne programme "Active Health Care" up to date are summarized in Table 13.

Providing evidence for the need to make improvements to the indoor environment in public buildings was the main benefit of the "Active Health Care" programme. The detection of health hazards at levels exceeding legally binding threshold values immediately resulted in corrective actions funded from the municipal budget. A proactive approach to avoiding pollution problems has also been developed and implemented. It includes the following two lists of recommendations:

- recommended low emitting building materials for school construction/ renovation; and
- low emitting toys, furniture and other items used in schools.

Conclusions

Based on findings from the Cologne programmes, "Classical Pollutants" and "Active Health Care", as well as findings from similar programmes in Germany, the following school-based exposures have been identified as important factors that affect the health and well-being of pupils and the learning process:

- Elevated CO_2 level, an indicator of air stuffiness
- Classical pollutants including asbestos (see the German asbestos regulations [BAUA, 2014] for more information), PCB, wood preservatives (PCP, lindane), VOCs and aldehydes
- Dampness and mold
- Poor room acoustics
- Inadequate lighting
- Inadequate kitchen hygiene
- Inadequate hygiene and sanitation.

The following steps are recommended as a way to move forward:

Step 1: Ventilate school buildings properly.

Step 2: Identify buildings with problems listed above and develop a building cadaster describing the following:

Table 12. Parameters, measurements, and assessment criteria of the school monitoring programme, "Active Health Care", in Cologne, Germany

Parameters	Measurements	Assessment criteria
Dampness with / without mold infestation	Structural-physical measurements using analysers (for dampness of building materials) and infrared thermography Mold measurement by external accredited laboratories according to DIN ISO IEC 17025 (2005)	Mold Remediation Guideline (UBA, 2005)
Ventilation quality	CO_2-measurements according to VDI 4300-9 (2005)	Guideline for Indoor Hygiene in School Buildings (UBA, 2008) DIN EN 13779 (2007)
Air conditioning systems	Hygiene inspection according to VDI 6022 (2011)	VDI 6022 (2011) DIN EN 13779 (2007)
Room acoustics	Measurements according to DIN EN ISO 3382 (2009)	DIN 18041 (2004)
Lighting	Exploratory measurement using a lux meter	DIN EN 12464-1 (2011)
Kitchen hygiene	Inspection according to Protection Against Infection Act (Bundesregierung, 2013) and Food Law	Protection Against Infection Act (Bundesregierung, 2013) Food law
Drinking water	Investigations according to Drinking Water Ordinance (Bundesregierung, 2001) and Protection Against Infection Act (Bundesregierung, 2013) DVGW Guidelines (DVGW, 2004)	Drinking Water Ordinance (Bundesregierung, 2001) Protection Against Infection Act (Bundesregierung, 2013) DVGW Guidelines (DVGW, 2004)
Sanitation and hygiene	Inspection according to Protection Against Infection Act (Bundesregierung, 2013), VDI 6000 Bl. 6 (2006)	Protection Against Infection Act (Bundesregierung, 2013) VDI 6000 Bl. 6 (2006)
Chemicals/indoor air pollutants	Depending on problem/ question, according to corresponding DIN or VDI regulations	Corresponding DIN or VDI regulations

DIN = Deutsches Institut für Normung (German Institute for Standardization)
DVGW = Deutsche Vereinigung des Gas- und Wasserfaches (German Technical and Scientific Association for Gas and Water)
IEC = International Electrotechnical Commission
VDI = Association of German Engineers

Table 13. Results of the "Active Health Care" programme, Cologne, Germany

Parameters	Findings	Remedial action recommended/taken
Dampness with/without mold infestation	Deficiencies in ~30% of school buildings	Recommendation of remediation according to regulations of the Federal Environment Agency
Ventilation quality	Pilot study of 35 schools: deficiencies in 80% of schools	Remediation (increase of ventilation area) or implementation of ventilation plans
Air conditioning systems	Pilot study of 50 schools: deficiencies in 64% of schools	Removal of maintenance and constructional deficiencies
Room acoustics	Assessment based on 241 measurements: 53% of measured values exceeded recommended level	Acoustic retrofitting of sound-absorbent materials
Lighting	Deficiencies in 28% of buildings	Recommendation of remediation (to meet recommended German lighting values)
Kitchen hygiene	Deficiencies in ~85% of schools	Operators were informed about constructional deficiencies and/or structural deficiencies
Drinking water quality	Pilot study of 38 schools: 24% of 426 measurements of drinking water quality did not meet the existing standards	Intensive water jetting and re-measure; in single cases constructional modifications were necessary
Sanitation and hygiene	Deficiencies in 70% of schools	Operators were informed about constructional deficiencies and/or structural deficiencies

- use of interior building materials with high levels of emission of chemical pollutants;
- use of asbestos-containing materials;
- building design, operation and maintenance problems resulting in indoor dampness and mould;
- room acoustics;
- lighting; and
- unhygienic sanitation facilities and kitchens.

Step 3: Address problems identified in step 2.

Step 4: Develop and implement standards for establishing and maintaining a healthy school environment, focusing on sustainable practices during new construction and renovations. A list of recommended low emission materials would be helpful.

Step 5: Implement standards for regular monitoring, evaluation, and follow-up action.

3.2.6 WHO Schools Survey

Survey objectives and design

The WHO Regional Office for Europe has coordinated the development of survey protocols, training and technical support to facilitate the implementation of school surveys in volunteering countries. The survey aims at closing critical data gaps and producing comparable and consistent data on the school environment. The methodology was developed in collaboration with the European Commission JRC, the Finnish Institute for Health and Welfare (THL) and Women in Europe for a Common Future (WECF) (WHO Regional Office for Europe, 2011) and other institutions. Information about the indicators to be included in the survey, and technical documents outlining its design and methodology were presented at the Extraordinary Second meeting of the European Environment and Health Task Force as background materials describing a supplemental approach for monitoring the implementation of school-related Parma Declaration commitments in volunteering countries (WHO Regional Office for Europe, 2010).

The survey has a stratified clustered design, where geographic strata can be defined according to conditions in a specific country. Geographic clusters are selected using a standardized sampling schema. Schools are then randomly sampled from each cluster, and measurements and inspections are carried out during one school year during the cold season in order to characterize highest levels of indoor pollutants and lowest ventilation rates.

The survey is designed to produce information for the following primary indicators:

- exposure to benzene, NO_2 and formaldehyde in classrooms (via IAQ monitoring using passive diffusion samplers)
- exposure to mould and dampness (via school inspections)
- exposure to stuffy air (via CO_2 monitoring)
- smoking in schools and on school grounds (via questionnaires for pupils and teachers)
- access to improved and adequately operated and maintained sanitation facilities (via inspections, and questionnaires for pupils and administration)
- hygienic practices of pupils (via questionnaire for pupils)
- proportion of children going to and from school by different modes of transportation modes (via questionnaire for pupils).

Data collection in participating schools starts with an interview with the school principal or administration officer using a standardized interview form. It is followed by a general inspection of school building(s) to describe structural characteristics, materials, and sources of air pollution, inspection of toilets and hand washing facilities using a standardized check list, and inspection of all indoor premises for mould and dampness using standardized log forms and portable moisture meters. Questionnaires on smoking rules and policies are administered to at least five teachers or employees in each school. Questionnaires for pupils include sections on the mode of transportation to school, smoking (general smoking habits and smoking in the school), and school sanitation and hygiene. It is recommended to administer the questionnaire to pupils age 12 years or older in three classes in each school (typically, 60 to 90 pupils).

During school inspection, three representative classrooms are selected for monitoring of selected indoor air pollutants (formaldehyde, benzene and NO_2), temperature, relative humidity and CO_2. The selection process takes in account the building's configuration and its position in relation to busy roads and other pollution sources. In addition, one outdoor site is selected for air quality monitoring. Monitoring is conducted during one school week. Passive diffusion monitors for benzene, formaldehyde and NO_2, and automatic CO_2 and carbon monoxide monitors are placed in the classrooms on Monday mornings and are collected on Friday afternoons. Classrooms where monitoring is conducted are inspected using a special, more detailed form. In addition, teachers maintain classroom use diaries during the monitoring week.

Standard operating procedures (SOPs) and data collection forms, as well as data analysis procedures and recommendations, are available from the WHO European Centre for Environment and Health in Bonn, Germany upon request.

Preliminary survey results

This report includes the results of school surveys, conducted from 2012 to early 2014, in five European countries: Albania, Croatia, Latvia, Estonia and Lithuania. Analysis of data from these pilot surveys was conducted at WHO. A summary of data collection activities in these five countries is provided in Table 14. The average age of pupils who filled out survey questionnaires varied from 13.1 years in Albania to 15.7 years in Estonia. While surveys in Albania, Estonia, Latvia and Lithuania were pilot projects involving limited numbers of schools, the survey in Croatia involved a large number of schools throughout the country. It was conducted in stages starting with a pilot project in two schools, followed by a two-stage national survey with the first stage involving interviews, inspections and questionnaires for pupils and teachers in almost 200 schools and the second stage involving IAQ monitoring in a subset of 20 schools.

Data from similar ongoing school surveys in several countries (Serbia, Poland, Malta, Lithuania and Latvia) are not included in this report. They will be presented in separate publications.

Exposures to indoor chemical air pollutants

Exposures to benzene, formaldehyde and NO_2 were monitored using passive diffusion samplers, similar to those used in the SINPHONIE survey. Typically, samplers were installed in three classrooms and at one outdoor size in each school. Due to budgetary limitation, only three surveys in Albania, Croatia and Estonia included monitoring of these chemical pollutants. Carbon monoxide levels

Table 14. Summary of data collection

Parameter	Albania	Croatia	Estonia	Latvia	Lithuania	All countries
Parameter	12	199	4	4	10	229
Total number of schools involved	12	203	4	4	10	233
Interviews with school administration (sanitation, smoking, building characteristics, mould)	660	11 731	257	166	697	13 511
Questionnaires for pupils (sanitation, hygiene, smoking, transportation)	36	972	39	21	50	1118
Questionnaires for teachers (smoking)	12	23	4	4	10	53
Mould inspections, number of schools	42	1170	37	58	254	1561
Sanitation facilities inspected	36	66	12	12	12	138
IAQ monitoring, number of classrooms						

Notes: IAQ monitoring in Latvia and Lithuania included CO_2 and carbon monoxide only. Some Croatian data, which are still being processed and cleaned for analysis, were not used in this report.
Source: unpublished data from the WHO Schools Survey; Egorov et al. (2012).

were monitored using carbon monoxide sensors incorporated in some types of CO_2 monitors. Measurements were taken every minute. Only data collected during classes were included in analysis.

NO_2 levels were well below WHO guidelines in all schools (Table 15). Concentrations were similar at outdoor and indoor sampling sites suggesting that main sources are located outdoor and associated with traffic.

Benzene monitoring results are summarized in Table 16. A relatively high level of benzene (28.3 μg/m^3, almost six times higher than the EU limit of 5 μg/m^3) was detected in a rural school in Albania where indoor kerosene heaters were used in classrooms.

Formaldehyde levels were also below WHO guidelines in all classrooms (Table 17). The indoor levels were substantially higher than ambient levels confirming the presence of indoor sources of emission.

The levels of carbon monoxide were below the 1 ppm detection limit in most schools, except several rural schools in Albania, where carbon monoxide levels peaked during classes and dropped during breaks indicating the use of indoor combustion (kerosene heaters). The maximum level was 9 ppm (approximately 10.5 mg/m^3), which was maintained only during short time intervals (several minutes). This level is substantially below the short-term WHO guideline values of 100 mg/m^3 for 15 minute average and 35 mg/m^3 for one hour average. It should be noted, however, that the sample size was rather small: three out of four participating rural schools in Albania reported using indoor combustion heaters. If the use of kerosene heaters is common during the cold season in rural areas of some other countries, which did not participate in the survey, maximum carbon monoxide levels in some classrooms may potentially exceed WHO guideline levels.

Exposure to CO_2 (stuffy air) and ventilation rates

CO_2 levels were measured in three classrooms located on different sides of the building and on different floors in each participating school during one school week, from Monday through Friday. Automatic CO_2 monitors with data loggers were installed in places far from windows and doors. Measurements were taken

Table 15. Summary of monitoring results for NO_2 (μg/m^3)

Country	Type	Number of schools	Indoor			Outdoor		
			Number of sites	Median	90th percentile	Number of sites	Median	90th percentile
Albania	Rural	4	12	6.1	13.8	4	8.1	8.1
	Urban	8	24	6.2	19.6	8	10.9	33.7
Estonia	Rural	2	6	7.3	13.7	2	4.0	6.5
	Urban	2	6	8.4	13.9	2	3.7	4.4
Croatia	Rural	10	30	0.9	12.3	10	1.5	22.2
	Urban	12	36	2.0	11.3	12	3.1	14.9

Source: unpublished data from the WHO Schools Survey; Egorov et al. (2012).

Table 16. Summary of monitoring results for benzene (µg/m³)

Country	Type	Number of schools	Indoor sites			Outdoor sites		
			Number of sites	Median	90th percentile	Number of sites	Median	90th percentile
Albania	Rural	4	12	4.5	28.3*	4	1.9	2.0
	Urban	8	24	4.2	7.9	8	4.2	7.1
Croatia	Rural	10	30	0.7	11.4	10	0.8	6.0
	Urban	12	36	1.0	2.0	12	1.1	1.9

* This is also the maximum level for the survey.
Source: unpublished data from the WHO Schools Survey; Egorov et al. (2012).

Table 17. Summary of monitoring results for formaldehyde (µg/m³)

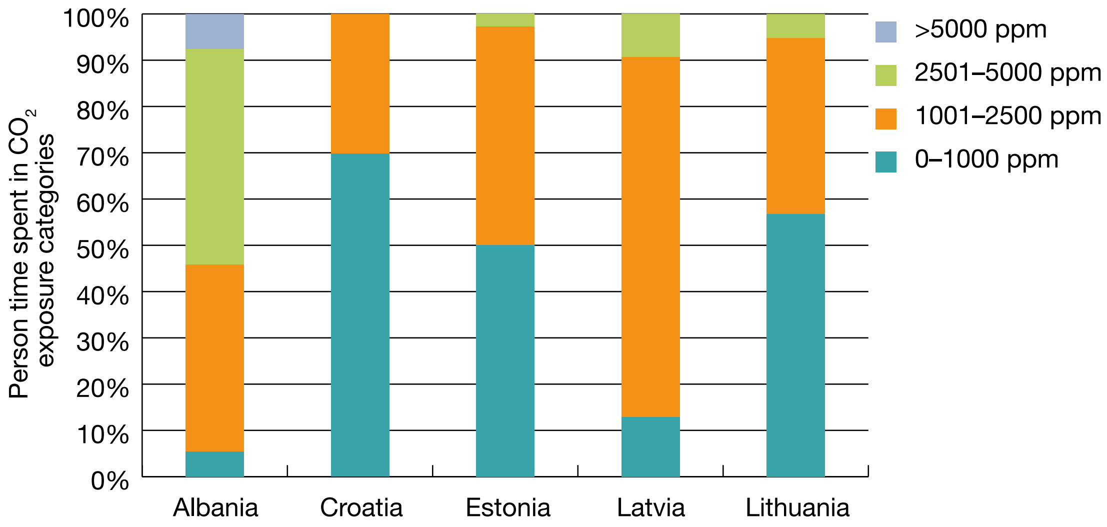
Country	Number of schools	Indoor sites			Outdoor sites		
		Number of sites	Median	90th percentile	Number of sites	Median	90th percentile
Albania	12	36	6.6	11.5	12	3.3	5.7
Estonia	4	12	10.7	14.9	4	1.7	2.2
Croatia	22	66	8.5	15.0	22	2.2	3.1

Source: unpublished data from the WHO Schools Survey; Egorov et al. (2012).

every minute. In addition, teachers in each classroom kept room occupancy diary recording the number and average age of pupils in each class, as well as actual schedule of classes. Each classroom was described in details using standardized classroom inspection form. The room volume, type of ventilation and other pertinent observations were recorded. Data from monitors were automatically uploaded to a specially developed Excel data analysis tool; data from classroom use diaries and classroom volumes were also entered. The tool employs Visual Basic macros to fit curves to CO_2 data in each classroom and to identify build-up, steady state and decay phases. The standard equations describing the build-up phase and steady state are solved to estimate air exchange rates (in hr^{-1} units) and ventilation rates in lps pp during classes. The tool also produces a summary of exposure to CO_2 (as proportion of person-time spent in each specified interval of CO_2 concentrations) and analyses data on relative humidity, temperature and carbon monoxide, if a CO_2 monitor using for data collection had these sensors.

There are no WHO or EU standards on CO_2 or ventilation rate applicable to schools. Therefore, the measured values are compared to existing national standards or guidelines. Elevated average CO_2 levels, in excess of the 1000 ppm health-based recommended limit in Germany were observed in many classrooms; in some countries pupils spent most of their time at CO_2 levels exceeding 1000 ppm or even 2500 ppm (Fig. 6). The highest CO_2 levels were measures in Albanian classrooms where highest weekly classrooms averages were above 5000 ppm, the maximum concentration of CO_2 which should not be exceeded even during a short interval in schools in the United Kingdom (EFA, 2006). It

Fig. 6. Percent of pupils' person-time in classrooms spent at specific CO_2 concentrations (ppm)



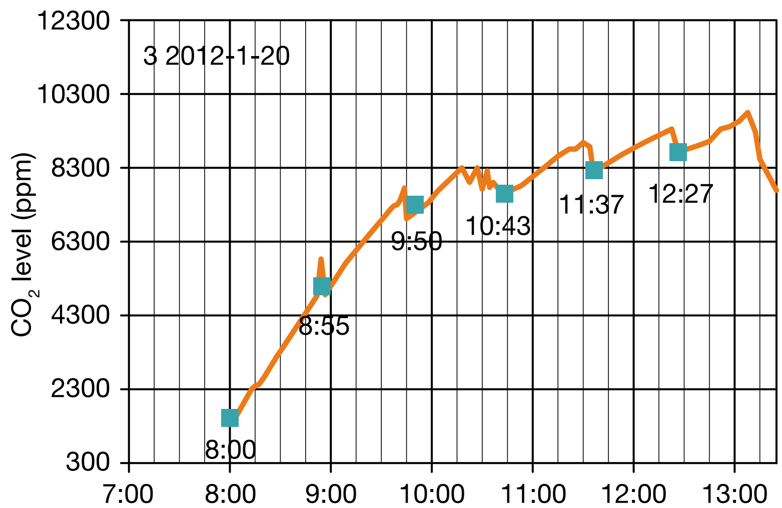
appears that the main reason for the very poor ventilation was the lack of adequate heating and, as a result, very low indoor air temperature during the cold season. In some classrooms, air temperature in the morning was below 10° C.

An example of CO_2 monitoring data in an inadequately ventilated classroom showing CO_2 reaching a maximum level of almost 10 000 ppm is presented in Fig. 7. Blue points mark the start of each class. Note the lack of CO_2 decay events during two morning breaks indicating that the classroom was not properly ventilated during these breaks.

The CO_2 level continued rising through the entire school day.

The results of analysis of ventilation rates based on CO_2 monitoring, classroom volume and classroom occupancy data are presented in Table 18. More than half of the inspected classrooms had ventilation rates below the European Norm (EN) and Federation of European Heating, Ventilation and Air Conditioning Associations (REHVA) limit value (3 lps pp), and almost 80% had ventilation rates lower than the American Society of Heating, Refrigerating, and Air-

Fig. 7. Example of CO_2 accumulation in a classroom with poor ventilation



Source: unpublished data from a selected school in the WHO Schools Survey.

Table 18. Overview of air exchange and ventilation rates from the WHO Schools Survey pilot studies (2011–2013)

Country	Schools	Classrooms	School days	Air exchange rate (h^{-1})	Ventila-tion (lps pp)	Classrooms with ventilation < 3 lps pp	Classrooms with ventilation < 7 lps pp
Albania	12	36	139	1.9	2.1	86 %	97 %
Croatia*	2	6	13	4.3	10.1	0 %	0 %
Estonia	4	12	26	2.8	9.7	10 %	40 %
Latvia	4	12	38	1.9	4.5	33 %	92 %
Lithuania	4	12	79	3.3	7.7	8 %	58 %
Total	**26**	**78**	**295**	**2.4**	**4.7**	**51 %**	**79 %**

*Only results from a pilot survey in two schools are included. The main survey in Croatia included CO_2 monitoring in 20 more schools (60 classrooms); data analysis is in progress.
Source: unpublished data, WHO Survey in Schools; Hanninen et al. (2012).

Conditioning Engineers (ASHRAE) standard (7 lps pp).

Exposure to mould and dampness, relative humidity and uncomfortable temperature

The WHO Schools Survey aimed at estimating the percentage of pupils at the country level who are exposed to dampness or mould in schools. Data collection was based on a systematic walkthrough of the buildings, standardized documentation of visual observations and surface moisture measurements using special moisture monitors. To the extent possible, inspections were conducted in all indoor premises in each school (including classrooms, hallways, bathrooms, and unoccupied spaces, such as basements).

Moisture content of interior building materials was measured using portable surface moisture meters. In each room, several measurements were taken from the floor and walls. If an area with elevated moisture content was detected, more measurements were taken to determine its boundaries and to estimate its area in square meters.

The protocol of the WHO survey combined building inspections with questionnaires and interviews. This helped to overcome problems associated with reporting bias and inaccuracy, while simultaneously taking into account the long-term perspective and breadth of background knowledge of the building administrators. Microbial determinations were not included in this survey. Data were entered in Excel forms or uploaded to a relational database (in this case, a SQL database). Analysis of data was conducted using a specially developed Excel data analysis tool or an SQL query.

Building upon the HITEA study experience, the WHO Schools Survey involved the development of a more detailed exposure assessment approach. Instead of dichotomizing entire schools as affected or not affected, the WHO schools survey dichotomised individual class rooms and other premises. Each room was dichotomized as "affected" or "not affected" based on a ratio of the area affected by mould/dampness to the floor area of the room. If mouldy odour was present, then the room was classified as "affected". Standard usage coefficients for different types of spaces, ranging from one (for regular classrooms) to 0.1 (for indoor premises which are only occasionally used by pupils) and room floor area data were used to estimate the proportion of person-time that pupils spent in mould/dampness-affected spaces in each school. At the country level, the proportion of school time that pupils spend in affected spaces was estimated by taking into account the number of pupils in each participating school (Table 19).

Relative humidity in classrooms was measured during one school week in one to three classrooms per school using data loggers with relative humidity sensors. Average values for the entire monitoring period (including nights) were estimated. Temperature was also measured and recorded during one school week using temperature sensors with data loggers (they were integrated in CO_2 monitors). Average temperature values were estimated for school time (excluding nights) to assess pupils' exposure to uncomfortable temperature in classrooms.

An example of classroom temperature and relative humidity fluctuations in a classroom without heating system is presented in Fig. 8. In the morning the temperature was 7 °C and then it increased up to 15 °C during the day. Moisture emitted by the occupants also raised the relative humidity to over 80%. The average CO_2 level during classes in that classroom was almost 6000 ppm and median ventilation rate was less than 1 lps pp.

Table 19. Country-level estimates of the percent of time that pupils are exposed to mould and dampness in schools

Country	Number of schools inspected	Total number of pupils	Overall percent person-time exposed	Lowest percent person-time exposed in a school	Highest percent person-time exposed in a school
Albania	12	7 440	46.1%	0%	77.4%
Croatia	23	10 750	15.8%	0%	71.5%
Estonia	4	958	6.5%	0%	12.9%
Latvia	4	1 650	36.0%	20.4%	66.4%
Lithuania	10	5 606	4.5%	0%	15.7%

Source: data from the WHO Schools Survey

In most (90%) classrooms in the Albanian survey, the average temperature during classes in winter was substantially below the 18° C Albanian minimum temperature standard for schools (information on the standard from the WHO policy questionnaire); the lowest weekly average temperature during classes was 10.1° C while the minimum temperature (usually at the beginning of classes in the morning) was as low as 6° C. In such schools, the lack of proper heating resulted in poor ventilation because windows were kept closed.

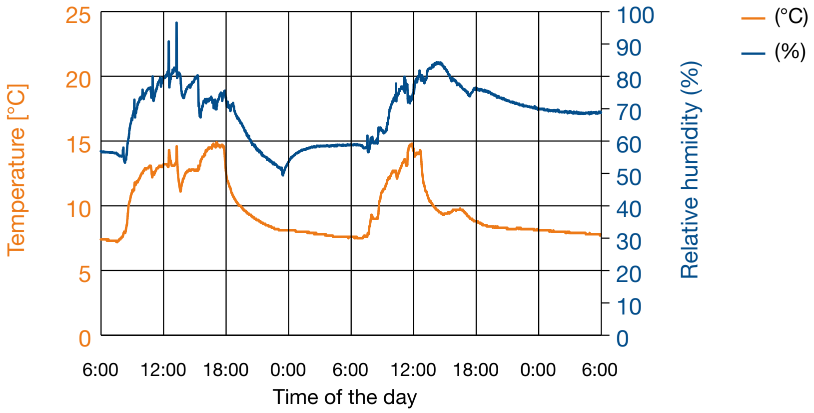
It should be noted that Albania was the only middle-income country which completed a school survey using the WHO protocol. It is likely that similar winter-specific problems exist in some other countries with similar socioeconomic conditions for which comparable data are not available. The Albanian survey demonstrates the need to close this data gap and, if problems with low indoor temperature, mould and dampness or poor ventilation are demonstrated, to design targeted interventions to improve conditions in schools.

Sanitation and hygiene in schools

Data on sanitation and hygiene

were collected using three methods: questionnaire for pupils, inspection of toilets and hand washing facilities by survey staff, and questionnaire for school administration. Survey staff used standardized checklists to assess all toilets and hand washing facilities in all participating schools. The cleanliness of facilities, availability of water, soap, toilet paper, hand driers or towels, presence of adequate light, level of privacy (cabins with doors which can be locked from inside) and other parameters were initially evaluated at a school level; country level

Fig. 8. Example of temperature and relative humidity patterns during two school days in a non-heated classroom



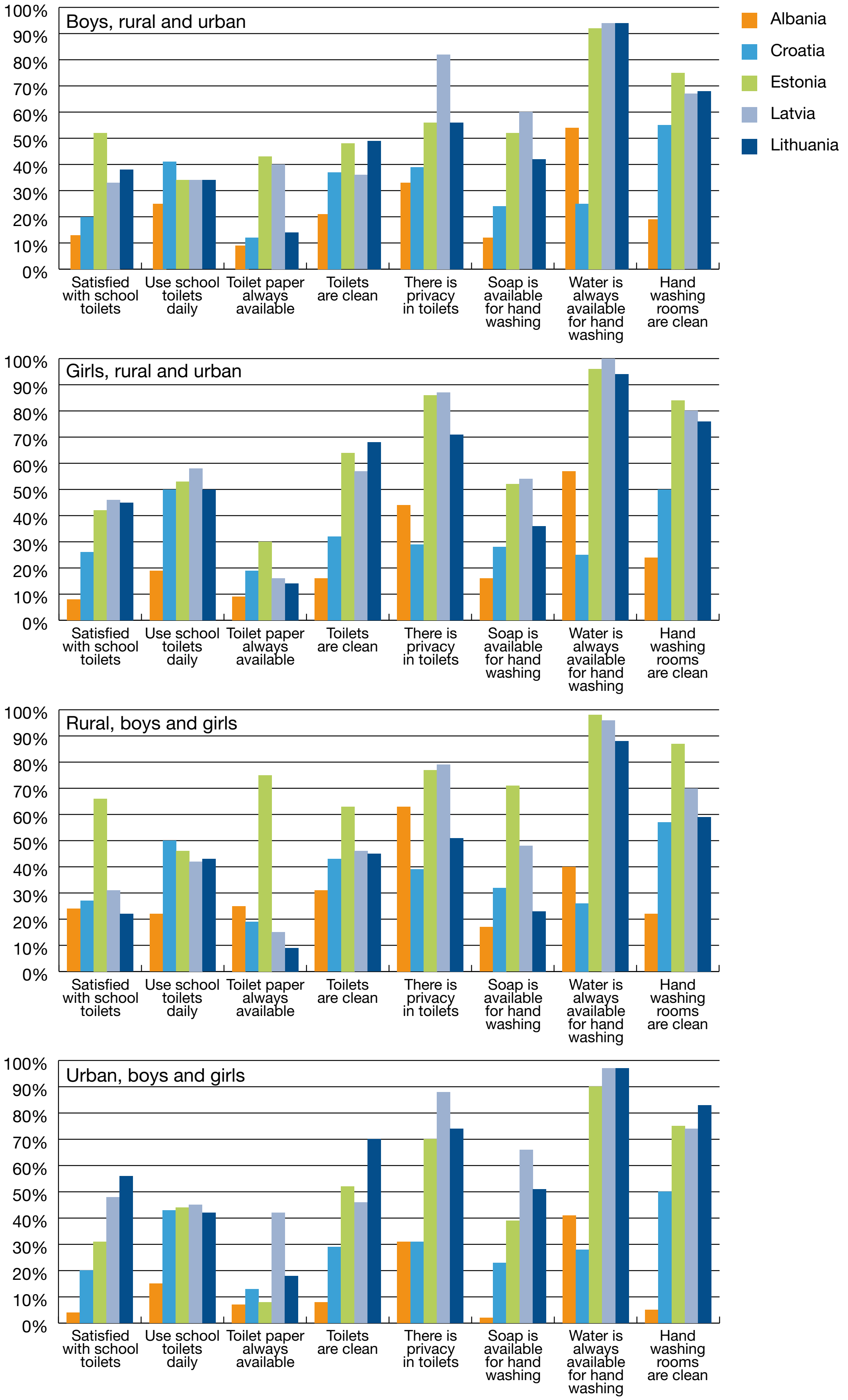
Source: data from one school in the WHO Schools Survey

parameters were estimated taking in account the size of each participating school. Questionnaires for pupils were used to collect data on their satisfaction with sanitation facilities, usage of facilities, availability of soap and toilet paper. School administrators answered standard questions on the type of toilets and hand washing facilities, and on maintenance and operation practices. Data from the survey were entered in Excel forms and analysed using standardized approaches.

Selected results of pupils' questionnaires are presented on Fig. 9. Insufficient availability of toilet paper and soap for hand washing were commonly reported problems in all countries. A majority of pupils in each country were not satisfied with school toilets; Albanian pupils had the lowest level of satisfaction. Girls were more likely to report using toilet daily than boys in all countries except Albania. Also, girls were more likely to be satisfied with privacy in toilets in four out of five surveys (except Croatia). In Albania, Croatia and Estonia, pupils in rural schools provided more favorable responses to most questions (except the availability of water for hand washing) than in urban schools. In Latvia and Lithuania, the pattern was inverted with urban pupils providing substantially more favorable answers to most questions. Further surveys in Albania, Latvia and Lithuania are expected to produce data on bigger numbers of schools and to more reliably characterize urban-rural contrasts in sanitation and hygiene in schools.

The results of pupils' questionnaires are corroborated by the results of inspections (selected data are shown on Fig. 10). None of the 42 Albanian school toilets inspected had sufficient toilet paper or comfortable temperature (inspections were conducted in winter) while no hand washing facility had sufficient soap. The differences between urban and rural schools were minor with the exception of the availability of toilet paper and soap in Lithuanian schools were the situation appeared substantially better in urban schools (67% vs. 21% of toilets had sufficient amount

Fig. 9. Percent of pupils who answered positively to selected questions about sanitation facilities in schools

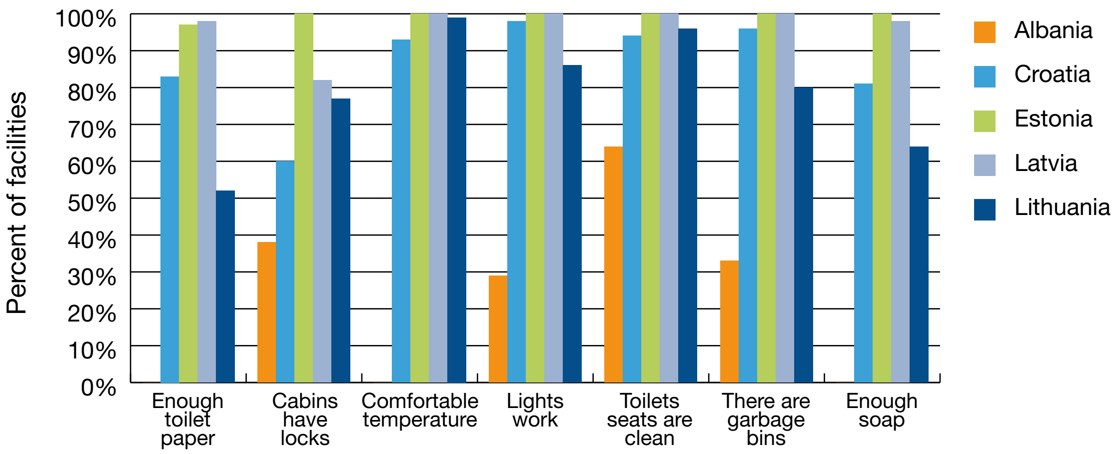


Source: data from the WHO Schools Survey of toilet paper and 83% vs. 21% of hand washing facilities had soap).

Smoking in schools

Data on the smoking behaviour of pupils were collected using questionnaires for pupils, which were administered in three classes in each participating school. The questionnaire included questions on general smoking behaviour, which were adopted from the Global Youth Tobacco Survey (GYTS). In addition, there were specially designed questions for assessing smoking inside the school building, in the school yard or elsewhere during the school hours.

Fig. 10. Selected results of inspections of sanitation facilities in schools



Source: data from the WHO Schools Survey

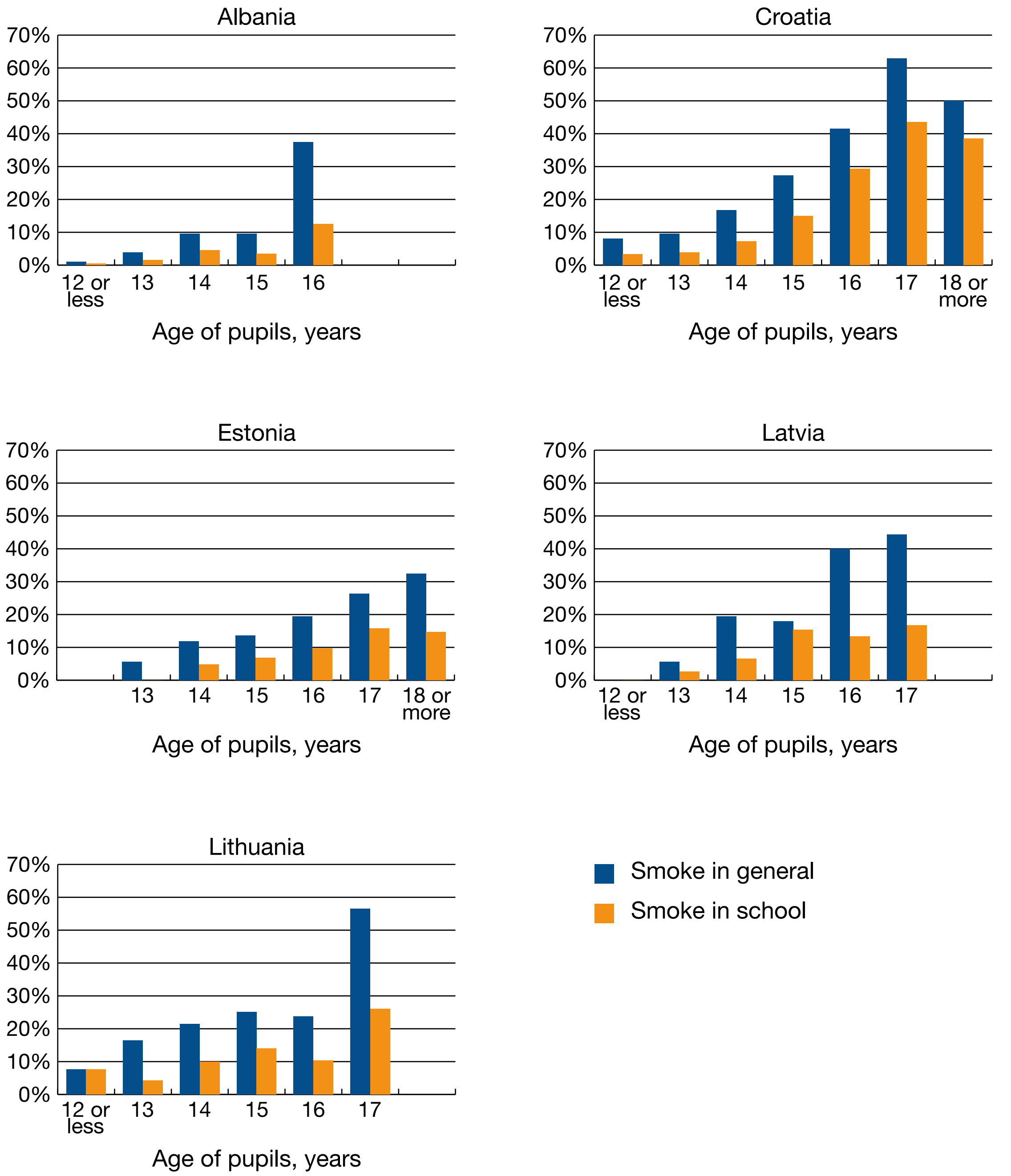
Questionnaires were given to pupils, age 11 years and older, by survey staff (rather than teachers) in order to maintain confidentiality. There were no personal identifiers in the questionnaire except gender and age.

The rate of smoking increased with age steeply (Fig. 11). In every age category, only a subset of pupils who reported smoking in any place at least once during the past month also smoked in the schools at least rarely. Overall, from almost half of all pupils who smoke in general also smoke in the school or on the school territory during school hours. Proportions of smokers who smoke in the school were rather similar in all participating countries ranging from 40.1% in Latvia to 46.5% in Lithuania. Some of the highest age-specific prevalence rates of smoking in general and smoking in the school were reported in Croatia. Almost one-third (29.4%) of Croatian pupils who smoke in the school do it every school day.

In addition, a short questionnaire form on smoking prevention rules was administered to teachers or other school personnel (minimum of five individuals per school). The data from this questionnaire were summarized as proportion of positive responses to each question, at the school and national levels. The results presented on Fig. 12 show proportions of school employees who answered positively to questions about smoking policies in schools. In all five countries, most responders believed that pupils are not allowed to smoke inside schools. However, substantial proportions of respondents in some countries believe that school employees are allowed to smoke outside school building on the school property during school hours.

More detailed results of analysis of teachers' questionnaires will be presented in WHO reports on school surveys. Similar questionnaire forms for teachers developed by WHO were incorporated in

Fig. 11. Percent of pupils who reported smoking in general and smoking in the school or on the school ground, by age



Source: unpublished WHO Schools Survey data.

the latest round of the GYTS. The results are currently being analysed.

Mode of transportation to schools

Data on the mode of transportation to schools were collected using questionnaire for pupils which were administered to three classes in each participating school. Pupils had to select the most common transportation method to schools from among four options: walking, cycling, using private car and using public transport.

Among all countries surveyed, Albania had the highest proportion of pupils walking to schools, both in rural and urban areas (Fig. 13). The use of bicycles was very uncommon in both rural and urban areas

Fig. 12. Percent of school employees who answered positively to questions about school smoking bans

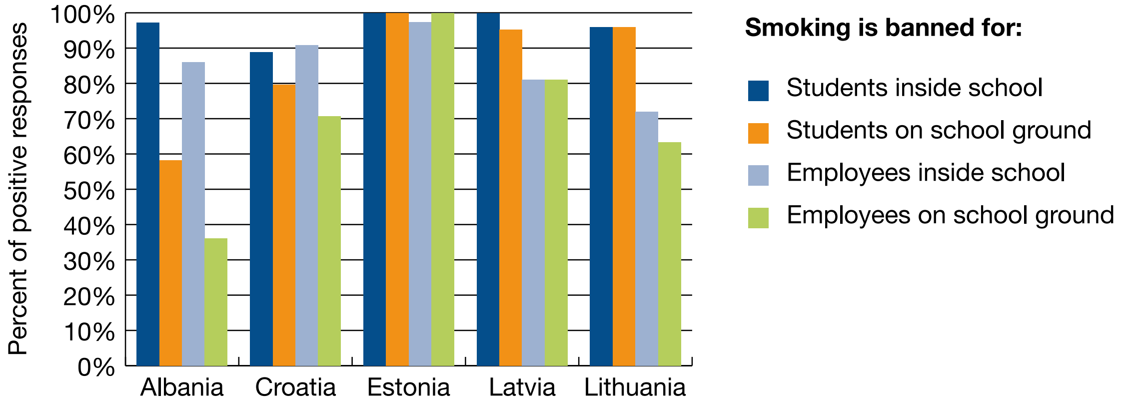
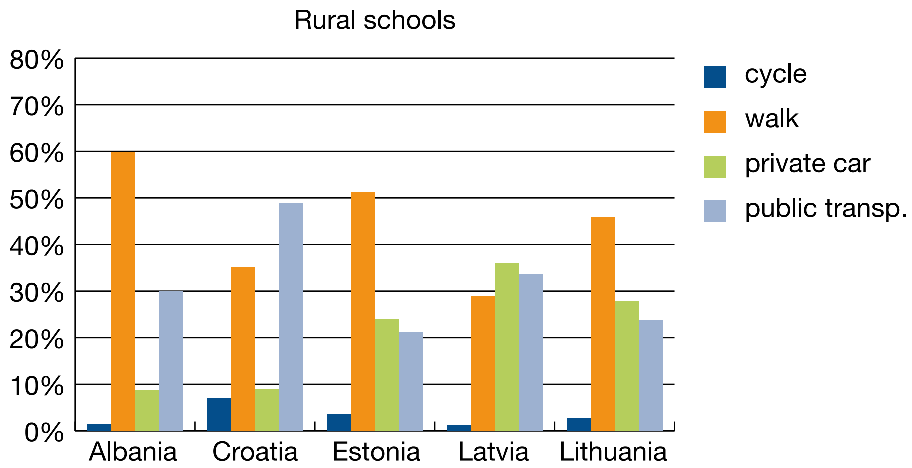
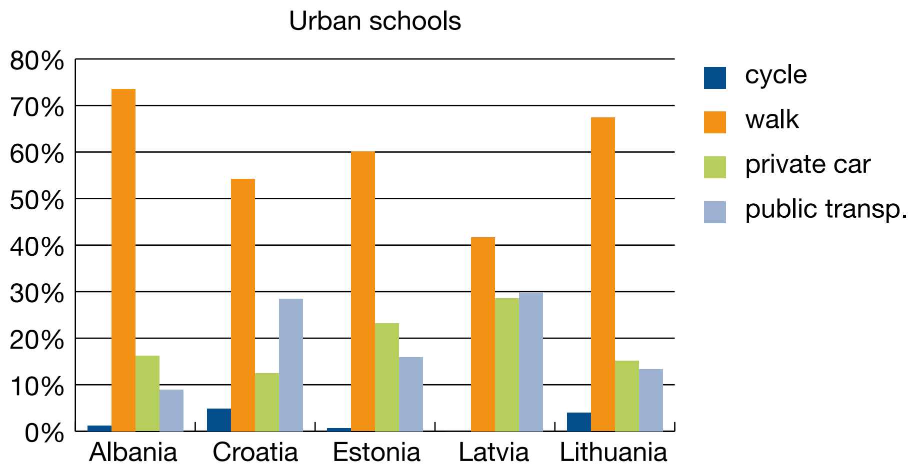


Fig. 13. Percent of pupils using different modes of transportation (cycling, private car, public transport or walking)





Source: data from the WHO Schools Survey.

in all five countries, suggesting the need to facilitate the use of this health-promoting and environmentally friendly mode of transportation. Further information on the presence of bicycle lanes, secure bicycle parking places at schools, and other infrastructure would need to be collected in order to identify specific areas for improvement.

3.2.7 National survey of sanitation and hygiene in public schools in Georgia

Background

Improving WASH and infrastructure conditions is an important component of education policy in Georgia. The national WASH survey in schools was conducted by the Educational and Scientific Infrastructure Development Agency (ESIDA) and UNICEF as an important step forward in this regard (UNICEF, 2013). The goals of the survey were to collect data on WASH infrastructure in the general education public schools and on hygiene behaviour in school pupils.

Survey design

The UNICEF methodology of Global Evaluation and Monitoring of WASH Conditions was applied in this survey. This methodology includes three basic methods of data collection:

1. face to face interviews with school principals/administrators;

2. facility inspection and pupils' hygiene behaviour observation (quantitative components); and

3. focus group discussions involving pupils and teachers (qualitative component of the survey).

For the quantitative components the sample size was 600 schools. The survey used stratified random selection of schools. All schools in Georgia were divided into 35 strata, and 600 schools were drawn proportionally from all strata using weighted random selection. For the qualitative component, focus group discussions were held with school teachers and pupils in the capital city and three selected administrative regions.

Summary of results

More than 70% percent of public schools have access to a piped water supply either inside or outside school buildings. However, only 30% of all schools (61% of schools in urban areas and 15% of schools in rural areas) have water pipes installed inside the school buildings. Four percent of schools in urban areas and 12% in rural areas use unimproved water sources as their main source of water; 6% of schools in rural areas have no water sources at all. In one administrative region the situation was especially problematic with 24% of all inspected schools having no water source.

The proportions of schools using unimproved sanitation (e.g. pit latrine without slab or bucket) were 9% in urban areas and 20% in rural areas. In addition, 0.2% of schools in rural areas had no toilets at all. Only 31% of the schools had sanitation facilities inside the school building. In general, Georgian public schools have a number of toilet compartments that are not sufficient for the number of pupils. In all schools there are, on average, 35 pupils per toilet seat/ compartment (WHO recommends that there should be no more than 25 pupils per toiled seat). In most schools (with the exception of some small schools in villages) there are separate toilets for boys and girls. Concerning the access of children with physical disabilities to the toilets, the situation generally is not satisfactory, as practically no schools had special arrangements for this category of children.

There is no possibility to wash hands in 11% of schools countrywide. Some administrative regions had almost 30% of such schools. Hand wash facilities located inside the school building were found only in 41% of all schools and in 46% of schools with piped water supplies. Approximately 70% of schools have hand wash facilities inside the toilet compartment or nearby.

Conclusions

The results of the survey demonstrate that most Georgian public schools do not meet the international standards for WASH in schools. The conditions are better in urban areas (especially in the capital city, Tbilisi) compared to rural areas. Targeted interventions are urgently needed to improve the situation. According to the opinions of different groups of stakeholders (school principals, teachers and pupils), the most important prerequisites for improving sanitation and hygiene conditions in schools are infrastructure rehabilitation and introduction of hygiene education.

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4. Summary of exposure to EH risk factors in schools

4.1 Exposure to chemical indoor air pollutants

The available data demonstrate that levels of main indoor pollutants are below the WHO Indoor Air Quality Guidelines in most schools. However, exposure surveys also demonstrated elevated levels of specific pollutants in some classrooms exceeding the WHO guidelines.

The levels of formaldehyde are well below the WHO guideline of 100 μg/m^3 in almost all classrooms. While earlier surveys (e.g. the school survey in Cologne in the late 1990-s early 2000-s, demonstrated that a sizable proportion of schools had high levels of this chemical exceeding the WHO guideline level (which was introduced later), more recent surveys, such as SINPHONIE, WHO Schools Survey and national pilot survey in France did not detect concentrations in excess of the WHO guideline. There is an important data gap in the eastern part of the Region and in low- and lower-middle-income countries. The use of low emission materials in schools and other source control measures should be further promoted across the Region in order to prevent potential episodes of high level exposure.

Pupils are also exposed to carcinogenic compounds in schools, such as benzene. While there is no WHO guideline values for this carcinogen (no safe level), a substantial proportion of schools have benzene levels exceeding the EU standard of 5 μg/m^3. The use of indoor combustion for heating may be an important source of exposure in winter in schools which lack central heating systems. While the use of indoor combustion devices, such as kerosene heaters, may be a common practice in some Member States, benzene monitoring data are not available in most low- and lower-middle-income countries.

Exposures to NO_2 are mainly related to outdoor traffic sources in most schools. While the surveys presented in this report did not identify schools with NO_2 levels in classrooms exceeding the short term WHO guideline level (200 μg/m^3 one-hour average); however, weekly average concentrations in some schools in two countries which participated in the SINPHONIE survey exceeded the WHO guideline for long-term exposure (40 μg/m^3 for one-year average). It should be noted that the available data do not characterize many countries with limited resources, where indoor combustion sources may be used in some schools during the cold season resulting in high NO_2 levels. Limited available data on IAQ in rural schools in some south-east European countries show that the use of kerosene heaters in classrooms may also be associated with exposure to carbon monoxide, although the levels tended to be below the WHO guidelines for this compound.

4.2 Exposure to dampness/mould in schools

Currently available data on exposure to mould/dampness in schools across the WHO European Region are poorly comparable due to the use of different monitoring methods and data analysis and interpretation approaches. Recently conducted multi-national HITEA and SINPHONIE surveys, as well as the ongoing

WHO School Survey, and municipal surveillance programme in Cologne (an example of city-level surveys in Germany) all used different methodologies. None of these surveys can be considered fully representative of the populations of school pupils in participating countries, as typically only a limited number of schools were included and the selection of schools was not fully random. For example, the methodological differences make it difficult to compare the results of HITEA with the results of WHO School Surveys without additional analyses of crude data. There is an urgent need to develop and apply harmonized inspection and data analysis approaches in order to produce comparable data suitable for integration in reference datasets.

Based on the available information, it appears that exposure to mould in schools is a widespread problem and, therefore, a large number of exposed pupils are at risk of developing adverse health effects. It also seems that the availability of local expertise in identifying dampness and mould problems, and resources for addressing them are limited in some countries. Training and awareness building measures are needed to improve surveillance and support targeted interventions.

Existing data are not sufficient for making conclusions about the magnitude of detrimental effects of school-based exposure to dampness and mould on children's health in the European Region. Data from low- and lower-middle-income countries are especially sparse. Given that the mould and dampness problems appeared to be most common in schools in a middle-income country in southeast Europe which participated in the WHO Schools Survey and in the SINPHONIE survey, and that data from many other countries with similar socioeconomic conditions are not available, it is imperative to support efforts aiming at closing this data gap.

The *WHO guidelines for indoor air quality: dampness and mould* (WHO Regional Office for Europe, 2009a) identified three goals for controlling indoor moisture. These goals, which are equally applicable in schools and residential buildings, are to: The verification code is 752760

1. control liquid water;
2. manage indoor humidity levels and condensation; and
3. carefully select building materials and hydrothermal assembly designs that minimize moisture problems.

Effective control of liquid water intrusion required specific measures during building design, construction, operation and maintenance stages. This involves establishment and maintenance of barriers preventing direct water entry and barriers to control moisture migration by capillary action (i.e. capillary breaks), control of condensation and indoor humidity levels through proper heating, ventilation and air-conditioning. Ventilation systems are intended to control the thermal environment, humidity and indoor pollutant levels. However, if not properly designed, installed and maintained, ventilation systems may actually contribute to moisture problems. This is because ventilation affects air and moisture flow in the building envelope and produces pressure differences within the building. Building materials should be chosen so as to minimize the risk of mould growth and dampness problems. Where moisture damage and or mould are observed, the source of excess moisture needs to be identified and removed. Affected building materials need to be cleaned or removed, depending in the degree of mould contamination.

School administration is responsible for providing a healthy workplace and learning environment, free of excess moisture and mould. Informing key stakeholders about the health significance of IAQ and factors that cause indoor air pollution is important for facilitating effective actions aimed at maintaining clean indoor air. Many of these actions are beyond the power of the individual building user and must be taken by public authorities through the relevant regulatory measures concerning building design, construction and maintenance, and through adequate housing and occupancy policies.

Dampness and mould may be particularly prevalent in poorly maintained buildings in low-income areas. Prevention and remediation of exposure in disadvantaged populations should be given a priority. Recommendations for specific climatic, economic and historic regions should be developed in order to efficiently control dampness-mediated microbial growth in buildings and to ensure desirable IAQ at manageable costs.

4.3 CO_2 levels and ventilation in classrooms

Data on CO_2 levels in classrooms are not collected on a regular basis in most countries. The most extensive national monitoring programme, which was recently initiated in France, will involve measurements of CO_2 levels in every school and kindergarten in the country. While some high-income countries, such as Finland, have a substantial proportion of schools equipped with mechanical CO_2-controlled ventilation systems, natural ventilation remains the most common ventilation method in the Region.

The available data show that poor ventilation and exposure to stuffy air are very common in many countries during the cold season. According to the results of SINPHONIE and WHO Schools Survey, the highest levels of CO_2 were detected in classrooms in a middle-income country in south-eastern Europe where levels about 5000 ppm (the maximum allowable peak level in the United Kingdom) were rather common. A combination of study air with very low indoor temperature and high relative humidity, which were detected in the same schools, makes a rather uncomfortable environment which is likely to have a strong detrimental impact on the learning efficiency and well-being of pupils. Recent studies demonstrated that exposure even to lower CO_2 levels (e.g. 2,500 ppm) is linked to reduced performance at various cognitive tests in children.

Technical and operational requirements for ensuring sufficient ventilation may include establishing the following: minimum number and surface area of vents in natural ventilation systems; minimum number of windows/window surface area; functioning heating systems and temperature controls; specifications of mechanical systems (e.g. exhaust only- or two-way systems); protocol for opening windows during classes and breaks; and CO_2-based demand-controlled mechanical systems. In practice, increasing teachers' awareness may also have substantial impact on the ventilation practices. Potential interventions to meet this aim include using non-logging display-only devices and traffic light indicators to inform teachers about the IAQ conditions and prompt them to take measures improving ventilation (e.g. opening windows or doors). Detailed recommendations and tools for ventilation in schools developed by the United States EPA (EPA, 2012) can be used to develop targeted interventions.

4.4 Sanitation and hygiene in schools

Sanitation and hygiene in schools remains a high priority in the WHO European Region. Recent surveys demonstrated the need for more targeted interventions, especially those aimed at rural populations in resource-limited areas. Problems with access to adequate hygiene and sanitation in schools persist despite the existence of comprehensive policies and regulations. Poor sanitation facilities in schools and poor hygiene are associated with transmission of infectious diseases and may adversely affect pupils well-being and, potentially, learning process.

While all countries have policies setting requirements for inspections of sanitation facilities in schools, very limited consistently collected data are available for international comparisons. Results of recent or ongoing surveys using standardized methodology developed by WHO and UNICEF demonstrated serious problems, especially in countries with limited resources. WHO surveys demonstrated high levels of dissatisfaction with school toilets among pupils in all five participating countries ranging from 55% to 90%. A majority of pupils in each country reported a lack of toilet paper. According to the results of UNICEF survey, almost 30% of schools in Georgia do not have access to piped water supply, only 15% of schools in urban areas have access to piped water inside school buildings while 20% of rural schools use unimproved sanitation. Overall, data suggest that urgent interventions are needed to improve the situation and reduce disparities among Member States. Limited available data also suggests that urban-rural disparity is pronounced in resource-limited settings.

In order to improve the availability and quality of sanitation facilities, and promote good hygiene practices in pupils, the following recommendations are proposed:

- improve inspections of sanitation facilities, in particular to take into account pupils' perceptions and needs;
- establish requirements for operation and maintenance of school toilets and hand washing facilities including guidance for regular cleaning, stocking soap and toilet paper, and protocols for reporting and addressing problems and complaints;
- improve awareness of school management of problems related to poor sanitation and hygiene facilities, including potential adverse impacts on health and educational outcomes, and develop approaches to stimulate the involvement of parents and pupils in monitoring and reporting; and
- improve operation and maintenance of sanitation and hygiene facilities, and implement further measures to improve the situation in lower-middle and low-income countries. Results of a survey in Georgia and available data from other lower-middle and low-income countries in the Region suggest that substantial investments in infrastructure are necessary in order to improve sanitation and hygiene in schools.

The Protocol on Water and Health allows Member States to set national targets on water, sanitation and hygiene in schools and programming of country-specific activities to incrementally advance progress towards goals set in the Parma Declaration.

4.5 Smoking in schools

The results of the WHO Schools Survey demonstrated that smoking in schools is a wide-spread problem in the five participating countries despite the existence of reasonably strong smoke-free policies in educational facilities in these countries. This may be due to a weak enforcement of existing policies. Rates of smoking in schools varied substantially among the five countries. The prevalence of smoking in general was appreciably higher than the prevalence of smoking in schools, suggesting that stronger enforcement of smoking bans by the school personnel may be effective in preventing smoking in schools.

A limitation of the WHO Schools Survey is that sampling focused on middle schools with children up to 15 or 16 years of age. Thus, few data from older teenagers (who, perhaps, are more likely to smoke) were collected. An example that indicates that older teenagers are more likely to smoke compared to younger teenagers is the very high rate of smoking (nearly 50%) in 17 and 18 year-old pupils reported in some high schools.

While adult smoking rates in most Member States have been relatively stable during the past several years, smoking rates among young people tend to increase in some countries. As most adult smokers started smoking before the age of 18 years, it is of paramount importance to ensure that school-age children do not pick up smoking habits and become addicted as. A large majority of Member States of the WHO European Region including all five countries that participated in the WHO Schools Survey have ratified the WHO Framework Convention on Tobacco Control, which requires strong actions aiming at preventing smoking in all indoor public places including educational facilities. Further actions are required in order to improve enforcement and compliance among school pupils and adults working in educational institutions.

4.6 Walking and cycling to schools

Cycling and walking are important means for children and adolescents to achieve the recommended level of at least one hour of moderate- to vigorous-intensity physical activity per day. The main takeaway message from the WHO Schools Survey is that walking to school is a prevalent commuting method while cycling is rather uncommon. Although cycling is a very healthy, cost-effective, and environmentally friendly mode of transportation, it is underutilized by pupils in all five countries which participated in the WHO Schools Survey. Potential reasons for not using bicycles may include safety concerns by parents and children, lack of bicycle lanes and other cycling infrastructure (e.g. secure bicycle parking spaces in schools) and weather conditions, particularly in winter. In countries where cycling is not a mainstream transportation method, the socio-cultural environment may need to be re-oriented towards supporting the use of cycling in the general population as well as in children and adolescents.

The following measures are recommended in order to increase levels of active mobility in school age children.

- Identify and address safety concerns and risks, and introduce measures to calm traffic and reduce the risk of collisions between vehicles and cyclists, and between pedestrians and cyclists, particularly near schools and in areas that pupils use for cycling to schools.
- Implement reduced speed limits (not higher than 30 km/h) in residential areas.
- Encourage the collaboration between school administration and local transport and community planners to integrate the need for active and independent mobility of children in local transport and urban development plans.
- Conduct awareness raising campaigns that promote cycling as a healthy, safe and enjoyable alternative mode of transportation to school.
- Ensure that there are bicycle lanes along the routes to school.
- Develop and maintain cycling infrastructure in schools, ensuring that there are adequate bicycle parking spaces.
- Monitor the use of cycling as a means of transportation to schools and collect information from pupils about their perceived barriers to walking and cycling to school in order to develop targeted interventions facilitating the use of cycling as a mode of commuting.

4.7 General conclusions

WHO Constitution defines health as "…a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity" (WHO, 1946). All components of health are greatly affected by indoor environments. Chemical and biological exposures in the indoor environment cause an estimated annual loss of two million healthy life years in the EU according to the estimates from the HEALTHVENT project (Hänninen & Asikainen, 2013). Exposures in schools, where children spend a substantial proportion of their time, are important in this context. Due to the high density of occupants, exposures to chemical and biological agents in schools can be substantially higher than in homes. In addition to causing diseases and adverse health symptoms, school-based environmental exposures may also negatively impact pupils' well-being, learning, and academic performance.

The economic development of Member States, in an increasingly globalized and competitive environment, will depend heavily on future generations of young people who are capable of effectively driving the societies forward. In order to succeed, these young people must first of all be healthy. They must also possess the social and academic skills which are necessary for successfully adapting to and mastering new technologies. Such skills are typically acquired by individuals during childhood, in kindergartens and schools. Thus, school environments need to be supportive, health-promoting, and conducive of the learning process. This means that schools have to be clean, safe and comfortable with adequate lighting, indoor air temperature and relative humidity, adequately ventilated classrooms, and functional sanitation facilities that pupils would not hesitate to use. Such environments not only reduce pupils' exposure to toxic substances and prevent diseases, but also enable and facilitate efficient and enjoyable cognitive development. Providing equitable environmental conditions in schools for all children, including those living in disadvantaged areas or belonging to vulnerable groups, is especially important for preventing unequal educational outcomes and promoting socioeconomic development.

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