Health Effects of School Environment
(HESE)

Final Scientific Report

Siena, January 2006

Study outline

As already reported in the mid-term report and in other interim reports, the study was conducted essentially as planned, although some adjustment on the timeline were needed due to local difficulties, particularly with ethical approval is some countries.

As proposed, the first year of the study was devoted to the design of a survey covering a wide range of European schools and the development of instruments for the evaluation of air quality in relation to health in schools.

Two points were quickly identified regarding this study: First of all, this was an unique opportunity to examine schools from different countries using a single, standardized procedure. Previous studies had been in fact conducted in some European countries, but the use of different protocols prevented the direct comparison of data from different part of Europe. Second, the resources that we had were too limited for a study representative of all the European schools, and our aim should have been limited to demonstrate the feasibility of such a study, still providing data from a sufficiently wide range of locations and on the wider possible array of parameters of air quality.

Accordingly, in a preliminary meeting (Paris October 17-18, 2003) a series of decisions were taken:

1. We would have studied a limited number of schools (two classes of each of four schools for each center). Schoolchildren of 9-10 years were selected according to the ISAAC II study. Each center would have sought some variability among selected schools (such as 2 in more polluted and 2 in less polluted areas, or new vs old, or affluent vs. less affluent area etc)
2. Air quality of all the schools would have been carefully characterized by objective measures.
3. Informations on respiratory symptoms and on heath-related aspects of air quality would have been collected by questionnaires to both children and their parents. The questionnaires would have been built on the ISAAC questionnaires.
4. A subsample of 5 children from each class would have been randomized for performing objective clinical tests and assessment of biomarkers.
5. To ensure standardization of the data, personnel from a single center would have participated in the measurement of environmental measures in all the schools.
6. All measurements would have been centralized in a single center: Uppsala for environmental samples and Aarhus for clinical samples, Pisa for database management and analysis.

Three questionnaires were developed specifically for the study (See Appendices).

a) A questionnaire for pupils, largely based on validated questions of the ISAAC questionnaire. The questionnaire also contained questions on the perceived air quality at school, on exposure to environmental tobacco smoke and on school-related symptoms.
b) A questionnaire for their parents, also based on the ISAAC questionnaire. This questionnaire also contains a series of questions regarding the pupil's and family medical history, home environment, food and lifestyle.
c) A questionnaire for teachers (one teacher for each class), containing questions about the school and classroom environment and on the policy of the school regarding air quality and on children with asthma.

We also devised a series of clinical tests selected to be both non-invasive and informative on possible irritative phenomena particularly of the nose and the eyes:

a) Skin prick tests with a standardized panel of allergens
b) Spirometry
c) Acoustic rhinometry before and after a local vasoconstrictor.
d) Collection of nasal lavage for the measurement of pH and interleukin 1
e) Collection of breath condensate for measurement of interleukin 8
f) Break-up time (time before an involuntary eye blink)
g) Tear film analysis using the Tearscope

Finally, the following environmental measures were planned.

a) Building inspection
b) Temperature
c) Relative humidity
d) Carbon dioxide (CO2)
e) PM10
f) Ultrafine particles
g) Ozone (O3)
h) Nitrous oxide (NO2)
i) Formaldehyde
j) Allergens in dust
k) Allergen in the air
l) VOCM (Microbial Volatile Organic Compounds) for molds and bacteria
m) Cultures of viavle molds and bacteria

Details of the methods are given in the Appendix A

One meeting was held in Uppsala in the days 20-30 November 2003 to acquaint all the groups to the clinical measurement to be performed. At least on personnel from each group participated in the meeting.

The protocol and materials for submission to local regulatory agencies for ethical approval were ready in early January 2004. Objections were received by three ethical committees (Siena, Paris, Uppsala). The main objection in Siena and in Paris was about performing clinical (albeit non-invasive) clinical tests in the school setting. In particular, skin prick tests were considered by some members as "less than minimally invasive", hence not justified in healthy children. The problem in Sweden was related to an excessive burden of applications to the local ethical committee, so that a certain number of applications were postponed regardless their quality.
The ethical committee in Siena was satisfied by the assurance that the skin test would have been performed by certified operators in a medically equipped room according to the requirements of the Italian Society of Allergy. This however was not sufficient in Paris, nor was successful a subsequent application in a different French city (Clermont Ferrand). Eventually, we were able to get it accepted in a third city (Reims), but with the condition that children had to be invited to go to the local hospital to perform the skin tests, rather than performing all the test in the school. This required two subsequent requests for extension of the project (first to June 2005 then to October 2005).

The field survey took a full week in each location. It was performed first in Udine (March 15-20, 2004), then in Siena (March 22-27, 2004), Oslo (April 12-17, 2004), Aarhus (April 19-23, 2004). Ethical approval in Uppsala was eventually obtained and the field survey performed in March 14-19, 2005. Finally, due to above mentioned difficulties with local ethical committees, performing the survey in Reims was not possible before the week 10-14 October 2005. Although this was actually after the official closure of the project (October 1 2005), and could not fully use the resources of the project to cover the expenses, we include the results of France in this report as they really belong to this study.

Two meeting to discuss the results were also held: one in Siena in September 2005 (before the survey in Reims) and one in Paris in November 2005 (again, after the official end of the project).

The schools investigated by each center are reported in Table 1. Only two schools were selected in

Aarhus because of local characteristics (few schools much larger than in other centers) and three in Uppsala. Nevertheless the total number of classrooms investigated was very close to the original target (46 vs 48). The characteristics of the schools included in the sample were sufficiently heterogeneous, including a broad range of age of the buildings and of location characteristics (Table 2).

Apart from the above mentioned problems with some ethical committees, in each location the group was faced with a variety of practical problems (such as setting the room for clinical exams, processing of the samples, transportation to the lab and the like) but all were solved locally and in most cases didn't result in loss of data. So overall, we demonstrated that our protocol was sustainable within the limit of our resources and all of its parts could be adopted in a wider survey.

Results

Outdoor environment

The results of measurements performed outside the schools are reported in Table 3 and 4. As anticipated, there was a good variety of environmental settings. The outdoor level of PM10 exceeded the current European level of 50 µg/m3 in 10 schools. Higher values of PM10, NO2 and ultrafine particles were detected in Udine, Aarhus and Reims, indicating an higher level of outdoor pollution (fig 1-4). In five of the schools (one in Siena, three in Udine and one in Reims) the level of NO2 outdoors was >25 ppm, indicating the presence of traffic close to the schools. Accordingly, a corresponding decrease in the levels of O3 was observed in those schools. A level of PM10 greater than 100µg/m3 was also observed outside four of those schools.

Indoor environment

The presence of some sources of environmental pollution inside the schools, as reported in teacher's questionnaires, are reported in table 5. Excessive dust in some location inside the school was reported by 70% of teachers, mold odor, dampness or water leaks by 37-47%, environmental tobacco smoke by 26%. Pollution sources inside the classrooms were much rarer (table 6), but signs of dampness/humidity or dust were reported in some of the classrooms.

The results of objective measurements inside the classrooms are reported in tables 7-11. The levels of PM10 were consistently higher in Siena, Udine and Aarhus, intermediate in Reims, and lower in Uppsala and in some classrooms in Oslo (fig 5). This was clearly associated to the presence of mechanical ventilation in the school building. This was present only in all the Swedish schools and

in two of the three Norwegian ones.
Temperature was apparently well controlled in most schools, except possibly in Reims, where the measurements were performed in days while the outside temperature was uncommonly high for the season.
The more striking result was the presence of very high levels of CO_2 inside the schools of 4 of the 6 centers. A mean level of CO_2 greater than 1000 ppm was observed in 31 of the 46 classrooms surveyed (67%). Of the remaining 15 classrooms, 13 belonged to schools with mechanical ventilation, including all the schools in Uppsala and in 2 of 3 in Oslo (Fig 6). There were some differences in the indoor levels of NO_2 and O_3 among different centers, mostly related to outdoor levels, but the levels were within safety limits in all the classrooms (Fig 7 and 8). The indoor levels of formaldehyde were consistently very low, consistently with the fact that none of the schools reported recent furniture (not shown).

The indoor levels of ultrafine particles were generally quite low, with very high levels recorded occasionally during snacks or meals due to orange peeling, which results in the formation of ultrafine particles. Indeed, indoor levels of NO_2, O_2. With those exceptions) ultrafine particles were consistently higher outside than inside the schools, suggesting the absence of indoor sources. In contrast, levels of PM10 and CO_2 were consistently higher inside, indicating the prevalence of indoor sources (fig 9).
Levels of total and of viable bacteria varied among centers, with higher levels observed in Siena and Reims (Table 10). The levels of both total and viable molds was somewhat lower in northern countries (Aarhus, Oslo and Uppsala) than in Reims, Udine and Siena. The types of bacteria and moulds more frequently identified is reported in fig 10 and 11.
Allergens were measured both in dust collected with a vacuum cleaner and in the air (collecting the particles deposed over a week on two Petri dishes). High levels of cat, dog and sometimes horse allergens (all considered to be originated outdoors, mostly carried in by of schoolchildren themselves through their clothings) were observed in classrooms of most centers. Air levels of the same allergens did vary somewhat independently of their presence in dust, with lower values observed in Oslo and Uppsala (Table 11). A level of cat, dog or horse allergen > 1000 ng/g in settled dust was observed in 20 (46%) classrooms (10 for cat, 15 dog,. 6 horse). In 10 cases the concentration of at least one allergen was higher than 2000 ng/g.

The high level of indoor CO_2 indicated that very poor ventilation is a very common problem in European schools. Not surprisingly, then, the presence of mechanical ventilation was strongly associated to better air quality parameters (Table 19). Mean levels of CO_2, humidity, PM10 and allergens in the air (total of cat, dog and horse allergens) were all significantly lower in schools with mechanical ventilation. As it could be expected, allergens in settled dust were not influenced by the presence mechanical ventilation, and the difference remained highly significant also after adjusting for allergens in settled dust, adjusted difference: 1314 (95% CI: 632-1996) ng/mg, $p<0,0001$. Thus, although the amount of allergens carried into the school was presumably similar, children in mechanically ventilated schools resulted less exposed to airborne allergens.

Outdoor level of PM10 was also significantly lower in schools with mechanical ventilation. This is because environmental air quality is better in Sweden and Norway, were those schools were located, as compared to other countries. However, the difference in indoor level of PM10 remained significant after adjusting for outdoor levels, with an adjusted difference of 57 (50-62) µg/m3 $p<0.0001$.

The levels of total and viable molds were significantly lower in classrooms of schools with mechanical ventilation ($p<0.0001$). Levels of total and viable bacteria also appeared somewhat reduced in schools with mechanical ventilation, but the difference did not reach statistical significance.

Light measurement were available from 5 centers (table 20). Average light in the classrooms was 765 ±85 lux (M ± SE), with great variability among centers: 75% of the classrooms in Siena and 60% in Oslo had a mean illumination lower than 500 lux, as compared with only 20% in Udine, 25% in Reims and 33% in Aarhus.

The characteristics of the studied populations (children questionnaire,parent questionnaire, and subsample randomized for clinical tests) are reported in table 12. There were some differences in the responses in some centers. In Italy and France the children questionnaire was completed in the classroom with the help of a survey operator. In Scandinavian countries, this was considered culturally unacceptable, and both questionnaires were completed at home. In Aarhus, it was decided not to administer the questionnaire to pupils. In Oslo, questionnaires were available only for the children selected for clinical tests. In Reims, the response rate by the parents was poor. Overall, however, response rate was satisfactory. Excluding Aarhus, where the children questionnaire was not used, the parent questionnaire was missing in 3.8% and the children questionnaire in 3.5% of cases.

The percentage of symptoms reported by pupils and by their parents are reported in tables 13 and 14. As expected, prevalence of recent respiratory symptoms was slightly higher in self-report than in parental report. Overall, however, the prevalence of respiratory disorders was similar to that observed in larger samples of the same populations in the ISAAC study.

Report of environmental tobacco smoke exposure at home is reported in figure 14. Overall, the percentage of children exposed to ETS at home was 34%, ranging from 17% in Uppsala to 48% in Reims.

Levels of Il1 and pH in breath condensate and of Il8 in nasal lavage are reported in table 15. Levels of Il8 did vary greatly in some centers (with particularly high values in Udine), although we could not identify any specific cause. Il1 levels were correlated with increasing levels of viable molds ($p<0.0001$). was positively correlated with the level of indoor PM10. ($r= 0.62 \pm 0.14$, $p <0.0001$). The Tearscope time was negatively correlated with light intensity ($p <0.01$) and with increasing PM10 ($p=0.05$).
The results of rhinometry before and after a local vasoconstrictor are reported in table 17, clearly showing that the vasoconstrictor do cause an increase in the volume both of the anterior and of the posterior region of the nose (fig 12 and 13). The increase in volume was significantly smaller in children with a positive skin prick test (1.9 ±01 vs 2.2 ±0.1, $p<0.05$) and increased significantly with the concentration of molds and with increasing ventilation ($p<0.001$).

Thus, despite the limited size of the sample, we identified a variety of biomarkers which are related with the quality of the indoor environment as well as with the clinical condition of the children.

We also investigated the perception of indoor and outdoor air quality, evaluated on a four points scale, by children, parents, and teachers.

Outdoor air quality as perceived by parents significantly correlated with outdoors levels of PM10 and of NO_2 ($p<0.001$), while when reported by pupils it failed to do so. In contrast, perception of indoor air quality by children, but not by parents, was significantly correlated with indoor measurement of PM10 ($p<0.05$). Neither one did correlate with levels of CO_2 or other parameters of indoor air quality. The perceived illumination reported by both parents and children was significantly correlated with objective measurements ($p<0.01$). All these correlation were very loose, with large overlaps. (tables 21 and 22)

The perception of indoor air quality by parents, however, was strongly correlated ($p<0.0001$) with the degree of overall satisfaction about the school, and negatively correlated with their perception that bad indoor air could affect school activity by their children and with the perception of cooperation by the school (fig 15). Similar correlations, albeit somewhat weaker, were observed for children. Eleven percent of the children reported that poor air quality affected their school performance. Interestingly, this percentage was higher in children reporting at least a wheezing attack in the last 12 months (20%) than in those who did not (9%, $p<0.05$).

Data from teachers (only one per each classroom) were too few for statistical correlation with environmental data. However, they appeared to slightly overestimate the quality of indoor air and to underestimate that of outdoor air as compared to both parents and children of their class ($p<0.05$).

A final aspect of our survey concerned the management of asthma attacks occurring into the schools.

Only two of the 21 schools (one in Oslo and one in Uppsala) reported to have a written policy for air quality. Only 1 reported the presence of a school nurse 5 days a week, all day, with 7 other reporting the presence only four (2 schools), two (3) or 1 (2) day per week, for 5 to ½ hour per day. In 11 schools (including all 8 in Italy, 3 in Reims, 1 in Oslo and 1 in Aarhus) a school nurse was never present. In only one of the schools (the same that had a nurse 5 days a week) there was an operator trained to administer a bronchodilator if a school nurse was not present. Only one school had a explicit policy about carrying asthma medications from home, and one had a written policy about treating asthma attacks. In short, none of the 21 schools fulfilled the US (http://www.nhlbi.nih.gov/health/public/lung/asthma/friendhi.htm) or the Australian (www.asthma.org.au) requirements for an “asthma friendly school”.

Accordingly, the management of asthma attacks occurring in schoolchildren in practice resulted poor. In the sample there were 70 children with a diagnosis of asthma according the parent report (13%). Of these, 52 reported at least one asthmatic symptom (wheezing, wheeze with exercise, nocturnal dry cough) or a report of an asthma attack or of taking any asthma medications during the previous 12 months (“current asthma”). In contrast, a total of only 11 asthmatics were known by the teachers. Among children with current asthma, 16 (31%) reported having had at least one asthma attack while being at school. According to their report, however, in only three occasions, however, an intervention of the school operators did occur: in one case a bronchodilator was given by a school nurse and in two it was self-administered on suggestion by a teacher. In all the other episodes the child self-administered a medication without intervention by a school operator, or nothing was done

Dissemination and exploitation of the results.

Increasing awareness of the importance of the school environment on children health and providing tools to improve air quality and health services for schools and communities was a major objective of our project. In fact, this was the major aim behind the rationale of our study. The strong delay in the schedule of the study however prevented to fully reach this objective according to our expectations within the time limits of the project. Nevertheless, the data of clinical relevance (such as results of spirometry and skin tests) were communicated to the families, and a report of the main findings and suggestions regarding the school building is being prepared for the school authorities. An abstract has been already presented at a major conference (Norback, D., Sestini, P., Elfman, L., Wieslander, G., Sigsgaard, T., Canciani, M., Ciarliegio, G., Annesi-Maesano, I., I., Nystad, W. and Viegi, G. (2006) Health effects of the school environment (HESE): Indoor environment in primary schools in Italy, France, Denmark, Norway and Sweden. Healthy Buildings HB 2006, Lisboa, Portugal), and manuscripts based on the results reported above are already on the work. We anticipate that our results will be presented with high visibility at the conference, on the Web site, and on publications of the European Respiratory Society (among members of our group are many current top officers of the society, including the President of the society, the President and the Web Coordinator of the Assembly of Occupation and Epidemiology, and the head of the working group on Occupational and environmental health.), as well by the European Federation of Asthma. Furthermore, we established a web site www.hese.info (an application for the www.hese.eu domain has also been filed) were the outline and methods of the study are available and were the results and tools will be made available. Te site has multi-lingual capability (although presently only English and Italian are operative) and information will be gradually provided in several languages, as soon as the analysis of data will progress.

Major conclusions

Despite some drawbacks due to bureaucractical problems and limited resources, we are convinced to have reached some outstanding results.

Fist at all, the report from a previous project funded by the Health & Consumer Protection DG of the European Community,(**Indoor Air Pollution in Schools**, 2001) , consisting in a review of the available literature, found a lack of field studies concerting school environment in European schools, with sparse reports suggesting that a variety of pollutants could have been present and advocated the need of larger studies on this topic. We proceeded just on this line, providing for the first time field data from a considerable number of schools representative of different European countries and environments, ranging from Scandinavian to the Mediterranean regions, from urban to rural areas, from new to very old buildings, and from heavily polluted to non-industrial areas. Indeed, the major strength of our work was that all the environmental measurements were performed with highly standardized and consistent methods, allowing an unbiased comparison among different schools and countries.

In addition, we provided validation of a number of tools (including procedures, questionnaires, clinical methods, biomarkers) proving their efficacy and sustainability across different cultural and environmental settings across Europe. Using these tools, we demonstrated several common pitfalls in air quality in European schools. These included poor ventilation, high presence of particulate, molds, and allergens. We also provide some evidence that most of these could be corrected by proper monitoring and corrective measures. Indeed, most of the problems appeared to be related to poor ventilation, which appears to extremely common in European classrooms. Not only poor ventilation results in accumulation of CO_2 at levels which could affect wellbeing and learning activities of schoolchildren and school personnel. It also results in increased humidity and presence of molds, and presence of mold and dampness is buildings is well known to be a strong risk factor for respiratory disease. Furthermore, it also results in a stronger exposure to airborne allergens. It is well documented that allergens -particularly pet allergens- carried in the school by healthy children with their clothings, can increase airway inflammation and cause allergy attacks in allergic classmates. Therefore, poor ventilation is likely to increase airway inflammation and the risk of asthma in allergic children and could even increase the risk of sensitization in healthy schoolchildren. We could also speculate that poor ventilation could increase the risk of transmission of airborne infections, particularly influenza and other common or less common respiratory viruses. We found that buildings equipped with mechanical had greatly improved ventilation and reduced levels the of CO_2, particles, and molds. Thus, improving ventilation has the potential to greatly reduce environment-related health problems in schools. The mechanical ventilation systems used in Swedish and Norwegian schools participating in this study are very expensive and are probably beyond the resources of most European countries, but luckily ventilation could be improved in most settings with less expensive methods. It must be kept in mind that improving ventilation can be a two-sided sword: while it reduces the burden of pollutants originated inside, it increases the entrance of outside pollutants. Thus, when the outdoor air quality is good, simple methods, sometimes as simple as a limited programmed opening of the windows, could practically address the problem. When the air quality outdoor is poor, such as in schools close to traffic, the more rational approach would be to reduce environmental pollution within reasonable standards (a measure that would benefit all the population and not just the schoolchildren), to deviate the traffic far from school areas, or to move the school to a safer area. Only when outdoor conditions are not amenable to control (such in Northern countries, where external whether can reach extremely rigid temperatures), then expensive methods of mechanical ventilation including extensive filtering and temperature-exchange systems are really necessary. Therefore, intervention studies are needed to assess the effectiveness of various options to improve ventilation.

Unexpectedly, illumination also resulted below acceptable standards in a consistent fraction of the schools. Although not related to respiratory problems, poor illumination has obvious effects on visual ability and could denote a poor attention to the environmental conditions.

In a subsample of children, we showed that many biomarkers (tear film stability, cytokines in breath breath condensate and nasal lavage) and measurements (rhinometry) can be performed with non-invasive procedures and are affected by environmental factors. Our study therefore provides evidence that these measurements could be used on a broader scale to investigate the health effects of the environment.

Using questionnaires, we showed that the perception of air quality by children, parents and teachers is broadly related to objective measurements, but it is not sufficiently precise to characterize the environment. Therefore, we advocate that an effective management of air quality should include monitoring of objective measurements. The same questionnaires, however, demonstrated that parents and schoolchildren highly value air quality in their overall evaluation of the school, and further prompts for programs to improve the school environment. The fact that children with wheeze report to be more frequently to be affected by poor air quality, also raises issues of fairness and equality towards these disadvantaged children, particularly since the prevalence wheezing diseases in children have greatly increased in recent years ans are possibly still increasing.

Finally, we also provide limited but compelling evidence of a very limited preparation of European schools to cope with issues about indoor environment and with environment-related health problems in schoolchildren. Although our sample was far from being representative of all the European schools, it certainly included schools from well developed parts of Europe and, since they accepted to participate in the survey, that were reasonably sensible to environmental and health issues. However, we found that their degree of preparation to face environment and health-related problems was overall dismally poor. The great majority had no policy for air quality control and no provision for assistance of children with environment-related diseases such as asthma. Many did not even provided the presence of a school nurse at any time. Accordingly, even in our limited sample, we showed that a consistent fraction of children with asthma experienced asthma attacks while at school, a figure similar to that recently observed in a greater sample of 20,000 adolescents in Italian schools (Sestini P et al; Gruppo Collaborativo SIDRIA-2.Asthma attacks at school in Italian adolescents. Epidemiol Prev. 2005 Mar-Apr;29(2 Suppl):77-9). However, we also found that, in the great majority of cases, the school operators were unable to provide adequate assistance, if any. All recent guidelines for childhood asthma strongly enforce the supervision of childcarers in the prevention and management of asthma attacks. At home, parents and other relatives usually take care of ensuring proper asthma control, in partnership with health operators. However, children spend a large part of their daytime at school, beyond the reach of their parents, and somebody is needed to surrogate their duties in this setting. If this dos not happen, like in the great majority of the surveyed schools (and likely in most European schools), these children are twice disadvantaged: firstly because they have the disease, and then a second time because thy cannot obtain proper assistance in the setting where they spend a good part of their time, possibly one of the most fruitful for the development of their capabilities.

Luckily, our survey demonstrates that at least in some schools these issues are at least in part addressed. This demonstrates that providing better care for disabled schoolchildren is indeed possible. However, these schools seems to be rare and the provision of services (for example the presence of a school nurse) very uneven across Europe, raising issues of disequality among children of different European countries. An effort is clearly needed to improve and homogenize school health services across Europe.

We acknowledge some limits of our study. First, the sample was not randomized and not ample enough to be considered representative of the whole European situation. However, it was sufficiently large to demonstrate the feasibility of a larger survey, to establish sustainable and effective methods, to clearly demonstrate the presence of a number of problems about the control of air quality in European schools and even to identify some practical possible corrective measures. Second, we had some problems of participation in some centers. These were largely due to cultural differences characteristic of the current European situation, such as different evaluation by ethical committees, increasing diffidence of the lay public toward medical research, particularly relating to personal privacy, and a few organization pitfalls. Overall, these did not affect the results of the study, and we are convinced to have faced them effectively, integrating the problems in our experience and expertise for further studies. Nevertheless, we think that a concerted intervention by the European Commission could be useful to address the increasing distrust of the public toward medical epidemiological research, as this could eventually result in a lower ability to detect and solve problems of the more disadvantaged European citizens as well as of the whole community. Finally, as reported above, exploitation and dissemination of the results has been to date less extensive that we would, but this was mostly due to time and resource constraints, and we are certain to correct this in the near future, as proved by the data presented in this report.

A number of issues remain to be addressed in future studies. First, a single time point could be too limited to fully characterize the environment to which schoolchildren are exposed during their school activities. Future studies should provide repeated environmental monitoring over the full year to study possible seasonal variations of environmental conditions.

Second, intervention studies should be performed to identify effective strategies to improve air quality as well as the health services provided by the schools.

Third, a larger sample could provide more representative data and could better define normal values and variations of biomarkers associated with environmental exposure.

In conclusion, we think that we have largely reached the objectives of our study, and we are sincerely convinced that we have accomplished more that it could be considered possible with the limited resources available.

Concluding remarks

The scientific interest on indoor pollution has been increasing since the second half of ‘80s (1-6). Scientific literature has underlined the role of indoor pollution in affecting health, because people generally spend the major part of their time indoors (1-6). It is also noteworthy that indoor air pollution, resulting from combustion of biomass fuels (coal, wood, and other biomass such as animal dung), is now recognized as relevant risk factor for respiratory disorders in developing countries (7).

Beside schools, indoor environments include dwellings, workplaces, day-care centres, bars, discotheques, and vehicles. The most important indoor pollutants are environmental tobacco smoke (ETS), particulate matter (PM), nitrogen dioxide (NO_2), carbon monoxide (CO), volatile organic compounds (VOCs), and biological allergens. In developing countries, relevant sources of indoor pollution include biomass and coal burning for cooking and heating. The concentration of these pollutants can be many times higher indoors than outdoors (6).

Indoor environments contribute significantly to human exposure to pollutants (8-9), alone or through complex inter-relationships with other pollutants (Molhave et al) or outdoor pollution (10, 7).

Indoor exposures can be related to health outcomes both in developed and developing countries (e.g. biomass and coal burning for cooking and heating) (6, 7).

Often, the concentrations of PM, CO, NO_2, and other indoor pollutants are elevated in developing countries due to lack of adequate ventilation (11). Furthermore, poverty, lack of investment in modern technology and weak environmental legislation may cause high indoor pollution levels in these countries (12).

Around 50% of the world’s population, almost 3 billion people, use biomass fuels as their primary source of domestic energy for cooking, home heating and light, ranging from near zero in developed countries to more than 80% in China, India and Sub-Saharan Africa. In Latin America, approximately 50 to 75% of households use biomass fuels for cooking, especially in rural areas. Wood is the most frequently used biomass fuel (7, 13).

Some studies, especially cross-sectional and case-control studies, have permitted to establish a suggested level of evidence for the relationship between this type of exposure and lung diseases in developing countries and determine quantitative estimates of relative risks (13-16). Smith (15) has suggested a strong evidence for acute respiratory infections in children, chronic obstructive pulmonary disease (COPD), lung cancer, and a weak evidence for tuberculosis in adults.

Recent conservative estimates show that between 1.5 million and 2 million deaths per year could be attributed to indoor air pollution (7, 17), approximately 1 million of these deaths occurring in children under 5 years because of acute respiratory infections, and other significant parts of the deaths occurring because of COPD and lung cancer in women (13). Today, indoor air pollution is globally ranked tenth as preventable risk factor causing the total burden of disease (7).

At present, there is evidence that indoor air pollution increases the risk of irritations, acute respiratory symptoms, bronchial hyper-responsiveness, respiratory infectious diseases, COPD, and atopic sensitization (immunologic disorders) (7, 18-24).

Strategies of prevention

HESE has clearly shown that school environments in Europe contains pollutants and microclimatic factors that can adversely affect schoolchildren's health. This project accumulates evidences with respect to the previous projects funded by the European Commission – DG SANCO and coordinated by the European Federation of Asthma and Allergy Patients Associations (EFA), the patient organization which understood the importance of indoor pollution as a risk factor for respiratory and allergic patients. Indeed, the idea of proposing HESE came out at the European Respiratory Society (ERS) Congress in Berlin on September 2001 within a workshop in which the results of the first EFA project, i.e. an inventory on the knowledge of indoor environment in Europe, were presented. Subsequently, while HESE was assembled, proposed and started to operate, EFA launched the2nd project indoor-related, i.e. THADE ("Towards Healthy Air in Dwellings in Europe"), to which one of the HESE participant took part, on behalf of ERS. It is to point out that THADE is widely referred to in the DG SANCO documentation related to "Developing the Environment and Health Information System Content 5: Document environment and health aspects of indoor air - Provisional issues for discussion". One limitation of THADE is the coverage of dwellings only, and the omission of public indoor spaces. For the latter, it is clear that there is a European added value of the HESE project, especially if a continuation and an enlargement of involved centers is envisaged.

There are several options for achieving an acceptable indoor air quality (table n.1). More details can be found in the American Thoracic Society (ATS) Workshop on indoor air pollution (25) and in the air quality guidelines of the WHO (26). Furthermore, guidelines and recommendations on indoor air quality in dwellings are reported in the EFA final document of the THADE project (the full-length report can be accessed from the EFA website: www.efanet.org) (27).

Pollutant sources may be removed, relocated, or reduced, while efficient home ventilation may reduce pollutants levels. Removal obviously represents the best control method even if it is not possible to adopt this strategy in all situations. However, individuals may choose to reduce or avoid the contact with some sources such as tobacco smoking (2). Indeed, behavioral counseling intervention by clinicians may induce subjects to avoid ETS exposure and to produce substantial benefits (28). Also restriction of smoking at home or enforced bans in public places seems to reduce the exposure (29).

About two-thirds of all dwellings in the developing countries depend primarily on biomass fuels. Electrified homes may provide a better indoor air quality (especially for a reduction of PM and CO levels) if compared with non-electric counterparts (30).

Natural ventilation varies according to building characteristics, occupant activities, and weather conditions, thus making it difficult to control air exchange. However, increasing air exchange seems to be an efficient method for reducing concentrations of all pollutants (2, 25).

Particles and gases can be removed from indoor air by cleaning devices, equipped with high efficiency particulate air (HEPA) filters, which operate by mechanical filtration, electrostatic precipitation, and negative ion generation (2).

Control of the indoor humidity levels (under 45-50%), high ventilation rates, use of air cleaners, removing carpets, and making use of encasings for beds, may reduce allergens concentrations inside homes (31).

Epidemiological surveys, such as the Prevention and Incidence of Asthma and Mite Allergy (PIAMA) study (32-33), the Inner-city Asthma Study (34), and the National Asthma Campaign Manchester Asthma and Allergy Study (^{NAC}MAAS) (35, 36), will allow to improve our knowledge on the effects of control measures on pollutants levels and related health outcome.

Future perspectives

The European Commission is funding EnVIE project, a European Co-ordination Action interfacing science and policy making in the field of indoor air quality. The project, planned for 2004-2007, is collecting and interpreting updated scientific knowledge to elaborate policy relevant recommendations based on a better understanding of the health impacts of indoor air quality (http://indoorairenvie.cstb.fr).

The FIRS -Forum of International Respiratory Societies- (ACCP, ALAT, APSR, ATS, ERS, IUATLD, and ULASTER), a cooperative union of transnational professional and scientific respiratory societies, has considered, as a global priority, the biomass fuels and the respiratory health. A project of FIRS on Biomass Fuels and Respiratory Health is going to be finished in 2006. The aim of the project is the reduction of the global negative impact of the exposure to biomass fuels. The involvement and engagement of governmental and non-governmental institutions will be needed to enhance and strengthen the scope of the project. Advocacy for changes in the ways of using biomass fuels and, more important, for replacement for more efficient and clean fuels will be the final interest of the project.

In conclusion, the available data indicate that indoor pollution largely affects respiratory health worldwide and protective programs of public health should be implemented.

Future research needs mainly to involve the assessment of long-term effects of indoor environments, along with a better knowledge of the mechanisms by which pollutants induce damage in exposed subjects. Moreover, it is necessary to better evaluate gender-related differences in vulnerability to indoor pollutants exposures.

An extension of the HESE study design to cover all the Member States of the European Union would be extremely worthwhile at this regard.

Table n. 1 – Strategies to control pollutants levels (Modified from ref. 4).

Pollutant	Control measures
Nitrogen dioxide (NO_2)	Pilotless ignition Kitchen ventilation Effective vent over source Electricity
Carbon monoxide (CO)	Pilotless ignition Vent emissions outside
Volatile organic compounds (VOCs)	Increasing air exchange Removal of sources
Environmental tobacco smoke (ETS)	Avoiding the exposure Restriction of tobacco smoking
Respirable particles	Vacuum cleaners with HEPA filters Increasing air exchange
Biomass fuels	Increasing use of natural gas Electricity
Allergens	Improving household hygiene Maintaining relative humidity < 45-50% Removal of carpets Vacuum cleaners with HEPA filters Avoiding use of humidifiers Using encasings for bedding Control of water leakage

HEPA: high efficiency particulate air

References

1. Samet JM, Marbury MC, Spengler JD. Health effects and sources of indoor air pollution. Part I. Am Rev Respir Dis 1987; 136: 1486-1508.

2. Samet JM, Marbury MC, Spengler JD. Health effects and sources of indoor air pollution. Part II. Am Rev Respir Dis 1988; 137: 221-242.

3. Samet JM, Spengler JD. Indoor environments and health: moving into the 21st century. Am J Public Health 2003; 93: 1489-1493.

4. Viegi G, Simoni M, Scognamiglio A, Baldacci S, Pistelli F, Carrozzi L, Annesi-Maesano I. Indoor air pollution and airway disease. Int J Tuberc Lung Dis 2004; 8: 1401-1415.

5. Brunekreef B. Indoor environment. In " Respiratory epidemiology in Europe. Annesi-Maesano I, Gulsvik A, and Viegi G eds. Eur Respir Mon 2000; 5 (Monograph 15): 384-399.

6. Bardana EJ Jr. Indoor pollution and its impact on respiratory health. Ann Allergy Asthma Immunol 2001; 87: 33-40.

7. Bruce N, Perez-Padilla R, Albalak R. Indoor air pollution in developing countries: a major environmental and public health challenge. Bull World Health Organ 2000; 78: 1078-1092.

8. Rojas-Bracho L, Suh HH, Koutrakis P. Relationship among personal, indoor, and outdoor fine and coarse particle concentrations for individuals with COPD. J Expo Anal Environ Epidemiol 2000; 10: 294-306.

9. Sarnat JA, Koutrakis P, Suh HH. Assessing the relationship between personal particulate and gaseous exposures of senior citizen living in Baltimore, MD. J Air Waste Manag Assoc 2000; 50: 1184-1198.

10. Jaakkola MS. Environmental tobacco smoke and health in the elderly. Eur Respir J 2002; 19: 172-181.

11. Smith KR. National burden of disease in India from indoor air pollution. Proc Natl Acad Sci U S A. 2000; 97: 13286-13293.

12. Briggs D. Environmental pollution and the global burden of disease. Br Med Bull 2003; 68:1-24.

13. Ezzati M, Kammen DM. The health impacts of exposure to indoor air pollution from solid fuels in developing countries: knowledge, gaps, and data needs. Environ Health Perspect 2002; 110: 1057-1068.

14. Smith KR. Indoor air pollution in developing countries: recommendations for research. Indoor Air 2002; 12: 198-207.

15. Smith KR, Mehta S. The burden of disease from indoor air pollution in developing countries: comparison of estimates. Int J Hyg Environ Health 2003; 206: 279-289.

16. Smith KR, Samet JM, Romieu I, Bruce N. Indoor air pollution in developing countries and acute respiratory infections in children. Thorax 2000; 55: 518-532.

17. Hong C. Global Burden of Disease from Air Pollution. World Health Organization – WHO, Geneva, 1995.

18. Viegi. G, Carrozzi L, Paoletti P, Vellutini M, Diviggiano E, Baldacci S, Modena P, Pedreschi M, Mammini U, Di Pede C, Giuntini C. Effects of the home environment on respiratory symptoms of a general population sample in Middle Italy. Arch Environ Health 1992; 47: 64-70.

19. Neas LM , Dockery DW, Ware JH, Spengler JD, Ferris BG, Speizer FE. Concentration of indoor particulate matter as a determinant of respiratory health in children. Am J Epidemiol 1994; 139: 1088-1099.

20. Nafstad P, Oie L, Mehl R, Gaarder PI, Lodrup-Carlsen KC, Botten G, Magnus P, Jaakkola JJ. Residential dampness problems and symptoms and signs of bronchial obstruction in young Norwegian children. Am J Respir Crit Care Med 1998; 157: 410-414.

21. Jaakkola MS. Environmental tobacco smoke and respiratory diseases. In: Annesi-Maesano I, Gulsvik A, Viegi G (eds). Respiratory epidemiology in Europe. Eur Respir Mon 2000; 5 (Monograph 15): 322-383.

22. Jaakkola JJK, Nafstad P, Magnus P. Environmental tobacco smoke, parental atopy, and childhood asthma. Environ Health Perspect 2001; 109: 579-582.

23. Simoni M, Carrozzi L, Baldacci S, Angino A, Scognamiglio A, Di Pede F, Sapigni T, Viegi G. The Po river delta (North Italy) epidemiological study: effect of pollutant exposure on acute respiratory symptoms and respiratory function in adults. Arch Environ Health 2002; 57: 130-136.

24. Simoni M, Jaakkola MS, Carrozzi L, Baldacci S, Di Pede F, Viegi G. Indoor air pollution and respiratory health in the elderly. Eur Respir J 2003; 21 (Suppl. 40): 15s-20s.

25. American Thoracic Society (ATS). Achieving healthy indoor air. Am J Respir Crit Care Med 1997; 156 (Part 2): 33s-64s.

26. World Health Organization. Air quality guidelines for Europe, 2nd ed. Copenhagen: WHO Regional Publications, 2000 (European series, No 91).

27. EFA (European Federation of Allergy and Airways Diseases Patients Associations. Towards Healthy Air in Dwellings in Europe, 2004. Available on website: www.efanet.org.

28. Wahlgren DR, Hovell MF, Meltzer SB, Hofstetter CR, Zakarian JM. Reduction of environmental tobacco smoke exposure in asthmatic children. A 2-year follow-up. Chest 1997; 111: 81-88.

29. Wakefield MA, Chaloupka FJ, Kaufman NJ, Orleans CT, Barker DC, Ruel EE. Effect of restrictions on smoking at home, at school, and in public places on teenage smoking: cross sectional study. BMJ 2000; 321: 333-337. Erratum in: BMJ 2000; 31: 623.

30. Rollin HB, Mathee A, Bruce N, Levin J, von Schirnding YE. Comparison of indoor air quality in electrified and un-electrified dwellings in rural South African villages. Indoor Air 2004; 14: 208-216.

31. Liccardi G, D'Amato G. Indoor prevention of respiratory allergy. In "The impact of air pollution on respiratory health". D'Amato G and Holgate ST eds. Eur Respir Mon 2002; 7 (Monograph 21): 226-240.

32. Koopman LP, van Strien RT, Kerkhof M, Wijga A, Smit HA, de Jongste JC, Gerritsen J, Aalberse RC, Brunekreef B, Neijens HJ; Prevention and Incidence of Asthma and Mite Allergy (PIAMA) Study. Placebo-controlled trial of house dust mite-impermeable mattress covers: effect on symptoms in early childhood. Am J Respir Crit Care Med 2002; 166: 307-313.

33. van Strien RT, Koopman LP, Kerkhof M, Oldenwening M, de Jongste JC, Gerritsen J, Neijens HJ, Aalberse RC, Smit HA, Brunekreef B; Prevention and Incidence of Asthma and Mite Allergy Study. Mattress encasings and mite allergen levels in the Prevention and Incidence of Asthma and Mite Allergy study. Clin Exp Allergy 2003; 33: 490-495.

34. Crain EF, Walter M, O'Connor GT, Mitchell H, Gruchalla RS, Kattan M, Malindzak GS, Enright P, Evans R 3rd, Morgan W, Stout JW. Home and allergic characteristics of children with asthma in seven U.S. urban communities and design of an environmental intervention: the Inner-City Asthma Study. Environ Health Perspect 2002; 110: 939-945.

35. Custovic A, Simpson BM, Simpson A, Kissen P, Woodcock A; NAC Manchester Asthma and Allergy Study Group. Effect of environmental manipulation in pregnancy and early life on respiratory symptoms and atopy during first year of life: a randomised trial. Lancet 2001; 358: 188-193.

36. Almqvist C, van Hage-Hamsten M. Cat and dog allergens - can intervention studies solve their inscrutable riddle? Clin Exp Allergy 2003; 33: 1167-1170.

37. Mølhave, L., Kjaergaard, S. K., Sigsgaard, T., and Lebowitz, M., Indoor Air **15**(6), 383-392 2005).

TABLES

Table 1. Centres, schools, and classes involved in the HESE Study.

Country	**Centre**	**Schools (classes) N**
1. Italy	Siena	4 (8)
	Udine	4 (8)
2. Norway	Oslo	3 (6)
3. Sweden	Uppsala	4 (9)
4. Denmark	Aarhus	2 (7)
5. France	Reims	4 (8)
Total	6	21 (46)

Table 2. Characteristics of the schools.

	Total (N=21) N (%)	Siena (N=4) N (%)	Udine (N=4) N (%)	Oslo (N=3) N (%)	Uppsala (N=4) N (%)	Aarhus (N=2) N (%)	Reims (N=4) N (%)
building age (yr)							
<10 (or recently restructured)	7 (33)	0	3 (75)	1 (33)	0	0	3 (75)
11-50	7 (33)	1 (25)	1 (25)	1 (33)	2 (50)	1 (50)	1 (25)
> 50	7 (33)	3 (75)	0	1 (33)	2 (50)	1 (50)	0
near high road traffic	7 (33)	0	2 (50)	1 (33)	2 (50)	1 (50)	1 (25)

Table 3. Environmental measurements outside the school.

	Total (N=21) Mean (SD)		Siena (N=4) Mean (SD)		Udine (N=4) Mean (SD)		Oslo (N=3) Mean (SD)		Uppsala (N=4) Mean (SD)		Aarhus (N=2) Mean (SD)		Reims (N=4) Mean (SD)	
PM_{10} (μg/m^3)	64.2	(68.1)	23.0	(17.5)	153.8	(100.0)	16.7	(6.4)	29.3	(22.6)	74.0	(12.7)	71.3	(21.4)
CO_2 (ppm)	399	(25)	368	(31)	403	(21)	402	(5)	421	(23)	393	(11)	403	(16)
NO_2 (μg/m^3)	19.4	(8.4)	14.9	(9.5)	28.1	(8.7)	NA		13.8	(4.4)	16.7	(5.0)	22.0	(4.6)
O_3 (μg/m^3)	49.4	(14.7)	53.6	(12.3)	50.3	(10.3)	NA		58.5	(3.2)	64.8	(8.4)	27.6	(3.5)

NA= not available

Table 4. Environmental measurements outside the school. Ultrafine Particulate Matter ($PM_{0.1}$)

	Total (N=46) Median (range)	Siena (N=8) Median (range)	Udine (N=8) Median (range)	Oslo (N=6) Median (range)	Uppsala (N=9) Median(range)	Aarhus (N=7) Median(range)	Reims (N=8) Median (range)
$PM_{0.1}$ (pt/cc)	12033 (2759-59262)	4959 (2795-7871)	15228 (11807-59262)	5570 (4758-12140)	5243 (3655-6491)	14137 (13978-14296)	12655 (5698-14335)

Table 5. Prevalence of pollution sources inside the schools. Report by teachers (Rr=response rate).

	Total (N=19) Rr=90% N (%)	**Siena (N=4) Rr=100% N (%)**	**Udine (N=4) Rr=100% N (%)**	**Oslo (N=3) Rr=100% N (%)**	**Uppsala (N=4) Rr=100% N (%)**	**Aarhus (N=2) Rr=100% N (%)**	**Reims (N=2) Rr=50% N (%)**
dust	17 (79) 2	4 (100)	3 (75)	3 (100)	3 (75)	2 (100)	2 (100)
mold smell	7 (37)	1 (25)	2 (50)	3 (100)	0	1 (50)	0
water damage	9 (47)	1 (25)	4 (100)	1 (33)	1 (25)	2 (100)	0
dampness	7 (37)	2 (50)	2 (50)	1 (33)	0	0	2 (100)
ETS*	5 (26)	1 (25)	0	1 (33)	0	2 (100)	1 (50)

* ETS=Environmental Tobacco Smoke

Table 6. Prevalence of pollution sources inside the classrooms. Report by teachers (Rr=response rate)

	Total (N=38) **Rr=90%** **N (%)**	**Siena (N=8)** **Rr=100%** **N (%)**	**Udine (N=8)** **Rr=100%** **N (%)**	**Oslo (N=6)** **Rr=100%** **N (%)**	**Uppsala (N=7)** **Rr=78%** **N (%)**	**Aarhus (N=5)** **Rr=71%** **N (%)**	**Reims (N=4)** **Rr=50%** **N (%)**
dust *not at al* *sometime a little* *usually a little* *very dusty*	4 (10) 16 (42) 10 (26) 7 (18) 1 miss	0 5 (63) 3 (37) 0	1 (14) 4 (57) 1 (14) 1 (14) 1 miss	0 3 (50) 1 (17) 2 (33)	0 4 (57) 0 3 (43)	1 (20) 0 3 (60) 1 (20)	2 (50) 0 2 (50) 0
humidity *not at all* *very little* *a little*	21 (68) 9 (29) 1 (3) 3 miss	6 (86) 1 (14) 0 1 miss	5 (63) 2 (25) 0 1 miss	4 (67) 2 (33) 0	3 (43) 3 (43) 0 1 miss	3 (60) 1 (20) 1 (20)	4 (100) 0 0
mold odor	1 (3)	0	0 1 miss	1 (17)	0	0	0
mold/dampness	3 (9)	2 (25)	0 1 miss	1 (17)	0	0	1 (25)

Table 7. Environmental measurements inside the classrooms. Particulate Matter (PM_{10}), Carbon dioxide (CO_2), and Nitrogen dioxide (NO_2).

	Mean (95%CI)	SD	Median	range
PM_{10} ($\mu g/m^3$)				
Total (N=45)	112 (91-133)	69	106	14-260
Siena (N=8)	148 (88-208)	72	141	69-247
Udine (N=8)	158 (118-198)	48	154	92-260
Oslo (N=6)	54 (9-99)	43	43	17-131
Uppsala (N=9)	33 (23-43)	13	32	14-53
Aarhus (N=7)	169 (124-214)	48	160	112-233
Reims (N=7)	112 (90-135)	24	106	86-151
CO_2 (ppm)				
Total (N=46)	1467 (1265-1670)	683	1490	525-3475
Siena (N=8)	1954 (1750-2157)	243	1970	1550-2359
Udine (N=8)	1818 (1115-2520)	840	1563	897-3475
Oslo (N=6)	1158 (357-1959)	763	686	634-2248
Uppsala (N=9)	681 (579-783)	133	657	525-934
Aarhus (N=7)	1568 (965-2171)	652	1434	561-2601
Reims (N=8)	1660 (1407-1913)	303	1611	1199-2194
NO_2 ($\mu g/m^3$)				
Total (N=45)	14.1 (11.7-16.6)	8.1	14.8	3.4-14.5
Siena (N=8)	10.63 (2.6-18.7)	9.6	5.7	4.7-26.4
Udine (N=7)	18.2 (8.0-28.4)	11.0	12.6	6.0-31.8
Oslo (N=6)	17.2 (9.1-25.3)	7.7	21.5	7.0-23.6
Uppsala (N=9)	16.1 (12.0-20.3)	5.4	17.3	7.0-20.7
Aarhus (N=7)	8.3 (3.46-13.04)	5.2	4.6	3.4-14.8
Reims (N=8)	14.6 (9.2-20.0)	6.4	17.2	4.6-22.5

Table 8. Environmental measurements inside the classrooms. Ozone (O_3), and Temperature.

	Mean (95%CI)	SD	Median	range
O_3 ($\mu g/m^3$)				
Total (N=41)	14.3 (9.80-18.71)	14.1	6.9	3.0-48.5
Siena (N=8)	8.3 (0.3-16.2)	9.5	4.5	3.0-31.0
Udine (N=7)	15.3 (4.6-26.0)	11.6	15.1	5.0-37.9
Oslo (N=6)	13.4 (0.6-26.2	12.2	8.5	3.0-34.7
Uppsala (N=6)	25.9 (8.5-43.3)	16.6	24.1	8.0-44.8
Aarhus (N=7)	19.8 (1.7-37.9)	19.6	6.9	3.0-48.5
Reims (N=7)	5.3 (0-11.1)	6.2	3	3-19.4
Temperature				
Total (N=46)	23.3 (22.7-23.9)	2.0	22.7	20.5-29.5
Siena (N=8)	21.1 (20.6-21.6)	0.6	21.2	20.5-22.2
Udine (N=8)	24.5 (23.0-26.0)	1.8	24.7	22.0-26.8
Oslo (N=6)	22.5 (22.0-23.0)	0.5	22.4	22.1-23.4
Uppsala (N=9)	22.3 (21.8 -22.8)	0.7	22.4	21.2-23.4
Aarhus (N=7)	23.3 (22.0-24.6)	1.4	23.5	20.8-24.7
Reims (N=8)	26.2 (24.9-27.4)	1.5	25.6	24.7-29.5

Table 9. Environmental measurements inside the classrooms. Ultrafine Particulate Matter ($PM_{0.1}$)

	Total (N=46) Median (range)	Siena (N=8) Median (range)	Udine (N=8) Median (range)	Oslo (N=6) Median (range)	Uppsala (N=9) Median(range)	Aarhus (N=7) Median(range)	Reims (N=8) Median (range)
$PM_{0.1}$ (pt/cc)	6575 (747-86178)	5575 (3327-61455)	13804 (7292-86178)	880 (747-5860)	3360 (1683-15121)	8503 (4380-25219)	9266 (4553-19938)

Table 10. Environmental measurements inside the classrooms. Bacteria and molds.

	Total (N=46)	Siena (N=8)	Udine (N=8)	Oslo (N=6)	Uppsala (N=9)	Aarhus (N=7)	Reims (N=8)
	Median (range)	**Median (range)**	**Median (range)**	**Median (range)**	**Median (range)**	**Median (range)**	**Median (range)**
Total Bacteria (nr/m^3)	31000 (4250-250000)	96500 (24000-140000)	7350 (4250-21000)	9800 (4850-28000)	31000 (5500-250000)	11000 (5000-110000)	83500 (49000-250000)
Viable bacteria (nr/m^3)	345 (46-5700)	600 (210-1200)	102 (50-640)	215 (46-360)	320 (120-950)	210 (49-5700)	1500 (560-2600)
Total mold (nr/m^3)	21000 (4150-240000)	57000 (22000-110000)	20000 (9500-48000)	5000 (4150-19000)	5500 (4850-44000)	6000 (5000-70000)	86500 (15000-240000)
Viable mold (nr/m^3)	120 (46-1400)	415 (60-920)	150 (91-1400)	86 (46-180)	53 (46-120)	28 (49-300)	670 (300-1100)

Table 11. Environmental measurements inside the classrooms. Air and dust allergens.

	cat		dog	
	median	**range**	**median**	**range**
***Air allergens* (ng/m2/day)**				
Total (N=46)	24	1-224	50	8-169
Siena (N=8)	42	11-120	52	9-162
Udine (N=8)	94	26-224	96	29-169
Oslo (N=6)	2	1-39	37	9-87
Uppsala (N=9)	8	2-18	10	9-169
Aarhus (N=7)	20	7-60	8	8-117
Reims (N=8)	45	5-71	58	9-113
Dust allergens (ng/g)				
Total (N=45)	426	100-5990	661	200-4564
Siena (N=8)	447	152-1022	786	200-1477
Udine (N=4)	761	227-1331	1013	597-1390
Oslo (N=6)	157	100-913	1748	200-2274
Uppsala (N=9)	430	298-5522	558	237-4564
Aarhus (N=7)	224	100-708	314	200-667
Reims (N=8)	1390	335-5990	844	250-3307

Table 12. General characteristics of the children. Number, Sex, and age.

	Total	Siena	Udine	Oslo	Uppsala	Aarhus	Reims
Sample 1 Total number (response rate, %) Males, N %	547 267 (40.8)	114 (NA) 37 (32.5)	111 (72) 58 (45.3)	29 (NA) 14 (48.3)	134 (59) 70 (52.2)	NA	159 (NA) 88 (55.3)
Age, mean (DS)	9.8 (0.8)	9.6 (0.7)	9.8 (0.7)	11.8 (0.3)	10.0 (0.6)	NA	9.6 (0.7)
Sample 2 Total number (response rate, %) Males, N %	552 248 (37.9)	97 29 (25.4)	116 (75) 60 (46.9)	24 (NA) 12 (41.4)	134 (59) 70 (52.2)	90 (60) 32 (35.6)	91 (NA) 45 (28.3)
Age, mean (DS)	9.9 (0.8)	9.8 (0.7)	9.8 (0.7)	11.8 (0.3)	10.0 (0.6)	9.9 (0.7)	9.5 (0.7)
Sample 3 Total number (response rate, %) Males, N %	234 99 (42.3)	40 13 (32.5)	41 18 (43.9)	29 14 (48.3)	40 18 (46.2)	54 19 (35.2)	30 17 (56.7)

Sample 1= report by children
Sample 2= report by parents
Sample 3=subsample of children with clinical measurements
NA=not available

Table 13. Children's health status. Prevalence of symptoms/diseases reported by children.

	Total (N=547) N (%)	Siena (N=114) N (%)	Udine (N=111) N (%)	Oslo (N=29) N (%)	Uppsala (N=134) N (%)	Reims (N=159) N (%)
lifetime wheeze	128 (23.4)	38 (33.3)	15 (13.5)	4 (13.8)	38 (28.4)	33 (20.8)
recent wheeze	67 (10.9)	20 (17.5)	8 (7.2)	1 (3.4)	13 (9.7)	25 (15.7)
missing	1 (0.2)				1 (0.7)	
asthma	81 (14.8)	27 (23.7)	6 (5.4)	3 (10.3)	26 (19.4)	19 (11.9)
missing	9 (1.6)	1 (0.9)			2 (1.5)	6 (3.8)
rec. dry cough/night	157 (28.7)	67 (58.8)	32 (28.8)	6 (20.7)	16 (11.9)	36 (22.6)
missing	42 (7.7)	1 (0.9)	1 (0.9)		1 (0.7)	39 (24.5)
lifetime rhinitis	193 (35.3)	56 (49.1)	25 (22.5)	8 (27.6)	35 (26.1)	69 (43.4)
missing	9 (1.6)	2 (1.8)	1 (0.9)		1 (0.7)	5 (3.1)
recent rhinitis	149 (18.2)	43 (37.7)	13 (11.7)	6 (20.7)	34 (25.4)	53 (33.3)
missing	18 (3.3)	6 (5.3)	3 (2.7)	1 (3.4)	1 (0.7)	7 (4.4)

Table 14. Children's health status. Prevalence of symptoms/diseases reported by parents.

	Total (N=550) N (%)	Siena (N=97) N (%)	Udine (N=116) N (%)	Oslo (N=24) N (%)	Uppsala (N=132) N (%)	Aarhus (N=90) N (%)	Reims (N=91) N (%)
lifetime wheeze	145 (26.3)	32 (33.0)	21 (18.1)	7 (29.2)	42 (31.3)	24 (26.7)	19 (20.9)
missing	1 (1.2)		1 (0.9)				
recent wheeze	45 (8.2)	6 (6.2)	5 (4.3)	2 (8.3)	15 (11.4)	9 (10.0)	8 (8.8)
missing	2 (0.4)		1			1	
asthma	69 (12.6)	11 (11.3)	9 (7.8)	2 (8.3)	25 (19.5)	16 (17.8)	6 (6.6)
missing	3 (0.5)	1		1			1
rec. dry cough/night	103 (18.0)	21 (21.6)	14 (12.1)	5 (20.8)	19 (14.5)	23 (25.6)	21 (23.1)
missing	4 (0.7)		1			1	2
lifetime rhinitis	121 (28.9)	33 (34.0)	39 (33.6)	7 (29.2)		13 (14.4)	29 (31.9)
missing	138 (25.0)	1	2	1	132		2
recent rhinitis	90 (21.5)	21 (21.6)	25 (21.6)	6 (25.0)		10 (11.1)	28 (30.8)
missing	139 (25.0)	1	3	1	132		2

Table 15. Cytokines (pg/mL) and Ph.

	Mean	SD	Median	range
Interleukin-1				
Total (N=148)	3.3	6.2	0.6	0.01-33.2
Siena (N=36)	7.5	8.9	3.7	0.3-33.2
Udine (N=18)	0.4	0.3	0.3	0.1-1.4
Oslo (N=26)	4.3	6.9	0.8	0.1-25.1
Uppsala (N=26)	2.9	4.3	0.8	0.05-15.3
Aarhus (N=42)	0.6	1.6	0.1	0.01-7.5
Reims NP				
Interleukin-8				
Total (N=232)	705	2252	271	0.4-23705
Siena (N=40)	238	395	130	3.9-2300
Udine (N=40)	2396	5076	870	100-23705
Oslo (N=29)	233	315	106	29-1331
Uppsala (N=40)	571	464	440	69-2674
Aarhus (N=54)	300	212	235	17-938
Reims (N=29)	429	465	262	0.4-1664
Ph				
Total (N=123)	6.3	0.9	6.2	4.2-8.5
Siena (N=33)	6.8	0.7	6.8	5.7-8.3
Udine (N=17)	6.0	0.4	6.1	5.3-6.8
Oslo (N=26)	5.9	0.4	5.8	5.3-7.3
Uppsala (N=28)	5.5	1.0	5.9	4.2-7.4
Aarhus (N=19)	7.3	0.5	7.3	6.5-8.5

Reims NP				

NP=not performed

Table 16. Tear film stability by Break-up Time (BUT) and Tearscope methods.

	Mean	SD	Median	range
BUT (sec)				
Total (N=233)	15.0	11.7	10.1	3-60
Siena (N=40)	9.4	6.7	7.0	3-30.0
Udine (N=41)	11.4	6.3	9.5	4.2-36.0
Oslo (N=28)	17.9	13.2	14.0	6-53.0
Uppsala (N=40)	12.6	10.5	9.0	5.0-60.0
Aarhus (N=54)	22.0	14.0	18.7	4.4-59.2
Reims (30)	15.5	11.8	11.7	5.0-52.3
Tearscope (sec)				
Total (N=179)	11.6	7.1	9.2	3.0-43.0
Siena (N=40)	11.4	7.3	8.8	3.0-41.0
Udine (N=41)	8.7	2.1	8.5	4.0-13.0
Oslo (N=29)	14.4	9.3	10.4	5.0-43.0
Uppsala (N=39)	11.0	6.6	9.0	4.0-30.0
Aarhus NP				
Reims (N=30)	13.7	8.5	10.6	4.0-36

NP=not performed

Table 17. Rhinometry. Measurements before decongestion and after decongesting with nasal spray. Minimal Cross-sectional Area (MCA) and nasal volume (VOL).

	Before		After	
	N	**Mean (SD)**	**N**	**Mean (SD)**
MCA (anterior part)				
Total	**233**	**0.70 (0.17)**	**180**	**0.71 (0.14)**
Siena	40	0.70 (0.21)	40	0.69 (0.18)
Udine	41	0.73 (0.18)	NP	
Oslo	29	0.66 (0.12)	28	0.68 (0.12)
Uppsala	40	0.74 (0.14)	39	0.72 (0.14)
Aahrus	53	0.66 (0.13)	53	0.73 (0.12)
Reims	20	0.70 (0.11)	20	0.76 (0.18)
MCA (posterior part)				
Total	170	1.00 (0.36)	127	1.11 (0.41)
Siena	40	0.98 (0.38)	40	1.07 (0.33)
Udine	41	1.06 (0.44)	NP	
Oslo	29	0.81 (0.20)	28	0.93 (0.25)
Uppsala	40	1.16 (0.35)	39	1.41 (0.46)
Aahrus	NP		NP	
Reims	20	0.83 (0.20)	20	0.94 (0.20)
VOL (anterior part)				
Total	170	2.44 (0.41)	127	2.44 (0.42)
Siena	40	2.37 (0.60)	40	2.32 (0.48)
Udine	41	2.51 (0.38)	NP	
Oslo	29	2.42 (0.36)	28	2.55 (0.28)
Uppsala	40	2.49 (0.29)	39	2.45 (0.41)
Aahrus	53	NA	53	NA
Reims	20	2.41 (0.25)	20	2.50 (0.47)
VOL (posterior part part)				
Total	170	6.14 (2.29)	127	7.15 (2.19)
Siena	40	5.62 (2.41)	40	5.93 (1.54)
Udine	41	6.75 (2.81)	NP	
Oslo	29	5.25 (1.11)	28	6.99 (1.67)
Uppsala	40	7.00 (1.85)	39	9.03 (2.15)
Aahrus	53	NA	53	NA
Reims	20	5.47 (2.10)	20	6.18 (1.48)

NP=not performed
NA= not available

Table 18. Children allergens. Number of positive test (%).

Allergen (N of children who performed tests)	Total	Siena (N=40)	Udine (N=41)	Uppsala (N=40)	Aarhus (N=54)
Grass (N=175)	33 (18.9)	8 (20.0)	13 (31.7)	6 (15.0)	6 (11.1)
DP (N=175)	30 (17.1)	5 (12.5)	13 (31.7)	1 (2.5)	11 (20.4)
DF (N=135)	29 (21.5)	4 (10.0)	10 (24.4)	NP	15 (27.8)
Alternaria (N=175)	7 (4.0)	3 (7.5)	1 (2.4)	0	3 (5.6)
Dog (N=133)	16 (12.0)	5 (12.5)	NP	6 (15.0)	5 (9.3)
Cat (N=175)	28 (16.0)	13 (32.5)	4 (9.8)	7 (17.5)	4 (7.4)
Birch (N=135)	9 (6.7)	NP	4 (7.3)	3 (7.5)	3 (5.6)
at least 1 positive test (N=175)	75 (42.9)	24 (60.0)	20 (48.8)	10 (25.0)	21 (38.9)

NP not performed

Legenda for Figures:

ASHRAE = American Society of Heating Refrigerating and Air Conditioning Engineers.
EPA = Environmental Protection Agency
WHO = World Health Organization
FISIAQ = Finnish Society of Indoor Air Quality and Climate

Table 19. Comparison of environmental parameters in schools with or without mechanical ventilation

	Mechanical ventilation		***Natural ventilation***	
CO2	669	(596-750)	1733	(1492-2014)
Ventilation	3	(2-4)	16	(11-22)
Relative humidity	20	(16-24)	45	(42-48)
Mean PM10	29	(22-39)	134	(118-152)
Air allergens	125	(62-249)	1192	(792-1793)
Dust allergens	1864	(1329-2615)	1950	(866-4390)
Tot moulds	8709	(6166-12302)	36064	(23807-54630)
Viable moulds	73	(54-99)	300	(189-476)
Tot bacteria	22115	(11211-43625)	35385	(18180-68874)
Viable bacteria	222	(119-415)	484	(278-845)
Outdoor humidity	44	(31-62)	42	(35-50)
Outdoor PM10	21	(14-33)	53	(30-94)

All units as in previous tables. (M with 95% CI in parenthesis)

Table 20. Light measurement in classrooms in different centers

Center	Mean	± SE (lux)
Aarhus	905	± 187
Siena	393	± 67
Udine	1099	± 234
Oslo	505	± 56
Reims	717	± 76
Average	765	± 85

Table 21.

Perceived quality of outdoor air and levels of PM10 and NO2 outside the school				
	PM10 ($\mu g/m^3$)		***NO2 ($\mu g/m^3$)***	
	Parents	***Children***	***Parents***	***Children***
Very poor	183± 108	68 ± 40	30 ± 9	22 ±7
Somewath poor	127 ±103	95 ± 81	25 ±9	22± 9
Gooud enough	81±61	80 ± 58	20 ± 8	21 ± 7
Very good	75 ±60	75 ± 60	19 ± 8	20 ± 8

M ±SD

Table 22

Perceived quality of indoor air and illumination and measurements inside the school				
	PM10 (μg/m³)		***Light (lux)***	
	Parents	***Children***	***Parents***	***Children***
Very poor	131± 46	185 ± 53	487 ± 255	505 ±238
Poor	159 ±56	133 ± 67	566 ± 406	595±395
Good	153±55	130 ± 54	810 ± 578	731 ± 492
Very good	155 ±51	64 ± 61	800 ± 443	760 ± 466

M ±SD

Appendix A. Matherial and Methods

Assessment of medical symptoms

Standardised questionnaires used in previous studies were used, to monitor upper and lower respiratory as well as ocular symptoms, headache, and fatigue (Wieslander et al., 2000), as well as the ISAAC-study (isaac.auckland.ac.nz)). These questionnaire also contains questions on personal factors and medical background data, such as smoking habits, medical consumption, allergies etc, as well as brief information about exposures in the home environment.

Physiological measurements

They included measurement of tear film stability (BUT), nasal patency measured by acoustic rhinometry, biomarkers of inflammation in nasal lavage fluid (NAL), dynamic spirometry, and biomarkers of inflammation in exhaled breath condensate. All investigations are performed in the actual school building, by an experienced nurse or specialist physician..

Eye investigation

Tear film break up time was estimated by a standardised method, self-reported BUT or BUT(s) measuring the time the subject could keep the eyes open without pain, when watching a fixed point at the wall. The method has been used previously (Wieslander et al., 1999; Wieslander et al., 2000), and has been shown to correlate well with the fluoresceine method for detection of tear film break-up time (BUT) (Wyon and Wyon, 1987). Tear film stability was also investigated directly, using a small eye microscope (Keeler Tearscope Plus. Keeler UK). The Tearscope projects a small net of lines on the ocular surface, and the breaking up time of the tear film can be observed directly, without adding fluoresceine. The Tearscope investigation was performed 1-2 minutes after the BUT(s) investigation.

Nose investigation

Acoustic rhinometry (Rhin 2000; wideband noise; continuously transmitted) is performed under standardised forms (sitting), after 5 min of rest, and prior to the lavage (Wålinder et al, 1998). The first measurement was performed after 5 minutes' rest (sitting), the second measurement was performed 10 minutes after decongestion (two douches of 140 ug xylometazolin-hydrochloride each, 5 minutes apart) (Wålinder et al., 1997). By means of acoustic reflection the minimum cross-sectional areas (MCA) on each side of the nose was measured from 0 and 22 mm (MCA1) and from 23 and 54 mm (MCA2) from the nasal opening. Also, the volumes of the nasal cavity on the right and the left sides is measured from 0 and 22 mm (VOL1) and from 23 to 54 mm (VOL2). The mean values are calculated from three subsequent measurements on each side of the nose. Data on nasal dimensions in the present study are presented as the sum of the values recorded for the right side and the left side.

Lavage of the nasal mucosa is made with a 20 ml plastic syringe attached to a rubber cork**(Sigsgaard et al, 2000).**
Fill the 10 ml syringe with tepidly saline (NaCL). Mount the nose-corks
The child (or the parents) keeps a plastic cup.
Help to keep the nose-cork tight one nostril at a time.
The child sits supine with the head bent forward (cheek towards the chest).
Fill the nasal cavity with 5ml *tepidly* saline. The child is instructed to tell when it tastes salt. It is not ment to overshoot..
After 30 sec the cork is loosened (medial side first) and the saline is collected in the beaker.
The procedure is repeated in the othe nasal cavity.
Samples are transferred to a centrifuge tube.
Working up the sample
Weigh the tube 1 decimal accuracy
Ad X ml 30 mM DTT and mix. (Use pipette #2, (One 1ml pipette only to NAL.) (X = 0,1169 * g lavage fluid or look at the scheme)
Put on ice for at least 15 min

Centrifuge (250 g)10 minutes.(3.500 varv/minut).
Supernatant is transferred to centrifuge tube and put on ice.
Supernatant is distributed into 5 cryotubes put into 20 centigrade

Investigation of lower airways
Lung function is measured by dynamic spirometry. Biomarkers of inflammation in condensed exhaled breath was measured, applying a simplified technical equipment modified developed by Torben Sigsgaard at Aarhus University, Denmark **(ask Torben on details).**

Building inspections
A detailed inspection of the school building, and each classroom involved in the study was performed. The buildings were visited and technical measurements performed the same days as the medical investigations. Details on constructions, materials, type of ventilation system, and signs of building dampness was recorded. In accordance with the procedure introduced in the Danish Town hall study (Skov et al., 1990), we calculated the shelf factor (length of open shelves in relation to room volume) and fleece factor (m2 of fabrics in relation to room volume. It was noted if the school were situated near (< 50 m) from roads with a heavy traffic.

Exposure measurements
Indoor climate parameters and chemical and microbial pollutants measured included room temperature, relative air humidity, carbon dioxide (CO2), particles (PM10); ultrafine particles (PM0.1), formaldehyde, nitrogen dioxide (NO2); ozone (O3), volatile organic compounds (VOC), moulds, bacteria and allergens in settled dust and airborne dust. All measurements were performed during normal activities and under representative conditions. Outdoor measurements was performed during the same time period and by the same methods as the indoor measurements, except for allergens which were only measured indoors..

Illumination
Illumination was measured by a Hagner (ECI) Instrument at the pupils desks in each classroom (12-20 representative measurements). Mean, min and max values were calculated, as well as the proportion of desks with an illumination below 500 lux, a recommended minimum value for good illumination. In addition, the total effect of all fluorescence tubes or light bulbs in the class room was noticed, and the illumination effect per square meter of floor area was calculated (W/m2).

Climate and ventilation
Temperature, relative air humidity, and CO_2 were measured with a Q-Trackt^{TM} IAQ Monitor (TSI Incorporated, ST Paul, Minnesota, USA), a direct reading instrument with an in-built data logger, sampling one minute average intervals. The instrument was calibrated by the local service laboratory in Uppsala, prior to the measurements in the schools. The Q-track instrument was placed at 0.9 m above the floor. The measurements were performed during 2-4 h, when the classrooms had a full class. The number of persons in the classroom was noticed, as well as the number of open windows and open doors . The fresh air supply in the classrooms was calculated from the estimated equilibrium CO_2 concentration (ppm), by the formula below: The equilibrium CO_2 concentration was estimated manually from the CO_2-graphs.

$$A=P/(C_{mean}-C_0)*10^6/3600$$

Where A is the personal outdoor air supply rate, P denotes the personal emission rate of CO_2 in L/s, and C_{mean} and C_0 denote the mean CO_2 levels in the classroom, and in the outdoor air respectively (Norbäck et al., 1992). In the calculations, we assumed a personal CO_2 emission equal to sedentary office work at sea level (18 L/h), and the mean outdoor CO2-level measured by the Q-track instrument. (407 ppm). The air exchange rate was calculated by dividing the estimated total outdoor air flow (m^3/h), with the total volume of the classroom.

Particle measurements

Particles were measured during 1-2 h with both P-Trak™ (Model 8525 Ultrafine Particle Counter) measuring particles in the size range 0.02 to 0.1 micrometer, and Dust- Trackt™ (Model 8520) with a sensor type 90 degree light scattering laser photometer, measuring particles from approximately 1- 10 micrometer (PM10) (TSI Incorporated, USA). The instruments were calibrated regularly by the local service laboratory in Uppsala, Sweden.

Airborne moulds and bacteria

Airborne micro-organisms were sampled on 25 mm nucleopore filters with a pore size of 0.4 m and a sampling rate of 1.5 l/min for 4 hours. The total concentration of airborne moulds and bacteria, respectively, was determined by the CAMNEA method (Palmgren et al., 1986). Viable moulds and bacteria were determined by incubation on two different media. The detection limit for viable organisms was 30 colony forming units (cfu) per m^3 of air

Volatile organic compounds

Formaldehyde was sampled by diffusion samplers impregnated with 2.4-dinitro-phenylhydrazine (Levin et al. 1988). The samplers were analysed by liquid chromatography at department of Occupational Medicine, Örebro, Sweden. Volatile organic compounds (VOC), other than formaldehyde were measured by parallel sampling on two charcoal tubes (Anasorb 747, SKC 226-81) and one synthetic polymer tube (XAD-7; SKC 226-95). The air sampling rate was 0.2 l/min for each tube, and the sampling time was four hours , In addition, the average concentration of VOCs over 7 days was measured by sampling on diffusion samplers ORSA-5). Each charcoal tube was desorbed with 1 ml of carbon disulphide. The ORSA samples were desorbed with 2 ml of carbon disulphide, and analysed by the same method as for the charcoal tubes. The synthetic polymer tube was desorbed with 1 ml methylene chloride. All samples were analysed by gas-chromatography mass-spectrometry (GC-MS), following previously published methods (Norbäck et al., 1995).

Ozone and nitrogen dioxide

Indoor and outdoor NO_2 and O_3 was sampled by diffusion sampling during 7 days, with one sampler in each classroom, and one sampler outside each school. The indoor samplers were placed on one of the walls in the classroom, about 1.5 m above the floor. The outdoor samplers were placed at the opening of a plastic box, hanging in a rope outside a classroom window, well-protected from rain.

There are different types of diffusion samplers for inorganic air pollutants. "Palmes tube" has been the most widely used passive sampler for NO_2 (Palmes et al., 1976). When used outdoors it can be considered a semi-diffusive sampler because wind induced turbulence causes a significant active movement of air inside the sampler (Campbell et al., 1994). In addition, sunlight and NO_2 formation within the tube may also cause sampling artefacts in this sampler (Heal et al., 1999). Because of these disadvantages, we used ”badge type” sampler fully based on the theory for diffusion sampling (Ferm and Svanberg, 1998; Ferm 2001a). The lower detection limits for one week sampling is 0.4 $\mu g\ NO_2\ m^{-3}$ and 4 $\mu g\ O_3\ m^{-3}$. The NO_2 sampler has been compared to active sampling in a routinely managed network (Ferm and Svanberg 1998) and the O_3 sampler has been compared with direct reading instruments based on UV (Sjöberg et al., 2001, Ferm 2001b). The precision is ±5% for both samplers. The samplers were prepared and analysed at an accredited laboratory (IVL Swedish Environmental Research Institute; Gothenburg, Sweden).

Allergen analysis

Two samples of settled dust was collected from each classroom, on from the corridor side and the other from the window side. Dust was collected by a vacuum cleaner with 1200 W electric effect (Siemens Super XS) provided with a special dust collector (ALK Abello, Copenhagen, Denmark)

equipped with a Millipore filter (pore size 6 µm). The filter is made of cellulose acetate, and according to the manufacturer it retains 74% of particles 0.3-0.5 µm, 81% of particles 0.5-1.0 µm, 95% of particles 1-10 µm and about 100% of larger particles (>10 µm). Vacuum cleaning was performed for totally 4 minutes per sample, 2 minutes on the floor and 2 minutes on other surfaces (desks, chairs) as in previous school studies (Smedje et al., 1997). The filters were sealed in plastic bags and stored at –20 °C until extraction.
The dust on the ALK-filters were weighted, and 100 mg of fine was extracted with 2 ml of phosphate buffered saline containing 0.05% Tween 20 (1/20 w/v) for two hours at room temperature with continuous rotation. Mixture of dust and extraction buffer was centrifuged at 4 500 rpm for 10 min followed by another at 10 000 rpm for 10 minutes. The supernatant was transferred to Micro-tubes and stored frozen at –20 °C until allergen analysis.

Airborne dust was collected on two Petri-dishes in each classroom, each with a surface area of 0.0124 m2. They were placed on horizontal surfaces in the classroom, at 1-1.5 m height and were kept for 6-8 days (usually 7 days). This method have been previously used in Sweden to measure airborne cat allergen levels in the classrooms (Karlsson et al., 2002).

The extraction of the Petri-dishes dust was started by adding 3 ml of PBS with 1% BSA into the base part of he Petri-dishes. After gentle stirring for 1 hour, the solution was transferred from the base part to the lid, and left for another 1 hour. Evaporation was minimised by keeping the Petri dish closed during the extraction. The liquid was removed to an Eppendorf tube, and centrifuged at 10,000 rpm for 10 min. The supernatant was collected and stored at -20 C until further analysis.

Allergen levels were determined using two-site sandwich ELISA for cat (Fel d 1) (INDOOR Biotechologies Ltd., USA) and horse allergen (Equ c x) (MABTECH, Stockholm, Sweden) (Emenius et al., 2001) using monoclonal antibodies. Dog allergen (Can f 1) was measured by a monoclonal/polyclonal ELISA using anti-Can f 1 mAb 6E9 for allergen capture and polyclonal rabit anti-Can f 1 for detection. The assays were basically performed according to the protocols provided by the manufacturer except for the dog assay where the horseradish peroxidase labelled goat anti-rabbit immunoglobulin was from DAKOPATTS, Denmark. Allergen concentrations were expressed as ng/g dust, except for horse allergen concentrations which were expressed as Units/g dust, where 1 Unit is equal to 1 ng protein of a horsehair and dander extract used as standard (Allergon, Valinge, Sweden and NIBSC, Hertfordshire, UK). Protein determination was performed on the standard with the micro-BCA method (Pierce, Rockford, USA) using BSA as standard. Samples with intraassay CV>10% were re-analysed.

Petri dishes with low levels of cat allergen (Fel d 1 <1.0 ng/ml) by conventional ELISA were re-analysed by amplified ELISA. It was applied by using a commercial signal amplification kit (AMPACtm, Dako Cytomation Ltd, UK) according to the manufacturers protocol. The standard curve range was 5.0-320 pg/ml.

References

Campbell GW, Stedman JR and Stevenson K (1994). A survey of nitrogen dioxide concentrations in the United Kingdom using diffusion tubes, July-December 1991. Atmospheric Environment, 28, 477-486

Emenius G, Larsson PH, Wickman M, Harfast B (1998). Dispersion of horse allergen in the ambient air, detected with ELISA. Allergy;56, 771-4.

Ferm M, Svanberg P-A (1998). Cost-efficient techniques for urban- and background measurements of SO_2 and NO_2. Atmospheric Environment, 32, 1377-1381

Ferm M (2001a).The theories behind diffusive sampling. In: Proceedings of International Conference Measuring Air Pollutants by Diffusive Sampling, Montpellier, France 26-28 September

2001a. pp. 31-40

Ferm M (2001b).Validation of a diffusive sampler for ozone in workplace atmospheres according to EN838. In: Proceedings of International Conference Measuring Air Pollutants by Diffusive Sampling, Montpellier, France 26-28 September 2001b. pp. 298-303

Heal M R, O'Donoghue MA, Cape JN (1999). Overestimation of urban nitrogen dioxide by passive diffusion tubes: a comparative exposure and model study. Atmospheric Environment, 33, 513-524

Karlsson AS, Hedren M, Almqvist C, Larsson K, Renström A (2002) Evaluation of Petri Dish sampling of cat allergen in airborne dust. Allergy, 57,164-168.

Levin J-O, Lindahl R, Andersson K (1988). High performance liquid chromatographic determination of formaldehyde in indoor air in the ppb to ppm range using diffusive sampling and hydrazone formation. Environ technol Letter, 9, 1423-1430.

Norbäck D, Ancker K, Johanson G (1992). Field evaluation of CO_2 detector tubes for measuring outdoor air supply rate in the indoor environment. Indoor Air, 2, 58-64.

Norbäck D, Wieslander G, Edling C (1995). Occupational exposure to volatile organic compounds (VOC), and other air pollutants from the indoor application of water based paints. Annals of Occupational Hygiene, 39,783-794.

Palmes ED, Gunnison AF, DiMattio J, Tomczyk C (1976). Personal sampler for nitrogen dioxide. Am. Ind. Hyg. Assoc. J., 37, 570-577

Palmgren U, Ström G, Blomqvist G, Malmberg P (1986). Collection of airborne micro-organisms on Nucleopore filters, estimation and analysis-CAMNEA method. J Appl Bacteriology;61, 401-6.

Sigsgaard T, Bonefeld-Jorgensen EC, Kjaergaard SK, Mamas S, Pedersen OF. Cytokine release from the nasal mucosa and whole blood after experimental exposures to organic dusts.
Eur Respir J. 2000 Jul;16(1):140-5

Sjöberg K., Lövblad G., Ferm M., Ulrich E., Cecchini S. and Dalstein L(2001). Ozone measurements at forest plots using diffusive samplers. In Proceedings of International Conference Measuring Air Pollutants by Diffusive Sampling, Montpellier, France 26-28 September 2001, pp.116-123

Skov P, Valbjorn O, Pedersen BV (1990) Influence of indoor climate on the sick building syndrome in an office environment. Scand J Work Environ Health;16, 363-471.

Smedje G, Norbäck D, Edling C (1997). Asthma among secondary school pupils in relation to the school environment. Clin Exp Allergy, 1997a, 27, 1270-1278.

Wieslander G, Lindgren T, Norbäck D (2000). Changes of ocular and nasal signs and symptoms of aircrew, in relation to the ban of smoking on intercontinental flights. Scand J Work Environ Health;26,514-522.

Wieslander G, Norbäck D, Nordström K, Wålinder R, Venge P (1999). Nasal and ocular symptoms, tear film stability, and biomarkers in nasal lavage, in relation to building dampness and building design in hospitals. Int Arch Occup Environ Health;72,451-461.

Wålinder R, Norbäck D, Wieslander G, Smedje G, Erwall C (1997). Nasal mucosal swelling in relation to low air exchange rate in schools. Indoor Air;7,198-205.

Wålinder R, Norbäck D, Wieslander G, Smedje G, Erwall C, Venge P (1998). Nasal patency and biomarkers in nasal lavage -the significance of air exchange rate and type of ventilation in schools. Int Arch Occup Environ Health; 71, 479-486.

Wyon NM and Wyon DP. Measurement of acute response to draught in the eye (1987). Acta Ophtalmol;65,385-92.

Appendix B**.** Teacher's questionnaire about the classroom

During the cold season, are there any days when it is very cold inside the classroom, so to be uncomfortable?

- Never
- Rarely
- Sometimes
- Often

During the cold seasons, are there any days when it is very hot inside the classroom, so to be uncomfortable, because the heating system is too high?

- Never
- Rarely
- Sometimes
- Often

During the cold season, are there any days when outside is cold and windows glasses became steamy?

- Never
- Rarely
- Sometimes
- Often

During the hot season, are there any days when it is very hot inside the classroom, so to be uncomfortable?

- Never
- Rarely
- Sometimes
- Often

In the classroom, do ever sunshine hit directly on some of the benches?

- No
- Yes

How humid is usually the classroom?

- Not at all
- Very little
- A little humid
- Definitely humid

Have you ever noticed a mouldy/earthy or cellar-like odour inside the classroom?

- No
- Yes

Have there ever been visible signs of moisture damage such as damp stains or spots, deterioration or darkening of surface materials in the ceiling, walls, or floors, or signs of condensation of water on surfaces in the classroom?

- No
- Yes

How dusty is usually the classroom?

Not at all
Sometimes a little dusty
Usually a little dusty
Very dusty

How would you score the illumination of the classroom?

Very poor
Rather poor
Rather good
Very good

How would you score the indoor air quality of the classroom?

Very poor
Rather poor
Rather good
Very good

Overall, how comfortable is the classroom in your opinion?

Very uncomfortable
Rather uncomfortable
Rather comfortable
Very comfortable

During school activities, do children use glue, paint, enamels or other products for artwork with an irritant smell?

No
Yes

If YES:

Were are they stored?

In an air-tight chest, into the classroom
In a normal chest or on the shelves, into the classroom
In an air-tight sealed chest, outside the classroom
In a normal chest or on the shelves, outside the classroom

If yes: what precautions are taken when they are used?

None
Windows are open
Used under a hood

To your knowledge (because of official documents or because it was communicated by parents), how many children of the classroom have asthma?

N.....
I don't know

APPENDIX C

Teacher questionnaire about the school (If the same teacher fills more than one classroom form, this part shall be filled only once)

In the school are kept any animals with furs or feathers (birds, cats, dogs, ferrets, guinea pig, mice etc)?

No
Yes

While the children are in the school, are ever used paints, soaps, or other cleaning products with an irritant smell (such as chlorine)?

No
Yes

Are there places in the school with much dust?

No
Yes

If Yes: which ones?

Any classroom	No	Yes
Bathrooms	No	Yes
Gym	No	Yes
Corridors	No	Yes
Kitchen	No	Yes
Canteen	No	Yes
Basement	No	Yes
Offices	No	Yes

Other places (please, specify)..................

Do you notice a mouldy/earthy or cellar-like odour inside the school?
If Yes: where?

Any classroom	No	Yes
Bathrooms	No	Yes
Gym	No	Yes
Corridors	No	Yes
Kitchen	No	Yes
Canteen	No	Yes
Basement	No	Yes
Offices	No	Yes

Other places (please, specify)..................

Is there a history of water damage such as leakage from water pipes or washing machines, boiler, refrigerator, freezer, or cooling of the ventilation system in the school building?
If Yes: where?

Any classroom	No	Yes
Bathrooms	No	Yes
Gym	No	Yes
Corridors	No	Yes
Kitchen	No	Yes

Canteen	No	Yes
Basement	No	Yes
Offices	No	Yes

Other places (please, specify)..................

Have there ever been visible signs of moisture damage such as damp stains or spots, deterioration or darkening of surface materials in the ceiling, walls, or floors, or signs of condensation of water on surfaces in the school?

If Yes, where?

Any classroom	No	Yes
Bathrooms	No	Yes
Gym	No	Yes
Corridors	No	Yes
Kitchen	No	Yes
Canteen	No	Yes
Basement	No	Yes
Offices	No	Yes

Other places (please, specify)..................

Have you ever seen cockroaches inside the school?

Never
Rarely
Sometimes
Often

Is your school free of tobacco smoke at all times, including during school-sponsored events?

No
Yes

If not, where in the school do people smoke tobacco?

Any classroom	No	Yes	
Bathrooms		No	Yes
Gym		No	Yes
Corridors		No	Yes
Kitchen	No	Yes	
Canteen	No	Yes	
Basement		No	Yes
Offices			

Other places (please, specify)..................

How do you perceive the **illumination in the school**? *very poor illumination*
(If the illumination is varying, *rather poor illumination*
try to give an average rating) *rather good illumination*
very good illumination

How do you perceive the **indoor air quality in the school building**?
(If the air quality is varying, *very poor air quality*

try to give an average rating) *rather poor air quality*
rather good air quality
very good air quality

How do you perceive the **outdoor air quality outside the school**?
(If the air quality is varying, *very poor air quality*
try to give an average rating) *rather poor air quality*
rather good air quality
very good air quality

Do you think that the ability to do the school work is reduced because of **poor indoor air quality in the school?**
No
Yes

Does your school have a written Indoor Air Quality management plan?
No
Yes
If YES

Does it reduce or eliminate allergens and irritants that can make asthma worse, like:
Cockroaches
No
Yes
Dust mites
No
Yes
Moulds
No
Yes
Pets with furs or feathers
No
Yes
Strong odours or fumes (such as erase boards, copy machines, art and craft supplies, pesticides, paint, perfumes, chemicals)
No
Yes

How often is a school nurse in your school?
____ days/week
For many hours each time? ______ hours/day

If a nurse is not in your school all day, every day, is a nurse regularly available to help the school write asthma plans and give the school guidance on asthma issues?
No
Yes

a) Is someone assigned and trained to give asthma medications?
No
Yes

b) Does the school nurse supervise and monitor that person at least monthly?
No
Yes

Is there a written policy that allows children to take asthma medications at school as prescribed by their doctor and permitted by parents?

No
Yes

a) If yes: Does the written policy specify whether children may carry and administer their own medications?

No
Yes

b) If no: is the medication in the places where the child can access it all day, every day?

No
Yes

c) If no: where is it located?

___teacher ___classroom __nurses' office __main office other:___________

d) Is there a functional plan for asthma medications on field trips?

No
Yes

Does your school have a written Asthma Action Plan for each child with asthma in case of a severe asthma episode?

No
Yes

If yes: a) Does that plan include what action to take?

No
Yes

b) Does that plan include whom to notify and when?

No
Yes

Is there a procedure established to discuss the asthma management measures together with the student, teacher and parents?

No
Yes

Is there an established asthma education plan that includes general asthma information, asthma management plans, asthma emergency procedures, and asthma medications for each of the following:

a) All school staff (including teachers, bus drivers etc)? No Yes
b) Students with asthma? No Yes
Classmates of students with asthma? No Yes
Parents? No Yes

If in your school there is not an educational program for all school staff, is there a program for teachers about children's asthma?

No, there are no programs for teachers about asthma

Yes, there are voluntary programs for teachers about children's asthma
Yes, at least one teacher is required to attend a program about children's asthma
Yes, every teacher is required to attend a program about children's asthma

Regarding physical education
a) Do students have options for fully and safely participating in physical education class and recess activities?
No
Not always
Yes

b) Is pre-medication available, if needed?
No
Not always
Yes
Are modified activities available, if needed?
No
Not always
Yes

Are (for example) instructors and activity monitors aware of individual needs?
No
Not always
Yes

Appendix D : **Questionnaire for pupils**
SCHOOL:
TODAY'S DATE:
Day Month Year

YOUR NAME:
YOUR AGE: years at last birthday

YOUR DATE OF BIRTH: Day Month Year

Are you?:

MALE
FEMALE

1 Have you ever had wheezing or whistling in the chest at any time in the past?
No
Yes

IF YOU HAVE ANSWERED "NO" PLEASE SKIP TO QUESTION 7

2 Have you had wheezing or whistling in the chest in the past 12 months?
No
Yes

IF YOU HAVE ANSWERED "NO" PLEASE SKIP TO QUESTION 7

3 How many attacks of wheezing have you had in the past 12 months?
None
1 to 3
4 to 12
more than 12

4 In the past 12 months, how often, on average, has your sleep been disturbed due to wheezing?
Never woken with wheezing
Less than three times in the last 12 months
Less than once per month
Between one and three nights per month
One or more nights per week

5 In the past 12 months, has wheezing ever been severe enough to limit your speech to only one or two words at a time between breaths?
No
Yes

6 In the last 12 months, how much did wheezing influence your activity in the following areas?

Sports and physical activities
School attendance
Night sleep

Playing activities
Friendships
(For each item: Not at all, a little, more than a little, a lot)

6 bis
Have you had wheezing or whistling in the chest in the last 30 days?
No
Yes

7 In the past 12 months, has your chest sounded wheezy during or after exercise?
No
Yes

8 In the past 12 months, have you had a dry cough at night, apart from a cough associated with a cold or chest infection?
No
Yes

9 Have you ever had asthma?
No
Yes

IF YOU HAVE ANSWERED "NO" PLEASE SKIP TO QUESTION 14

10 In the past 12 months, did you use any drugs (pills, sprays, nebulizers or any other remedies) for asthma?
Never
Yes, occasionally, when needed
Yes, regularly for at least 2 months

11 Did you ever had an asthma attack while at school?

No
Yes

IF YOU HAVE ANSWERED "NO" PLEASE SKIP TO QUESTION 14

12 Where did these attacks occur at school (please mark all the answers which apply)?

In the classroom
In the gym
In the bathroom
Outside
Other (please specify)................................

13 During which school activities did these asthma attacks occur (please mark all the answers which apply)?

Normal teaching

Exercise
Art activities (painting, gluing etc)
Break
Other (please specify)................

14 Do you have cough on most days (4 or more days per week) outside common colds?

No
Yes, for less than 1 month per year   Yes, for 1-2 months per year
Yes, for 3 months or more per year
-> For how many years did your child have this cough?   ....

15 Do you have phlegm on most days (4 or more days per week) outside common colds?

No   Yes, for less than 1 month per year
Yes, for 1-2 months per year
Yes, for 3 months or more per year
-> For how many years did your child have this phlegm?   ....

Rhinitis: All questions are about problems which occur when you DO NOT have a cold or the flu.

16 Have you ever had a problem with sneezing, or a runny, or blocked nose when you DID NOT have a cold or the flu?

No
Yes

IF YOU HAVE ANSWERED "NO" PLEASE SKIP TO QUESTION 21

17 In the past 12 months, have you had a problem with sneezing, or a runny, or blocked nose when you DID NOT have a cold or the flu?

No
Yes

IF YOU HAVE ANSWERED "NO" PLEASE SKIP TO QUESTION 21

18 In the past 12 months, has this nose problem been accompanied by itchy-watery eyes?

No
Yes

19 In which of the past 12 months, did this nose problem occur? (Please tick any which apply)

January   February   March   April   May   June
July   August   September   October   November   December

20 In the past 12 months, how much did this nose problem interfere with your daily activities?:

Not at all
A little
A moderate amount
A lot

21 Have you ever had hay fever?

No
Yes

22 Have you ever had an itchy rash which was coming and going for at least six months?

No
Yes

IF YOU HAVE ANSWERED "NO" PLEASE SKIP TO QUESTION 27

23 Have you had this itchy rash at any time in the past 12 months?
No
Yes

IF YOU HAVE ANSWERED "NO" PLEASE SKIP TO QUESTION 27

24 Has this itchy rash at any time affected any of the following places: the folds of the elbows, behind the knees, in front of the ankles, under the buttocks, or around the neck, ears or eyes?

No
Yes

25 Has this rash cleared completely at any time during the past 12 months?
No
Yes

26 In the past 12 months, how often, on average, have you been kept awake at night by this itchy rash?

Never in the past 12 months
Less than one night per week
One or more nights per week

27 Have you ever had eczema?
No
Yes

28 In the last 7 days, have you been exposed to cigarette or other tobacco smoke of other people?
No
Yes

IF YOU HAVE ANSWERED "NO" PLEASE SKIP TO QUESTION 34

29 Where did exposure to tobacco smoke occur? (Please check more than one answer, if needed)
at home
at school
in other places

30 **For how many hours a day have you been exposed to tobacco smoke from others?**

	At home	At school	In other places
1 hour or less			
1-5 hours			
6 or more			

31 For how many days have you been exposed to tobacco smoke from others in the last week?

	At home	At school	In other places
1 day			
2 days			
3-5 days			
6-7 days			

32 How do you judge your exposure to tobacco smoke from others in the past week?

	At home	At school	In other places
Light			
Moderate			
Heavy			

33 How many hours ago were you exposed to tobacco smoke for the last time?

1 hour or less
2-5 hours
6-10 hours11-15 hours
16-24 hours
2-4 days
more than 4 days

QUESTIONS ON HOW YOU PERCEIVE THE SCHOOL ENVIRONMENT

34. How do you perceive the **illumination in the school**? (If the illumination is varying, try to give an average rating)

very poor illumination
rather poor illumination
rather good illumination
very good illumination

35. How do you perceive the **indoor air quality in the school building**?
(If the air quality is varying, try to give an average rating)

very poor air quality
rather poor air quality
rather good air quality
very good air quality

36. How do you perceive the **outdoor air quality outside the school**?
(If the air quality is varying, try to give an average rating)

very poor air quality
rather poor air quality
rather good air quality
very good air quality

37. Do you think that the ability to do the school work is reduced
because of **poor indoor air quality in the school**?

No Yes

MARK WITH AN X SOMEWHERE ON THE SCALES BELOW:

How satisfied are you with the school?

totally dissatisfied ______________________________ totally satisfied

How stressful is the school work to you?

no stress ______________________________ extremely stressful

How does you perceive the climate of co-operation at school?

very poor ______________________________ very good

IF YOU HAVE ANY COMMENTS, PLEASE WRITE THEM ON THE BACK SIDE OF THE PAPER

APPENDIX E

PARENT's Questionnaire

SCHOOL:

TODAY'S DATE: Day Month Year

CHILD'S NAME:

CHILD'S AGE: years

CHILD'S DATE OF BIRTH: Day Month Year

(Tick all your answers for the rest of the questionnaire)

The questionnaire is completed by:

Mother Father Both Other (specify)...............................

Is your child a:

MALE
FEMALE

Is your child a:

1. Caucasian
2. Asian
3. Black
4. Middle-Oriental
5. Other

1 Has your child ever had wheezing or whistling in the chest at any time in the past?

No
Yes

IF YOU HAVE ANSWERED "NO" PLEASE SKIP TO QUESTION 9

2 Has your child had wheezing or whistling in the chest in the past 12 months?

No
Yes

IF YOU HAVE ANSWERED "NO" PLEASE SKIP TO QUESTION 9

3 How many attacks of wheezing has your child had in the past 12 months?

None
1 to 3
4 to 12
More than 12

4 In the past 12 months, how often, on average, has your child's sleep been disturbed due to wheezing?

Never woken with wheezing

Less than three times in the last 12 months
Less than once per month
Between one and three nights per month
One or more nights per week

5 In the past 12 months, has wheezing ever been severe enough to limit your child's speech to only one or two words at a time between breaths?

No
Yes

6 In the past 12 months, did your child's wheezing occur in association with colds or influenza?

Only during colds or influenza
Only outside colds or influenza
Both during and outside colds and influenza

7 In the last 12 months, how much did wheezing influence the quality of life of your child in the following areas?

	Not at all	**A little**	**Moderately**	**A lot**
Sports and physical activities				
School attendance				
Night sleep				
Playing activities				
Friendships				

8 Has your child had wheezing or whistling in the chest in the past 30 days?
Yes
No

9 In the past 12 months, has your child's chest sounded wheezy during or after exercise?
No
Yes

10 In the past 12 months, has your child had a dry cough at night, apart from a cough associated with a cold or chest infection?
No
Yes

11 Has your child ever had asthma?
No
Yes

IF YOU HAVE ANSWERED "NO" PLEASE SKIP TO QUESTION 20

12 At which age did asthma attack(s) occur?

Only during the first two years of age
Only after two years of age
Both before and after two years of age

13 At which age did the last asthma attack occur? .....

14 In the past 12 months, did your child use any drugs (pills, sprays, nebulizers or any other remedies) for asthma?

Never
Yes, occasionally, when needed
Yes, regularly for at least 2 months

15 Did your child ever had an asthma attack while at school?

No
Yes

IF YOU HAVE ANSWERED "NO" PLEASE SKIP TO QUESTION 18

16 Where did these attacks occur at school (please mark all the answers which apply)?

In the classroom
In the gym
in the bathroom
In the outside
Other (please specify).................................

17 During which school activities did these asthma attacks occur (please mark all the answers which apply)?

Normal teaching
Exercise
Art activities (painting, gluing etc)
Break
Other (please specify)................

18 How were these asthma attacks managed (please mark all the answers which apply)?

Nothing was done
The child did self-administered his/her anti-asthma drug
The school operators invited the child to take his/her anti-asthma drug
The school operators provided an anti-asthma drug for the child
The parents were called
The child was taken in charge by the school nurse or physician
The emergency health service was called, or the child was sent to the hospital

19 Is your child allowed to use his/her own anti-asthma medications while at school?

No
Yes, but only when the teacher thinks that it is necessary
Yes, freely

20 Does your child have cough on most days (4 or more days for weeks) outside common colds?

No
Yes, for less than 1 month per year

Yes, for 1-2 months per year
Yes, for 3 months or more per year
---> For how many years did your child have this cough? ....

21 Does your child have phlegm on most days (4 or more days for weeks) outside common colds?

No
Yes, for less than 1 month per year
Yes, for 1-2 months per year
Yes, for 3 months or more per year
--> For how many years did your child have this phlegm? ....

22 Has your child ever had a problem with sneezing, or a runny, or blocked nose when he/she DID NOT have a cold or the flu?

No
Yes
IF YOU HAVE ANSWERED "NO" PLEASE SKIP TO QUESTION 26

23 In the past 12 months, has your child had a problem with sneezing, or a runny, or blocked nose when he/she DID NOT have a cold or the flu?

No
Yes
IF YOU HAVE ANSWERED "NO" PLEASE SKIP TO QUESTION 27

24 In the past 12 months, has this nose problem been accompanied by itchy-watery eyes?

No
Yes

25 In which of the past 12 months did this nose problem occur? (Please tick any which apply)

January February March April May June
July August September October November December

26 In the past 12 months, how much did this nose problem interfere with your child's daily activities?:

Not at all
A little
A moderate amount
A lot

27 Has your child ever had hay fever?
No
Yes

28 Has your child ever had allergic rhinitis different from hay fever (dust, animals etc)

No
Yes

29. Have you noticed hypersensitivity/allergy to **cats** in your child? No Yes
If no, have you suspected that your child has hypersensitivity/allergy to **cats**? No Yes

30. Have you noticed hypersensitivity/allergy to **dogs** in your child? No Yes
If no, have you suspected that your child has hypersensitivity/allergy to **dogs**? No Yes

31. Have you noticed hypersensitivity/allergy to **pollen** in your child? No Yes
If no, have you suspected that your child has hypersensitivity/allergy to **pollen**? No Yes

32 Has your child ever had allergy to foods?
No
Yes

IF YOU HAVE ANSWERED "NO" PLEASE SKIP TO QUESTION 34

33 Which food caused allergy?:
It was not identified
Milk
Eggs
Peanuts
Fruits
Fish
Other food (please specify).....

34 Are there any allergic disorders in the family? Mark with an X in applicable places even if the symptoms has disappeared.

	Father	Mother	Siblings
Asthma			
Allergic nasal symptoms			
Eczema			

35 Have your child ever had an itchy rash which was coming and going for at least six months?

No
Yes

IF YOU HAVE ANSWERED "NO" PLEASE SKIP TO QUESTION 41

36 Has your child had this itchy rash at any time in the past 12 months?

No
Yes
IF YOU HAVE ANSWERED "NO" PLEASE SKIP TO QUESTION 41

37 Has this itchy rash at any time affected any of the following places: the folds of the elbows, behind the knees, in front of the ankles, under the buttocks, or around the neck, ears or eyes?

No

Yes

38 At what age did this itchy rash first occur?
Under 2 years
Age 2-4 years
Age 5 or more

39 Has this rash cleared completely at any time during the past 12 months?
No
Yes

40 In the past 12 months, how often, on average, has our child been kept awake at night by this itchy rash?

Never in the past 12 months
Less than one night per week
One or more nights per week

41 **Has your child ever had eczema?**

No
Yes

42 During the first two years of life, did your child suffer any episodes of pneumonia, bronchitis, bronchiolitis or asthmatic bronchitis?
No
Yes

43 Did your child ever suffered from tooth ache?
No
Yes

IF YOU HAVE ANSWERED "NO" PLEASE SKIP TO QUESTION 45

44 Did your child suffer from tooth ache in the past 12 months?

No
Yes

45 Does your child have an important health problem?
No
Yes (Please specify).................

46. INFORMATION ABOUT CURRENT DIETARY HABITS

	Never	Rarely	Once a week	More than once per week	Almost daily
How often is your child eating fish dishes?					
How often is your child eating meat dishes?					
How often is your child eating fruit?					
How often is your child eating vegetables?					
How often is your child drinking milk?					
How often is your child eating yoghurt, or other products from fermented milk?					
How often is your child out eating fast-food? (hamburgers, pizza, hot dogs etc.)					

47 What types of fat/oils is used at cooking at home?
Butter Margarine Olive oil Rape seed oil Other cooking oils

QUESTIONS ABOUT THE CURRENT HOME ENVIRONMENT OF YOUR CHILD
48. What type of building are you living in now? (answer by making a ring around one alternative)

Single family house Detached house Apartment Farm Other type

49. Which year did your child move to the current dwelling? (year).............

50. Which year (approximately) was the house constructed? (year).............

51 Is there any tobacco smoking indoors in the dwelling? Yes daily Yes often 1-4 times/ week Yes sometimes 1-3 times/month No, never

52 How many smokers live in the house with your son?

None
One
Two
Three or more

53 How many cigarettes in total are smoked in the house where your child lives, on average, each day ?
None
One or two
3 to 5
5 to 10
10 to 20
More than 20

54. Have the interior of your dwelling been painted during the last 12 months? No Yes

If yes, **when was it painted**?____________month_____________year

If yes, what was painted? (answer by writing a ring around one or many alternatives)

Ceiling Walls Joinery/woodworks Floors Metal pipes/radiators Others

55. What type of floor material is in **your childs bedroom?** (answer one alternative)

Plastic(Vinyl/PVC) Linoleum wood/parquet Wall-to-wall carpet Tiles Others

56 Has the child or any other family member any pets in the dwelling?
No Yes

If yes, what type of pet:

57.Have any of the following been identified in your dwelling during the **last 12 months**?
Water leakage or water damage indoors in walls, floor or ceiling *No* *Yes*
Bubbles or yellow discoloration on plastic floor covering or black discoloration on parquet floor *No* *Yes*
Visible mould growth on indoors on walls, floor or ceilings *No* *Yes*

The smell of mould in one or more rooms (not the basement) *No* *Yes*
Any other smell(odours in the home, If yes describe the odour: *No* *Yes*

58 . Is it common with dampness/condensation on the **lower part of the windows in winter**?
No Yes

59 .Have any dampness problems/water damage occurred in the dwelling during the **last 5 years**
No Yes

If yes, please give a description below of what was the cause of the dampness problem/water damage

CURRENT SYMPTOMS: HAS YOUR CHILD HAD ANY OF THE FOLLOWING SYMPTOMS DURING THE LAST <u>THREE MONTHS</u>:

	Yes, daily	Yes, often 1-4 times/ week	Yes, sometimes 1-3 times/month	No, never
60.Rashes on hands or forearms?				
61.Rashes on the face or throat?				
62.Eczema? If yes, where?				
63.Itching in the face or on the throat?				
64.Itches on hands or forearms?				
65.Eye irritation (redness, dryness, itch)?				
66.Swollen eyelids?				
67.Headache?				
68.Nausea?				
69.Runny nose/nasal catarrh?				
70 Nasal obstruction/blocked nose?				
71.Throat dryness?				
72.Sensation of catching a cold?				
73.Sore throat?				
74.Irritative cough?				
75 .Breathing difficulties?				
76. Feeling tired and out of sort?				

77 Does any of these symptoms improve when your child is away from **school**?
No *Yes* *Do not know*

If yes, which symptoms? (write the number of the questions): ....

***78** Does any of these symptoms improve when your child is away from the **dwelling**?*
No *Yes* *Do not know*

If yes, which symptoms? (write the number of the questions): ....

QUESTIONS ON HOW YOUR CHILD PERCEIVES THE SCHOOL ENVIRONMENT

79. How does your child perceive the **illumination in the school**? (If the illumination is varying, try to give an average rating)

very poor illumination
rather poor illumination
rather good illumination
very good illumination

80. How does your child perceive the **indoor air quality in the school building**?
(If the air quality is varying, *very poor air quality*

try to give an average rating) *rather poor air quality*
rather good air quality
very good air quality

81. How does your child perceive the **outdoor air quality outside the school**?
(If the air quality is varying, *very poor air quality*
try to give an average rating) *rather poor air quality*
rather good air quality
very good air quality

82. Does your child think that the ability to do the school work is reduced because of **poor indoor air quality in the school**?
No Yes

MARK WITH AN X SOMEWHERE ON THE SCALES BELOW:

83 How satisfied is your child with the school?

totally dissatisfied ____ totally satisfied

84 How stressful is the school work to your child?

no stress ____ extremely stressful

85 How does your child perceive the climate of co-operation at school?

very poor ____ very good

IF YOU HAVE ANY COMMENTS, PLEASE WRITE THEM ON THE BACK SIDE OF THE PAPER

Appendix F

Classroom Inspection Form

Data:
School name:..............School No:.......................
Inspection code:.................. (School No-Room No: example: 36-1)
Room No..................Classroom...........................
MeasUrement of Air change (Air circulation):
Record until the concentration decreases to 5ppm, or for a maximum of 15 mins.
Start time:................ ppm:.................................
Stop time................................... ppm:................................

DUST SAMPLING (usE OF THE vacuum CLEANER):
Pass the vacuum cleaner for 4 minutes on the half of the room closer to the window. Divide equally between furniture/empty surfaces and floor.
Filter n☜......................(Sampled room nr-F, example: 36-1-F)
Repeat on the other half of the room:
Filter n☜:..................... (Room No nr-K, example. 36-1-K)

DUST, CARBON DIOXIDE, TEMPERATURE, RF
Sample close to the desk, with doors and windows closed, during a lesson plus break (approximately 40 + 20 minutes).Transform to logarithm (log2)
Q-trak: test n☜..................... Start time:..................
Dusttrak: test n☜.................... Start time:...................
P- trak: test n☜.................... Start time:...................

SAMPLER:
Each sampler is labeled with the sampling code, example 36-1

VOC(volatile organic compounds) Ozone NO2 formaldehyde Petri dishes /allergen

Date mountedDate............ Time:.......
Date dismounted Date............... Time:.......
Code of measurement n☜:............................

BUILDING:
Year built (ca)................*Year of last major restructuring/refurbishing* ....
N☜ stories over ground: ....
Basement: Yes ( ) No ( ) Underground ( )
External walls masonry (concrete) ( ) Wood ( )
External roof inclined ( ) flat ( )
Floor scaffolding masonry (concrete) ( ) wood ( )
Internal walls masonry (concrete) ( ) wood ( )
Ventilation natural (absent - non mechanical) F ( ) FT ( )
F= franluft (aspiration that send air outside)
FT=fran o tillluft (air circulation)
Room
Floor: Ground floor, Underground,
1☜ ( ), 2☜ ( ), 3☜ ( ), 4☜ ( )
Room dimensions: length:............. width:................ height............m
length:................ width:.................... height..............m
surface ....m^2 volume.........m^3

Floor material (surface) plastic ( ) linoleum ( ) carpet ( ) wood ( ) *masonry (tiles etc) ()* other ( )
If linoleum: is it older than 1992?
Wall covering: wood ( ) paint ( ) wallpaper ( ) other ( )
Noise-absorbing panels on the walls:..............m^2

Were the walls painted in the last 12 monts?
If yes: was it an anti-mould painting: No Yes

Roof covering:: Noise-absorbing panels ....% of the total surface
Plaster ( )
Wood ( )
Other ( )
Ventilation To: omblandande don (area mixer?)
Lagimpulsdon (Low flow mixer?) ( )
Non mechanical ventilators on the windows or in the external walls ( )
Mo ventilator: ( )
Other:.................. (please specify)
FROM: Non mechanical ventilators on the ceiling (?) ( )
Mechanical ventilator on the ceiling (?) ( )
No ventilator: ( )
Other:............... (please specify)

Air conditioning yes () No ()

Heating system: radiator ( ) Warm air ( ) Heated ceiling ( ) Heated floor ( ) No heating system ()
Inspection Code n☜:.........................
Lights: Ceiling units per room : quantity: ....
covering: metal ( )
plastic ( )
Light source: ......Watt Lamps per unit:...
Light unit at the blackboard: Quantity:......
Cover: metal ( ) plastic ( )
Light source :...........Watts Lamps per unit:
Total W:...........W/m^2

Windows

Glass area ....x .... m . Number:.... orientation: (S/N/O/E)
Glass area ....x .... m . Number:.... orientation: (S/N/O/E)
Glass area ....x .... m . Number:.... orientation: (S/N/O/E)
total glass surface àà.m^2Day light factor..............

Blackboard: black/green ( ) white ( )

Textile surface on the walls......................................m^2
Textile surface on the floor (moquette).....................m^2
Total textile surface/volume of the room
Open shelves...............................m
meters of shelves/volume of the room
There is any furniture or door made of particleboard, plywood or wood laminate, which is one year old or less?
No, Yes
Number of ornamental plants:............n of which benjamin ficus n☜.......
Personal Computer yes ( ) no ( )
washbasin yes ( ) no ( )
Damp damages on the walls, floor or ceiling yes ( ) no ( )
Floor irregularities (wavy, irregular,, color change, blackened parquet) yes ( ) no ( )
Visible mould on the walls, floor or ceiling yes ( ) no ( )
Mould smell yes ( ) no ( )
Other smells (please specify):.....................................
Cleaning method
:floor dry cleaning days per week:...
Humid cleaning days per week:...
wet cleaning days per week:...
Cleaning of surfaces (dusting tables, shelves etc) days per week:...
Cleaning of textile surfaces (moquette) days per year:..