Air quality in schools and childcare settings
SINPHONIE

FINAL REPORT

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Schools Indoor Pollution and Health: Observatory Network in Europe

Executive summary

1. Introduction

Indoor air quality (IAQ) may have respiratory and other health related effects and affect general well-being due to possible presence of several specific indoor pollutants of different causes and sources. Schools constitute a particularly delicate indoor environment because schoolchildren represent a special susceptible group of the population. In Europe, more than 71 million students and almost 4.5 million teachers spend many hours of their days inside pre-primary, primary and secondary schools. Children spend more time in schools than in any other place except at home. The occurrence of pollutant-related disturbances at school may affect their health, growth, opportunities and performance at learning and their cultural and social development. An increase in the prevalence of bronchial asthma has been documented in the last decades of the 20th century in the industrialised world, including Europe. Asthmatic children are known to be exceptionally sensitive to effects of poor air quality. Furthermore, children at school are beyond the direct control of their parents or other family caretakers, who are commonly responsible for their care and for the care of their surroundings. Schools are therefore a particularly critical setting for this susceptible population group exposed. Additionally there is large evidence on the potential detrimental role to health of a variety of indoor pollutants which can be found in school environments.

A report by EFA in 2002 identified various IAQ problems in schools from European countries and found a lack of standardised methodologies as well as studies on consequences to health or on the effect of different local policies regarding school buildings.

Addressing environmental determinants of health such as IAQ has been a very important area of European action on health over the last two decades. The Parma Declaration of WHO Europe, endorsed by 53 countries in 2010, called on Member States of the WHO region to implement measurable actions in order to reach the targets set. Its associated Regional Priority Goal 3 on preventing disease through improved outdoor and indoor air quality states: "We aim to provide each child with a healthy indoor environment in childcare facilities, kindergartens, schools and public recreational settings, implementing WHO's indoor air quality guidelines and, as guided by the Framework Convention on Tobacco Control, ensuring that these environments are tobacco smoke–free by 2015."

During the last decade progressively an increasing attention has been given to the health-related impacts of IAQ in European schools and to the effectiveness of remedial measures, however, a Europe-wide co-ordinated action was not implemented. The SINPHONIE project (*Schools Indoor Pollution and Health: Observatory Network in Europe*) has been the first attempt ever to setup a scientific/technical network to act at EU level with a long-standing perspective for improving air quality in schools and kindergartens (hence reducing respiratory diseases among children and teachers due to outdoor and indoor air pollution) and also supporting future policy actions by formulating recommendations and risk management options for better air quality and associated health effects in the school environment.

SINPHONIE has been a challenging pilot research project in the fields of health, environment, transport and climate change which was funded by the European Parliament and run under the Public Health program of DG SANCO. It was designed to run for two years (2010-2012) and aimed at establishing an Observatory Network in Europe with the ultimate objective of improving air quality in schools and kindergartens on the long run.

The SINPHONIE consortium was made up of 38 partners from 25 countries, with one associated partner from Belgium covering a broad expertise in the fields of health, exposures, sources and policies related to indoor air quality in schools and its effects on health and productivity.

The SINPHONIE project, with its special focus on schools and childcare settings, aimed at capitalising on existing knowledge and information and to extend the range of information available, covering old and new EU member states and some of the Accession countries using a standardised procedure in order to be able to produce a set of recommendations, guidelines and good practices that ensure the best indoor environment for children in schools within the EU and at the same time inform existing and future policies related to the school environment. Gaining an understanding of children's exposure to particular indoor air pollutants, and evaluating the associated health risks, are prerequisites for appropriately supporting future policy actions.

The review performed within SINPHONIE confirmed that IAQ in schools is very important as it can impact on children's health, attendance and performance including respiratory problems such as asthma and allergies.

The few studies conducted on the effectiveness of remedial measures in European schools showed that schools frequently have IAQ problems because of poor building construction and maintenance, poor cleaning and poor ventilation. They also demonstrated that pollution at school is complex, variable, and has different impacts as various air pollutants (of physical, chemical and biological origin) can be found in classrooms, sometimes in elevated concentrations which can be harmful for health.

2. Objectives

The overall objective of SINPHONIE was to produce recommendations and guidelines on remedial measures in school environment to cover a wider array of situations in Europe and to disseminate these guidelines to relevant stakeholders able to take actions.

To enable the accomplishment of the overall objective, the required technical objectives of SINPHONIE were:

- To review critically and collate European (and non-European) research on the most indoor air relevant health effects and respective exposure contaminants in indoor air of schools, assessment of the policy relevance of their objectives and conclusions, and identification of epidemiological and toxicological research needs lying on the critical path for knowledge based policy development;

- To assess the building characteristics and the patterns of the everyday use of the selected classrooms influencing their IAQ;

- To measure the physical parameters (temperature, relative humidity and ventilation rate) and chemical and biological pollutants of indoor (and related outdoor) air in schools and childcares in all Europe in order to produce new exposure data for an array of pollutants: formaldehyde, benzene, pinene and limonene, naphtalene, nitrogen dioxide, carbon monoxide, carbon dioxide, radon, trichloroethylene, tetrachloroethylene, PAH and BaP, particulate matter (PM10 and PM2.5), allergens in dust and mould and bacteria in dust and the air;

- To evaluate the impact of externalities to the schools, as the traffic and the effects of climate change;

- To assess the influence of building characteristics, cleaning products and ventilation systems in exposure data obtained;

- To assess the impacts of outdoor air pollution abatement measures, including measures taken in the short term, on IAQ in schools and on the children exposure in school environments;

- To make a systematic source apportionment of indoor air pollutants in school environments in quantitative terms;

- To assess the influence of mixtures of pollutants in indoor air to the emergence of new pollutants, caused by chemical and biochemical interaction;

- To obtain data on health status of children by questionnaire surveys, and also by clinical tests, focusing on asthma, respiratory infections, upper respiratory tract symptoms, cough, wheeze, dyspnea, allergic rhinitis, bronchitis and school performance;

- To evaluate the impact of the indoor air in classrooms on the children’s health and performance in order to define priorities for policy development;

- To evaluate the effectiveness of appropriate ventilation to reduce ambient air pollution in schools;

- To produce recommendations and guidelines on remedial measures in school environment to cover a wider array of situations in Europe;

- To disseminate project outputs and recommendations to relevant stakeholders able to take actions on issues highlighted by the project.

3. Project methodology

The assessment of the air quality of the outdoor/indoor school environment and the associated health outcomes were evaluated throughout the European countries involved in SINPHONIE, taking into account inter-regional variability according to the following four European sub-regional groups:

1	Sweden"	Finland	Estonia	Lithuania				
2	Belgium	UK	France	Austria	Germany			
3	Poland	Slovakia	Czech Republic	Hungary	Romania	Bulgaria	Serbia	Bosnia Herzegovina
4	Italy	Portugal	Malta	Greece	Cyprus	Albania		

Health risk assessments were performed with particular attention to inhalation exposure and health effects such as irritation symptoms and respiratory diseases (i.e. airway allergic reactions) and focusing on vulnerable subjects (i.e. children).

The results of the health risk assessment helped to define priorities for policy development and to formulate risk management recommendations linked to the main specific IAQ problems identified, to report on gaps in the body of knowledge and express related research needs for further policy development, particularly in relation to IAQ audits and epidemiological and clinical studies linked to the school environment

4. Review of the impact of the action

4.1. Assessment of the outdoor/indoor school environment

Overall, IAQ auditing in schools across Europe was successfully performed and for the first time brings to the public comparable data on IAQ in 295 kindergarten and primary school classrooms in 22 European countries. Exposure levels among 6,904 pupils were assessed.

The analysis of 18 physical/chemical parameters (including key priority compounds recognised by WHO and European Commission) and 13 biological contaminants (including endotoxins (1 analyte), allergens (5 analytes) and fungal and bacterial DNA (7 analytes)) provided an excellent overview of the IAQ in schools across Europe.

The study on traffic-induced pollution and IAQ in classrooms highlighted the importance of:

R1. Controlling the quality of the outdoor air that enters the indoor environment by choosing "pollution-free" zones in which to build schools, or by imposing stricter measures to improve traffic conditions in the close vicinity of schools (e.g. in a radius of 1 km); and

R2. Ensuring adequate ventilation (by natural or mechanical means) in order to reduce pollutants of indoor origin and their associated health risks and to maintain good comfort conditions.

The organisation of the field campaigns was complex due to the large number of participating partners (in several countries more than one partner per country organised the main study fieldwork) and the very broad and varying range of experience in this area. However, the development of common tools and the organisation of dedicated training sessions offered harmonised procedures and criteria for the measurement campaigns while respecting the flexibility and capacity building status in the various participating labs. An appropriate quality control/quality assurance strategy was also put in place which greatly helped in enhancing data comparability.

A unique dataset of biological contaminants in schools in the European region has been produced, using highly standardised sampling approaches and state-of-the-art analysis, also taking into consideration the non-viable but nonetheless health-relevant portion of biological exposure. This dataset will stand as a reference for future assessments of biological agents in the school environment.

4.2. The outcome of the SINPHONIE data analysis and the health risk assessment

The data analysis and the health risk assessment performed within SINPHONIE made possible the quantification of the impact of air quality in European schools and kindergartens on the health of children, pre-school children and teachers.

The main results of the SINPHONIE data analysis in a nutshell:

RES 1: In the random sample, air quality in classrooms was poor, varying significantly among the schools and cities in the 23 European countries that participated in the SINPHONIE survey.

RES 2: According to existing guidelines a big proportion of schoolchildren, pre-school children and teachers were highly exposed to air pollutants and bio-contaminants.

RES 3: Exposure to elevated concentrations of particulate matter and gases as well as bio-contaminants which were found in classrooms and kindergartens was significantly related to symptoms and diseases currently observed in schoolchildren, pre-school children and teachers.

RES 4: More than 2% of children were reported suffering from asthma at school.

RES 5: Further investigations are needed to better assess the health burdens to people present in schools due to exposure to the air of the school environment.

RES 6: Existing standards for monitoring and evaluating the health burden associated to exposure indoor/outdoor air pollutants and bio-contaminants in the school environment are currently inadequate.

The key finding:

The results of the SINPHONIE project are greatly relevant to public health. Significant number of schoolchildren is exposed to health threats due to inadequate indoor/outdoor air quality in European schools, with childhood asthma and allergies being among the most widespread health effects.

5. Conclusions

5.1. General conclusions

IAQ in schools

European school buildings are used by large numbers of students, teachers and other school staff for long periods of the day. The studies carried out under the SINPHONIE project show that European schools frequently have IAQ problems because of polluted outdoor air, various problems related to buildings' construction, poor maintenance and cleaning. In some cases, the existing ventilation system is inadequate.

Indoor air pollutants

Common indoor pollutants in schools are particulate matter, volatile organic compounds, formaldehyde, radon and biological agents. Surprisingly, in some cases environmental tobacco smoke accounted for the burden of pollution observed. These air pollutants can be encountered in classrooms sometimes in elevated concentrations that are often higher than outdoors. As a result, school air quality can have an impact on the health, attendance and performance of children, teachers and school staff.

IAQ in relation to the outdoor school environment

Building construction, decoration and furnishing materials, damage to walls and ceilings as a result of water infiltration and the growth of fungi and moulds, and the activities of building occupants (e.g. smoking, the use of cleaning products, cleaning procedures, the use of paints, glues and other products, etc) are important sources of indoor pollution. Moreover, pollution originated in the outdoor environment (e.g. traffic-related or industrial pollution) and from the ground on which the buildings stand, ***are major sources of indoor air pollution*.**

Vulnerability of children

Poor IAQ in schools can cause discomfort, irritation and a variety of short- and long-term health problems; aggravate existing health problems, including asthma and allergies; spread airborne infectious diseases; reduce teacher, staff and student productivity; and increase absenteeism. ***Children are particularly vulnerable to indoor air–related problems that can be particularly harmful in the case of pupils and students suffering from allergies, asthma or airway hyper-reactivity*.**

The role of local authorities

The SINPHONIE outcome suggests that, **local school authorities** should as a matter of urgency provide an appropriate school environment by: promoting the avoidance of environmental tobacco smoke through smoking bans in all school spaces; avoiding construction conditions that favour the appearance of allergen sources and moisture/mould in buildings; ensuring adequate cleaning and maintenance; checking ventilation systems and undertaking the necessary remedial measures; checking heating systems to ensure satisfactory temperatures; providing appropriate information and training for students, teachers and the school staff responsible for management, maintenance and cleaning; and ensuring adequate periodical monitoring of health and IAQ parameters in schools.

The role of EU, national authorities, scientific societies

The EU, national authorities, scientific societies and all the organisations directly or indirectly involved in or concerned by this area have an important role to play in producing and implementing a multidisciplinary programme aimed at improving IAQ in schools. **Such a programme should promote:**

- initiatives, including **legislative initiatives**, to regulate school buildings in terms of design, construction, materials used, ventilation, safety, cleaning and building maintenance procedures, as well as smoking and the prevention of allergen production;

- **awareness-raising** campaigns and training aimed at children and their families, school staff, professionals, policy makers and the public; and

- **research** to develop sustainable measures aimed at improving IAQ in school buildings.

5.2. Specific conclusions, tools, recommendations

SCL 1. **Technical and logistical support** was offered for the development and implementation of common methodologies for measuring indoor air pollution in all the participating countries.

SCL 2. **New exposure** data were generated, unique in terms of wide European coverage and enhanced data comparability due to the use of harmonised procedures/tools. Related information on school buildings/classroom characteristics was also gathered, making it possible to study interactions between IAQ and pollution sources in the school environment.

SCL 3. The study of the predicted **impacts of climate change** focused on the need to strengthen or initiate measures for improving the heat resilience of school buildings.

SCL 4. **Physical procedures** were identified, such as air exchange rates, which — combined with parameters such as indoor activities, number of occupants, and indoor materials — contribute to the generation of indoor pollution levels. An understanding of the "impact" of exchange rates is essential for IAQ management in sensitive spaces such as classrooms.

SCL 5. When gathering such a variety of data from so many European countries, greater time should be spent initially on the **standardisation of approaches in order to harmonise over the measurement protocols and procedures to be employed.** For instance, the training session should be longer and more comprehensive in content, and a process similar to the Continuous Medical Education process should be implemented.

SCL 6. **Close collaboration** is advisable right from the outset of the study between those in charge of elaborating the questionnaires and those in charge of implementing the project's database.

SCL 7. In order to **facilitate an efficient data management and subsequent robust data analyses**, great attention should be given to the standardisation of data input gathering and assimilation procedures among the partners.

SCL 8. When planning a huge **multi-centre study such as SINPHONIE**, it is necessary to allocate more time for data cleaning, data validation and data analysis in order to perform robust data analyses and produce meaningful results including the elaborate of fruitful recommendations and guidelines.

SCL 9. Preliminary impressions from the SINPHONIE fieldwork suggest that IAQ in the school environment is a latent but consistent issue. **All the standardised tools developed and used during SINPHONIE represent important outputs that can be further used in similar multi-centre studies, as well as in routine controls.**

SCL 10. The **enormous SINPHONIE database** produced represents an important starting point from the perspective of the long-term monitoring of changes in future IAQ polices related to the EU school environment..

SCL 11. Several countries in Europe have **legislation** in place that directly or indirectly aims to improve hygiene in schools and the health of schoolchildren and staff. Many countries, however, do not have legislation in place that is primarily directed to improving IAQ in school buildings. A non-exhaustive overview was undertaken of information on the promotion of healthy school environments provided by SINPHONIE partners in their countries and also on other international initiatives. By analysing this information and the common aspects and differences, criteria were established to **support the prioritisation of possible measures**. These criteria are available to help stakeholders gain greater insight into the effectiveness, proportionality, practicality and monitorability of possible measures. An important step supporting this prioritisation process is to carry out cost-benefit analyses prior to the implementation of measures. Possible measures fall into five categories: 1) hygienic requirements for cleaning procedures and frequency; 2) awareness raising; 3) good ventilation practice; 4) the use of products/materials; and 5) technical intervention.

SCL 12. Communication and dissemination tools were used to inform the public, stakeholders and decision makers about the project results and achievements. As this research project was very complex, different communication tools were employed to convey the main message of the project to stakeholders and a variety of target groups.

Brochures accustomed for specific target groups were very useful during the implementation of the field activities. School staff, parents and children were very interested in the process and the brochures were served as awareness-raising tools. As the experts had not communicated directly with school staff, parents and children, the brochures helped to explain them the field activities in an easily understandable way.

The Final SINPHONIE brochure for schools provided tips and recommendations for a healthy school environment in Europe in 20 languages (www.sinphonie.eu).

SCL 13. The SINPHONIE project contributes significantly to the implementation of the Parma Declaration of WHO and the achievement of its Regional Priority Goal no 3.

5.3. Main conclusions and further steps

MCL 1. The SINPHONIE project, supported by the European Parliament and run under the Public Health Program of DG SANCO, was the first pilot project to monitor the school environment and children's health in parallel in 23 European countries.

The two-year SINPHONIE project brought together the multidisciplinary expertise of 39 institutions from 25 countries. One of its main objectives to collect information on indoor air quality and children's health from schools throughout Europe using comparable methodologies was successfully reached.

The project partners has started to use guidelines and recommendations on indoor air quality in schools in order to improve the air that children breath and to create a healthy school environment throughout the EU.

The SINPHONIE outcome will be disseminated to actors involved in the planning and management of school infrastructure; stakeholders and policy makers at European and national level; and local actors (building owners, teachers, pupils and parents). The project contributes to the fulfillment of the Parma Declaration commitments in terms of policy development and environmental health actions.

MLC 2. The project partners are envisaging to a following up the SINPHONIE project to fill in the research gaps identified and to contribute in setting up of harmonised guidelines and an inventory of best school practice on IAQ and children's health in Europe.

The results of SINPHONIE put in evidence important aspects concerning the complex pattern of the interrelations between physical, chemical and biological factors, exposures, sources/causes and health impacts on school children. The exposure to a mixture of physical, chemical and biological factors linked to a variety of indoor sources and its relation to the burden of disease observed in school children and staff needs to be further and deeply investigated in order to be able to protect the younger generation from a wide range of respiratory symptoms associated to poor IAQ in the school environment.

As 2013 is the Year of Air for Europe**,** it is an ideal opportunity to promote air quality and health in schools and call for actions at both, EU and MS levels. The outcome of the SINPHONIE project and its envisaged follow-up can greatly contribute in putting in place the aspirations of this important initiative and increase healthy and sustainable lifestyles in Europe.

Overall, SINPHONIE can be considered as a milestone project which provided standardised methodologies and tools and elaborated risk management options and guidelines for healthy air in school environments in Europe, yet it represented a unique opportunity and an excellent vehicle for capacity building for several national institutions mostly in the Eastern and Southern European countries. In this sense, it has been a clear case of 'technology transfer' on indoor air quality and health impact assessment in EU Member States. SINPHONIE's outcome is expected to trigger the need of undertaking further studies aimed at integrating exposures occurring in the school environment with home pollution loads, as children spend more than 60% of their time at home and also to elaborate and implement harmonised guidelines for a healthy school environment in Europe.

1 Overview

1.1 Objectives of the action

Indoor air quality (IAQ) may have respiratory and other health-related effects and affect general well-being due to the possible presence of several specific indoor pollutants from different causes and sources. Schools constitute a particularly delicate indoor environment because schoolchildren represent a special, susceptible group of the population.

The project’s in-depth research was aimed at obtaining more, new and better data in order to enhance the information available from schools and childcare settings in European countries, to explore the existing situation regarding IAQ in schools, and to put together an effective and fruitful set of proposals leading to new policies, new guidelines and new practices related to IAQ in EU schools.

The SINPHONIE project was designed to run for two years and the consortium was made up of 38 partners from 25 countries, with one associated partner from Belgium. All the partners have scientific expertise and an ability to disseminate project outcomes to relevant stakeholders such as policy makers, building designers, builders, building managers and building users, especially teachers and students. SINPHONIE is a complex research project in the fields of health, environment, transport and climate change, aimed at improving air quality in schools and kindergartens. SINPHONIE is a pilot project of the European Parliament. Technical support to project implementation was provided by DG SANCO.

The focus was on optimising the gathering and analysis of pre-existing data and scientific information, and also on carrying out an intensive and comprehensive field campaign in schools to obtain new data and additional information for less-studied areas of the EU.

All data were analysed in an integrated way in order to allow for a meaningful synthesis, so creating the conditions for the drafting of a set of reliable proposals. As a consequence, new pathways towards good IAQ in schools, including new good practices for designing/retrofitting, managing and using the schools of the future, will be designed and disseminated to stakeholders such as policy makers, designers, builders, building managers and building users, in particular teachers and students.

The required technical objectives are the followings:

To review critically and collate European (and non-European) research on the most indoor air relevant health effects and respective exposure contaminants in indoor air of schools, assessment of the policy relevance of their objectives and conclusions, and identification of epidemiological and toxicological research needs lying on the critical path for knowledge based policy development;

- To assess the building characteristics and the patterns of the everyday use of the selected classrooms influencing their IAQ;

- To measure the physical parameters (temperature, relative humidity and ventilation rate) and chemical and biological pollutants of indoor (and related outdoor) air in schools and childcares in all Europe in order to produce new exposure data for an array of pollutants: formaldehyde, benzene, pinene and limonene, naphtalene, nitrogen dioxide, carbon monoxide, carbon dioxide, radon, trichloroethylene, tetrachloroethylene, PAH and BaP, particulate matter (PM10 and PM2.5), allergens in dust and mould and bacteria in dust and the air;

- To evaluate the impact of externalities to the schools, as the traffic and the effects of climate change;

- To assess the influence of building characteristics, cleaning products and ventilation systems in exposure data obtained;

- To assess the impacts of outdoor air pollution abatement measures, including measures taken in the short term, on IAQ in schools and on the children exposure in school environments;

- To make a systematic source apportionment of indoor air pollutants in school environments in quantitative terms;

- To assess the influence of mixtures of pollutants in indoor air to the emergence of new pollutants, caused by chemical and biochemical interaction;

- To obtain data on health status of children by questionnaire surveys, and also by clinical tests, focusing on asthma, respiratory infections, upper respiratory tract symptoms, cough, wheeze, dyspnea, allergic rhinitis, bronchitis and school performance;

- To evaluate the impact of the indoor air in classrooms on the children's health and performance in order to define priorities for policy development;

- To evaluate the effectiveness of appropriate ventilation to reduce ambient air pollution in schools;

- To produce recommendations and guidelines on remedial measures in school environment to cover a wider array of situations in Europe;

- To disseminate project outputs and recommendations to relevant stakeholders able to take actions on issues highlighted by the project.

The *Table 1* and *Table 2* show the project Partners, the Advisory Committee and Consulting Tank experts.

Table 1. Partners

Partner number	**Acronym**	**Institution**
1	REC	Regional Environmental Center for Central and Eastern Europe **Hungary**
2	IDMEC-FEUP	Instituto de Engenharia Mecânica - Faculdade de Engenharia da Universidade do Porto **Portugal**
3	NIEH	National Institute of Environmental Health **Hungary**
4	JRC	**Joint Research Centre** Institute for Health and Consumer Protection European Commission
5	IPH-ALB	Institute for Public Health **Albania**
6	IPH-BH	Institute of Public Health **Bosnia and Herzegovina**
7	IEH	Institute of Environmental Health, Medical University, Vienna **Austria**
8	UBA-A	Planning & Coordination Substances & Analysis, Umweltbundesamt GmbH, Vienna **Austria**
9	VITO	Flemish Institute for Technological Research **Belgium**

Partner number	Acronym	Institution
10	NCPHA (former LABOREX)	National Center for Public Health and Analysis (former Laboratory Center for Health Risk Assessment) **Bulgaria**
11	LGH	Larnaca General Hospital **Cyprus**
12	CSGL	Cyprus State General Laboratory **Cyprus**
13	NPHI-CZ	National Public Health Institute **Czech Republic**
14	HPI	Health Board (former Health Protection Inspectorate) **Estonia**
15	THL	National Institute for Health and Welfare **Finland**
16	UPMC Paris 06	Université Pierre et Marie Curie Paris 06 **France**
17	CSTB	Centre Scientifique et Technique du Bâtiment **France**
18	UBA	Umweltbundesamt (Federal Environment Agency) **Germany**
19	UOWM	University of Western Macedonia **Greece**

Partner number	Acronym	Institution
20	NKUA	National Kapodistrian University of Athens **Greece**
21	UMIL	Università degli Studi di Milano **Italy**
22	USiena	Università degli Studi di Siena **Italy**
23	CNR Palermo	National Research Council (CNR) Institute of Biomedicine and Molecular Immunology (IBIM) Palermo **Italy**
24	FSM	Fondazione Salvatore Maugeri **Italy**
25	KTU	Kaunas University of Technology **Lithuania**
26	UMalta	University of Malta **Malta**
27	IOMEH	Inst. Occupational Medicine and Environmental Health **Poland**
28	UAVR	CESAM &University of Aveiro **Portugal**
29	UBB	Babes-Bolyai University **Romania**
30	UU	Uppsala University **Sweden**

Partner number	Acronym	Institution
31	TNO	Netherlands Organisation for Applied Scientific Research **The Netherlands**
32	HVDGM	Public Health Service Gelderland Midden **The Netherlands**
33	RIVM	Rijksinstituut voor Volksgezondheid en Milieu (National Institute for Public Health and the Environment) **The Netherlands**
34	NILU	Norsk Institutt for Luftforskning (Norwegian Institute for Air Research) **Norway**
35	PHA-SK	Public Health Authority of the Slovak Republic **Slovakia**
36	IV	Institute Vinca **Serbia**
37	MC	Medical Center Dr Dragisa Misovic **Serbia**
38	UCL	University College London **UK**
39	Associated partner	Hainaut Public Health Institute Belgium

Table 2. Advisory Committee and Consulting Tank Experts

	Advisory Committee	**Contact person**
1	ISPRA Institute for Environmental Protection and Research **Italy**	Luciana Sinisi
2	REHVA Federation of European HVAC Associations **Belgium**	Olli Seppanen
3	Public Hygiene in Hainaut **Belgium**	Marie-Christine Dewolf
4	**ERS** European Respiratory Society	Nadia Kamel
5	**HEAL** Health & Environment Alliance	Genon K. Jensen Anne Stauffer
6	Kings's College E&H **UK**	Frank Kelly
7	**EFA** European Alliance of Asthma and Allergy Association	Susanna Palkonen
8	Ministry for Rural Development **Hungary**	Zsuzsanna Pocsai

	Invited Consulting Tank Experts	Representative for
1	Stefania Romano	ITF Italian Trust Fund, Ministry of Environment, Land and Sea **Italy**
2	Stella Michaelidou-Canna	MoH-CY Ministry of Health **Cyprus**
3	Pawel Wargocki	DTU Technical University of Denmark **Denmark**
4	Torben Sigsgaard	Aahrus University **Denmark**

The SINPHONIE project, with its special focus on schools and childcare settings, aimed at capitalising on existing knowledge and information and to extend the range of information available, covering old and new EU member states and some of the Accession countries using a standardised procedure in order to be able to produce a set of recommendations, guidelines and good practices that ensure the best indoor environment for children in schools within the EU and at the same time inform existing and future policies related to the school environment. Gaining an understanding of children's exposure to particular indoor air pollutants, and evaluating the associated health risks, are prerequisites for appropriately supporting future policy actions.

Gaining an understanding of children's exposure to particular indoor air pollutants, and evaluating the associated health risks, are prerequisites for providing policy recommendations. Research of this nature involves monitoring indoor environments; undertaking the toxicological assessment of chemical hazards; and monitoring health impacts related to the indoor environment.

In order to implement the technical objectives of the project a comprehensive research design was developed, as you can see bellow 'Sinphonie research design'. The tasks of the project were addressed in different work packages to carry out the project properly.

WP1: Management and coordination.

WP2: Background report

WP3: Assessment of outdoor/indoor school environment:

WP3.1- Characterization of the school buildings;

WP3.2 - Physical and chemical measurements;

WP3.3 – Measurements of biological contaminants;

WP3.4 – Environment context and modeling.

WP4: Assessment of health outcomes:

WP4.1 - Clinical field survey;

WP4.2 - Clinical tests and noninvasive biomarkers.

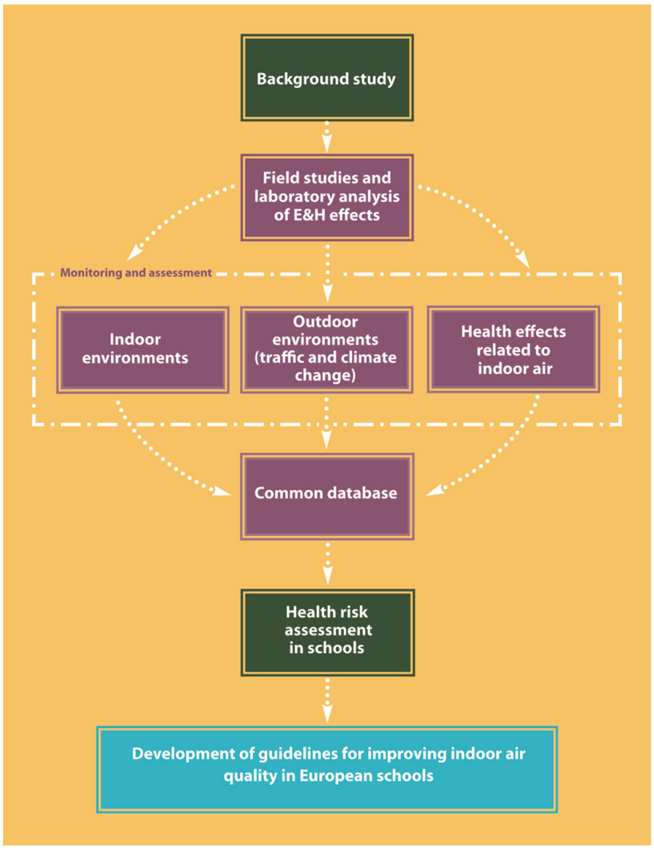
WP5: Data management, cross analysis and database.

WP6: Health risk assessment.

WP7: Risk management and development of guidelines and recommendations.

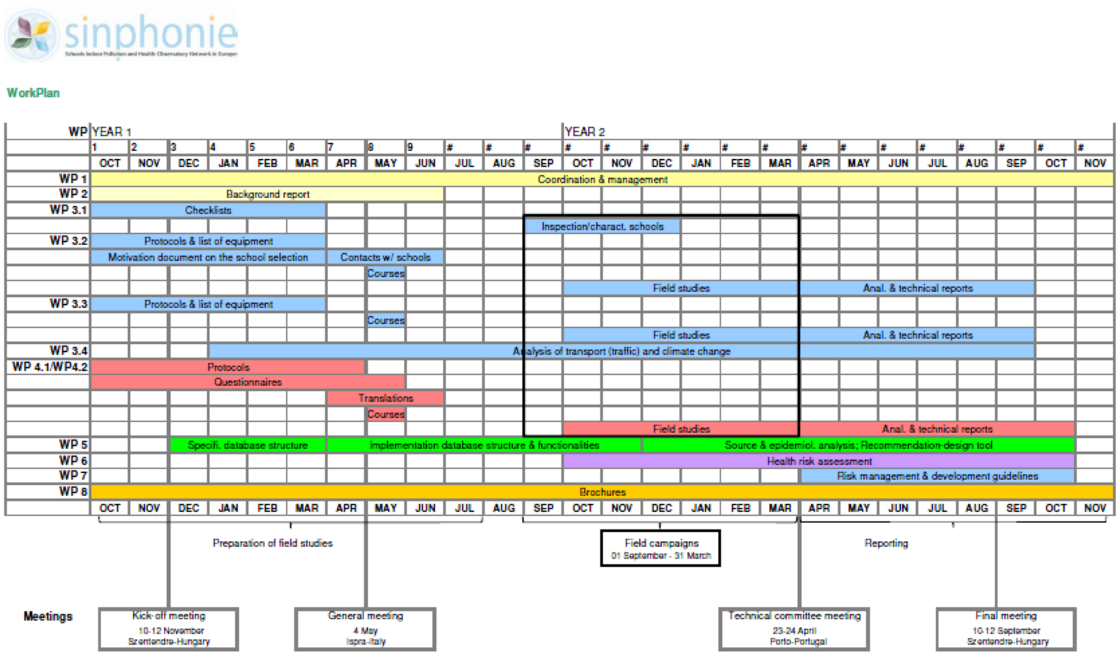
WP8: Communication and dissemination.

The SINPHONIE Research design



In the period 1 October 2010 – 30 September 2011, several activities were completed in the fields of management and coordination **(WP1)**; and the overall organisation and planning of the field studies in terms of physical, chemical and biological aspects as well as the assessment of the health status of children in the selected schools **(WP3 and WP4)**. A database was designed **(WP5)** to facilitate the coherent use of the experimental data obtained for school environment characteristics and the health of children. A critical literature review **(WP2)** was undertaken, collating data and research on the most relevant health effects and identifying the need for epidemiological and toxicological research in order to achieve knowledge-based policy development. The evaluation of information already available in the field requires in-depth background research undertaken by experienced scientists based on scientific evidence of the health impacts of exposure and their causes/sources. Besides providing an opportunity for updating knowledge in the field, this research will contribute to the assessment and appropriate integration of the field study outcomes **(WP3 and WP4)**. ***(See the updated work plan below and in Annex 1, 1.3.1.)***

Workplan of the SINPHONIE project



The dissemination of outcomes is ensured by activities throughout the project involving students, teachers, school staff and parents, thus cultivating a proactive attitude towards better IAQ in schools and, hopefully, by extension at home **(WP8)**.

In the period October 2011 – September 2012, activities were completed according to the work plan, mainly regarding management and coordination **(WP1)**; and the overall organisation and implementation of field studies in terms of physical, chemical and biological aspects as well as the monitoring and assessment of the health status of school children **(WP3, WP4)**. Work continued on the design, validation and cleaning of the database **(WP5)** to facilitate the coherent use of experimental data obtained for school environment characteristics and children's health. The literature review **(WP2)** involved the critical review and collection of data and research on the most relevant health effects; and the identification of needs for epidemiological and toxicological research critical to knowledge-based policy development **(WP3, WP4, WP5)**. The environment and health data collected from the countries were uploaded to the project website (www.sinphonie.eu) and validated and cleaned by NILU and the partners working on WP3, WP4, WP5 according to criteria developed by the WP5 team.

In the period October 2012 – December 2012, the first result of the data analysis was prepared by UPMC Paris and NIEH for discussion among the project experts. Further analysis of the database was commented and elaborated by the leaders/co-leaders of WP3, WP4, WP6 and WP7 and finalised in the current report. The WP6 used the SINPHONIE data for health risk assessment of children in schools and provided input for the WP7 on development of recommendations for schools to improve indoor air quality.

1.2 Results achieved

The main results are summarised in the table below. The results achieved are in line with the project deliverables for the whole reported period.

Table 3 : Updated list of submitted deliverables since project starting date

Del. N°	**WP N°**	**Deliverable name**	**Month of completion**	**Status of the deliverable**	**P (public) / I (Internal)**	**Uploaded to the website***
D.1.1	1	First progress report	6	Submitted as First Progress Report	I	Yes
D 1.2	1	Interim report	12	Submitted as Interim Report	I	Yes
D 1.3	1	Third progress report	18	Submitted as Third Progress Report	I	Yes
D 1.4	1	Final report	26	Submitted as Final Report	I	Yes
D 2.1	2	Background report	9	Submitted with Interim Report	I	Yes
D 2.2	2	A web site that will contain information on SINPHONIE research questions and data, namely the distribution of environmental factors in schools and kindergartens and related health problems in children and teachers. This will be done in connection with WP8 – Communication & dissemination	9	Submitted as part of the project website	I	No
D 2.3	2	Final User Interface and access to databases and additional files	9	Submitted as part of the project website	I	No
D 2.4	2	A CD containing a significant portion of the database	9	Submitted on Final Report CD	I	No
D 2.5	2	Peer reviewed articles describing the issue, interpretations and results of the various studies as well as on the long term of the SINPHONIE study	9	Submitted with Final Report	I	No
D 2.6	2	A report describing a mechanism to prioritize	9	Submitted within	I	Yes

Del. N°	WP N°	Deliverable name	Month of completion	Status of the deliverable	P (public) / I (Internal)	Uploaded to the website*
		substances/agents		D2.1		
D 3.1.1.	3	School and classroom checklists	9	Submitted with Interim Report	I	Yes
D 3.1.2	3	Data on school and classroom characterization	18	Submitted on Final Report CD	I	Yes
D 3.2.1.	3	Protocol for indoor/outdoor measurements of physical and chemical parameters in schools	6	Submitted with First Progress Report	I	Yes
D 3.2.2.	3	A motivation document on the school selection and the main- and case study organisation	9	Submitted with Interim Report	I	Yes
D3.2.3	3	Report on the results of the main study and the case studies	22	Submitted with Final Report	I	Yes
D 3.3.1	3	Protocols for sampling of biological contaminants in schools	6	Submitted with First Progress Report	I	Yes
D 3.3.2	3	Datasets with concentrations of the general fungal and bacterial markers ergosterol and endotoxin measured from settled dust, and indoor relevant allergen(s) measured from vacuumed floor dust in classrooms	18	Submitted on Final Report CD	I	Yes
D3.3.3	3	Datasets with concentrations of specific fungal and bacterial groups measured via quantitative PCR from settled dust in classrooms	18	Submitted on Final Report CD	I	Yes
D3.3.4	3	Dataset with concentrations of specific fungal and bacterial groups measured via QPCR from indoor and outdoor air in study schools	18	Submitted on Final Report CD	I	Yes
D3.4.1	3	Report on the impact of traffic on IAQ	22	Submitted with Final Report	I	Yes
D3.4.2	3	Report on the impact of climate change on IAQ	22	Submitted with Final Report	I	Yes
D 4.0.1	4	Questionnaires for the assessment of the children's and the teachers' respiratory health	8	Submitted with Interim Report	I	Yes

Del. N°	WP N°	Deliverable name	Month of completion	Status of the deliverable	P (public) / I (Internal)	Uploaded to the website*
D 4.0.2	4	Assessment of absenteeism from schools (or kindergartens) due to respiratory diseases	24	Submitted with Final Report	I	Yes
D 4.0.3.	4	Protocol for spirometric testing and evaluation	7	Submitted with Interim Report	I	Yes
D 4.0.4	4	Protocol for attention/concentration testing	7	Submitted with Interim Report	I	Yes
D 4.1.1	4	Data on current policies and practices about IAQ-related health issues and asthma management in schools across Europe	7	Submitted within D6.1	I	Yes
D 4.1.2	4	Questionnaire data	18	Submitted on Final Report CD	I	Yes
D 4.1.3	4	Lung function data	18	Submitted on Final Report CD	I	Yes
D 4.1.4	4	Attention/concentration test data	18	Submitted on Final Report CD	I	Yes
D 4.2.1	4	Data on nasal patency of schoolchildren	18	Submitted on Final Report CD	I	Yes
D 4.2.2	4	Data on break-up time in schoolchildren	18	Submitted on Final Report CD	I	Yes
D 4.2.3	4	Data on exhaled Nitric Oxide in schoolchildren	18	Submitted on Final Report CD	I	Yes
D 4.2.4	4	Data on inflammatory cytokines in NAL	18	Submitted on Final Report CD	I	Yes
D 4.2.5	4	Data on inflammatory cytokines in EBC	18	It was not performed by WP4 in line with the decision of the health experts	---------	----------
D5.1	5	Report on the relationships between main building characteristics, building materials, furniture, consumer products, ventilation systems, outdoor air, IAQ in European schools	24	Submitted with Final Report	I	Yes
D5.2	5	Report on the impact of air quality in schools and health in children and teachers	24	Submitted with Final Report	I	Yes
D5.3	5	Report on the links between other schools parameter and health in	24	Submitted within D5.1	I	Yes

Del. N°	WP N°	Deliverable name	Month of completion	Status of the deliverable	P (public) / I (Internal)	Uploaded to the website*
		children and teachers				
D6.1	6	Report on the scientific basis for risk assessment in schools and childcare settings	24	Submitted with Final Report	I	Yes
D7.1	7	Report on Summary of policies/recommendation/guidelines	26	Submitted with Final Report	I	Yes
D7.2	7	Report on Summary of main results obtained and the European guidelines for healthy environment within European schools	26	Submitted within D7.1	I	Yes
D 8.1.	8	Information brochures to children, parents and school staff about the importance of IAQ and the importance of their collaboration	6	Submitted with First Progress Report	P	Yes
D 8.2.	8	Website	6	Submitted with First Progress Report	P	Yes
D8.3	8	Reports to children, parents and school staff with the results of the survey realized in the schools	26	Submitted with Final Report	P	Yes

* Deliverables with the status “P (public)” have been uploaded to the public area of the website. Deliverables with the status “I (internal)” have been uploaded to the password-protected area of the website.

1.3 Identified problems and corrective actions taken

The SINPHONIE project was implemented in line with the project timetable, which was updated during the General Assembly at the JRC in Ispra on 4 May 2011, and at the Technical Committee meeting in Porto in April 2012. (See Annex 1.4)

The **Technical Committee meeting** was held on 26–27 April 2012, at IDMEC-FEUP in Porto, Portugal, to discuss the first outcomes of the environment and health data analysis and the structure of the final report, including the data analysis. All WP leaders and co-leaders and the Coordination Committee attended the two-day meeting. After several common and group discussions the TC agreed on the next steps concerning data validation and the finalisation of the common database and analysis. (See Annex 1.4: SINPHONIE Technical Committee meeting 26–27 April)

The **final project meeting/closing meeting** was held on 11–12 September 2012, at the REC in Szentendre, Hungary. During the meeting preparations began on the final report to DG SANCO. During the two-day meeting the results of the SINPHONIE project were presented and the main aspects of the topic were discussed during a panel session. The next steps for providing the final narrative and financial report, and also the planned content of the general report, were presented according to the two-month project extension. (See Annex 1.4. Project closing meeting, Szentendre, 11–12 September 2012.)

No major problems have been identified during the project period. The last six months of the project required the strong coordination of data updating and data uploading to the website. The project protocols work very well and support the efficient implementation of the project. In order to maintain the good pace of database finalisation, the WP5 team and the project coordinator relied on daily email communication with the partners. The two-month extension to the project was very valuable and ensured the good quality of the database, data analysis and reporting.

1.4 General conclusions

The list bellow contains some general conclusion mainly on IAQ in schools, the outdoor school environment and the vulnerability of children. Other specific technical and policy related conclusion are in chapter 4.

IAQ in schools

European school buildings are used by large numbers of students, teachers and other school staff for long periods of the day. The studies carried out under the SINPHONIE project show that European schools frequently have IAQ problems because of polluted outdoor air, various problems related to buildings' construction, poor maintenance and cleaning. In some cases, the existing ventilation system is inadequate.

Indoor air pollutants

Common indoor pollutants in schools are particulate matter, volatile organic compounds, formaldehyde, radon and biological agents. Surprisingly, in some cases environmental tobacco smoke accounted for the burden of pollution observed. These air pollutants can be encountered in classrooms sometimes in elevated concentrations that are often higher than outdoors. As a result, school air quality can have an impact on the health, attendance and performance of children, teachers and school staff.

IAQ in relation to the outdoor school environment

Building construction, decoration and furnishing materials, damage to walls and ceilings as a result of water infiltration and the growth of fungi and moulds, and the activities of building occupants (e.g. smoking, the use of cleaning products, cleaning procedures, the use of paints, glues and other products, etc) are important sources of indoor pollution. Moreover, pollution originated in the outdoor environment (e.g. traffic-related or industrial pollution) and from the ground on which the buildings stand, ***are major sources of indoor air pollution*.**

Vulnerability of children

Poor IAQ in schools can cause discomfort, irritation and a variety of short- and long-term health problems; aggravate existing health problems, including asthma and allergies; spread airborne infectious diseases; reduce teacher, staff and student productivity; and increase absenteeism. ***Children are particularly vulnerable to indoor air–related problems that can be particularly harmful in the case of pupils and students suffering from allergies, asthma or airway hyper-reactivity*.**

2 Consortium management

2.1 Management and coordination

Project management and coordination tasks were facilitated by the efficient operation of all managing bodies (Coordination Committee, Technical Committee, Advisory Committee and Steering Committee). The monitoring of the project, following project execution, was harmonised with reporting by the WP leaders. The Coordination Committee was responsible for the management of the overall scientific scope of the project and of the technical activities.

Coordination Committee members were the REC, IDMEC, NIEH and JRC. Coordination/management activities covered administrative, financial and contractual issues, as well as connections with DG SANCO and all official external contacts on behalf of SINPHONIE.

The Consortium Agreement, signed by all the partners, describes the tasks and responsibilities of the project coordinator (a. 5.1.), the Coordination Committee (b. 5.2.), the Technical Committee (c.5.3.), the Steering Committee (d. 5.4) and the Advisory Committee (e. 5.5). (See in Annex 1.5)

These committees functioned well according to the Consortium Agreement and the project workplan.

The Advisory Committee (AC) and a panel of experts were formed in order to integrate representatives of institutions with recognised competence in the field, whose contributions were considered of great benefit to the project. *Table 4* lists the AC members and expert consultants.

Table 4. Advisory Committee and expert consultants

	Advisory Committee	**Contact person**
1	ISPRA Institute for Environmental Protection and Research **Italy**	Luciana Sinisi
2	REHVA Federation of European HVAC Associations **Belgium**	Olli Seppanen
3	Public Hygiene in Hainaut **Belgium**	Marie-Christine Dewolf
4	**ERS** European Respiratory Society	Nadia Kamel

	Advisory Committee	Contact person
5	**HEAL** Health & Environment Alliance	Anne Stauffer
6	Kings's College E&H **UK**	Frank Kelly
7	**EFA** European Alliance of Asthma and Allergy Association	Susanna Palkonen
8	Ministry for Rural Development **Hungary**	Zsuzsanna Pocsai
	Invited expert consultants	**Organisation represented**
1	Stefania Romano	Italian Trust Fund (ITF), Ministry of Environment, Land and Sea **Italy**
2	Stella Michaelidou-Canna	MoH-CY Ministry of Health **Cyprus**
3	Pawel Wargocki	DTU Technical University of Denmark **Denmark**
4	Torben Sigsgaard	Aarhus University **Denmark**

The first meeting of the AC and CC was held in Ispra during the meeting of the General Assembly on 4 May 2011 before the field activity in the schools. The second meeting was held in Porto during the Technical Committee meeting in April 2012, and the third in Szentendre during the project closing meeting on 11–12 September 2012. These two meetings focused on the SINPHONIE data analysis and interpretation of results.

Members of the AC and CC are critically reviewed the results of the project, focusing on data analysis and policy recommendations on IAQ in schools.

2.2 Communication

In order to facilitate communication between the consortium members, centralised e-mail addresses were created (Coordination_Sinphonie@rec.org; coh@rec.org; sinphonie@fe.up.pt). The coordinator and CC members used centralised e-mail–based communication, meetings, and the project website (www.sinphonie.eu) to share project materials (protocols, questionnaires, timetable for the school campaign, group purchasing of equipment, minutes of meetings etc.).

2.2.1 Meetings

Kick-off meeting, REC, Szentendre, Hungary (10-12 November 2010)

At this two-day meeting, the status, key objectives and components of each WP were presented, and the main aspects of future work were highlighted and discussed. All 38 partners were present at the meeting and the project was successfully launched.

WP5 meeting, TNO, Delft, the Netherlands (17 January 2011)

Almost all WPs were involved in this WP5 meeting to discuss the SINPHONIE database structure. The meeting was organised by TNO.

WP5 meeting, Amsterdam, the Netherlands (28 June 2011)

This WP5 meeting was held to facilitate progress in the development of the database structure. Only some of the WPs were present. One further step was required to finish the database structure.

SINPHONIE General Assembly, JRC, Ispra, Italy (4 May 2011)

The concept of a combined event comprising the General Assembly and environment and health training was developed by the CC and proved very successful. The project partners who attended the training were able to participate in the GA. The GA reviewed the objectives, design and work plan of the project and informed participants about the most important issues related to project coordination (signing of the Consortium Agreement, distribution of pre-financing among partners; finalisation of First Progress Report). Members of the Advisory Committee and expert consultants were also present at the GA and were encouraged to provide comments.

The draft of the WP2 baseline report was presented and a general overview of existing epidemiological and toxicological research results concerning IAQ was provided, based on published articles and reports. The initial conclusions were that there is a general lack of data; that Europe is not covered entirely; and that surveys more generally cover children than teachers. This reinforced the importance of the SINPHONIE project for IAQ monitoring in schools and the health assessment of children.

The tasks of WP3 were presented in line with the main messages and highlights of the project. The leaders and co-leaders of WP3 and WP4 played a key role in the preparation and implementation of the field studies and had to be in direct contact with local teams in the countries. The assessment of the outdoor/indoor school environment (WP3) and the assessment of health impacts (WP4) were discussed at the GA. A detailed description of the database structure and functionalities (WP5) was presented, as was the project's communication and dissemination plan (WP8).

SINPHONIE E&H Training, JRC, Ispra, Italy (2–3 May 2011, 5–6 May 2011)

Preparation for the field studies in the 25 countries (which took place between October 2011 and March/May 2012) required two days for environment training and two days for health training for the technical assistants and E&H experts. The training was organised by the JRC along with the CC and WP leaders. A total of 80 participants from the 25 countries updated their knowledge and developed their competencies for the country field activities.

The minutes of the listed meeting above are in the Annex 1.4.

WP5 meeting, Paris, France (16 February 2012)

All WPs were involved in the WP5 meeting to discuss the SINPHONIE database structure. The meeting was organised by UPMC Paris 06. An additional telephone conference was organised on 9 March 2012. (See in Annex 1.4.)

Technical Committee meeting, Porto, Portugal (26–27 April 2012)

The Technical Committee meeting in Porto, Portugal, was organised according to the workplan to discuss the first outcomes of the analysed environment and health data and the structure of the final report, including the data analysis. (See in Annex 1.4.)

After several common and group discussions the TC agreed on the final steps for data validation and the finalisation of the SINPHONIE common database and the analysis plan. (The detailed agenda, list of participants and meeting presentation can be found on the project website, www.sinphonie.eu > partner area> WP1>meetings)

SINPHONIE meeting, DG SANCO, Luxembourg (21 June 2012)

The topics of this consultation meeting were the project deliverables, the agenda for the closing event in Szentendre, and the foreseen project outcomes according to the DG SANCO contract. (See in Annex 1.4.)

SINPHONIE project closing meeting, REC, Szentendre, Hungary (11–12 September 2012)

The meeting focused on the results of the project and the preparation of the final report. The director of DG SANCO, a senior expert from WHO and a representative of the EP were present at the meeting to discuss the possibilities for a follow-up to the project. As underlined during the meeting, the project outcomes and the dissemination of results are the key elements of this project. Participants agreed on the need for further analysis and a follow-up to the project. (See in Annex 1.4.)

(The detailed agenda, list of participants and closing meeting presentation can be found on the project website, www.sinphonie.eu > partner area> WP1>meetings)

2.2.2 Conference calls

Before the most important project meetings, conference calls were used as an interactive tool for exchanging views on the goal, agenda and planned outcome of the meeting.

A Coordination Committee conference call took place on 19 April 2011 to prepare for the training at the JRC and to discuss project coordination tasks.

In March 2012, a conference call was held in preparation for the Technical Committee meeting in Porto to discuss the agenda and the interactive sessions.

On 8 August 2012 the Coordination Committee held a conference call to prepare the project closing meeting. The committee discussed the agenda for the meeting and the facilitation of the panels.

(See the minutes in the Annex 1.4.)

2.2.3 WebEx meetings

The Coordination Committee and WP leaders organised web meetings as and when necessary. The following WebEx meetings were organised:

- Coordination meeting (15 July 2010)

- Meeting of all WP leaders and co-leaders (28 October 2010)

- Meeting of WP3 leaders (10 March 2011)

- Video conference for WP4 leaders and the Coordination Committee (13 September 2011)

- Coordination Committee (5 March 2012) to prepare for the Technical Committee meeting in Porto in April.

The WebEx meetings were organised by the REC and IDMEC with the cooperation of WP leaders.

(The minutes of the meetings can be found in the Annex 1.4.)

2.3 Cooperation with other projects/programmes and external experts

2.3.1 Cooperation

The WHO European Centre for Environment and Health, in collaboration with the European Commission's Joint Research Centre (JRC), is coordinating the development of new indicators for exposure to indoor air pollutants. In this framework, the design and materials of the SINPHONIE project are being used as a pilot for the application of more recent expertise concerning the methodologies for field surveys of IAQ in schools and other children's facilities.

In January 2012, the WHO Bonn Office organised a pilot project in Albania and Croatia to test the methodology of the school survey and monitoring. The protocols of the SINPHONIE project provided some input to the WHO pilot project. The input of the SINPHONIE project to the WHO Europe pilot school survey was evaluated successfully at the workshop of INDOOR AIRM MONIT harmonisation framework project in Brussels on 18 December 2012.

2.3.2 Subcontracts

According to the SINPHONIE contract (Article II.13), the prior authorisation of the European Commission had to be requested for subcontracting during the project implementation period. In line with this requirement, the REC sent eight subcontracting requests to DG SANCO during the reported period. The subcontracts were acknowledged by DG SANCO. The subcontracts were mainly related to school monitoring and data entry.

3 Progress on Work Packages

3.1 Work Package 1: Management and coordination

WP1 coordination and project management were carried out according to the project work plan and the project contract with DG SANCO. The second transfer of project funding was made to the partners in January 2012. There was a delay in the case of five partners only.

The group purchase of equipment was documented by the REC. Based on the agreed purchasing, the partners received an updated budget for the transfer.

The project's Coordination Committee was involved in the preparation of the agenda for the Technical Committee meeting in Porto on 26–27 April 2012. The logistics for the meeting were coordinated by IDMEC.

The project closing meeting was held at the REC in Szentendre on 11–12 September 2012.

Preparations were managed mainly by the REC. The agenda was prepared by the CC. The meeting went very well and attracted more than 100 participants from 25 countries. The event provided a great opportunity for participants to discuss the final steps of project implementation and exchange views on the project outcomes. DG SANCO also congratulated the project team and the huge work undertaken by the project partners.

(The detailed agenda, list of participants, and closing meeting presentation can be found on the project website, www.sinphonie.eu > partner area> WP1>meetings)

3.2 Work Package 2: Background report

The **WP2** background report provides a systematic review summarising available information on school settings and on IAQ in schools and related health effects among both schoolchildren and teachers. In the context of SINPHONIE, this systematic review can be seen as the application of strategies that limit bias in the collection, critical appraisal and synthesis of relevant studies on the topic in question. Where possible, meta-analysis is used as part of this process. Systematic reviews were carried out on peer-reviewed publications dealing with school-related health problems, and rigorous, standardised methods were used for the selection and assessment of these publications. The systematic review was carried out mostly on observational (cross-sectional, case-control or cohort) studies, but also on intervention studies aimed at modifying air quality in schools and classrooms.

Methods included both a literature review and Internet research (including the proceedings of international conferences and congresses). The resulting review is critical, since it identifies the advantages and disadvantages of existing data and analysis. More specifically, the background methodology comprises five core tasks: 1) data collection; 2) data integration; 3) data analysis; 4) the creation of a user interface; and 5) technology transfer.

It is important to regard WP2 as an interactive instrument. Firstly, WP2 is necessarily linked to all WPs dealing with the research questions explored by SINPHONIE (WP3, WP4, WP5, WP6, WP7, WP8) in order to provide them with existing data. In addition, data obtained through SINPHONIE are assimilated by WP2 and included in the systematic review to be disseminated as a result of the project. An Internet tool or platform is added to ensure the immediate and efficient circulation of the identified background materials and the reviews carried out among project participants and, later on, to support the transparent and efficient dissemination of the scientific outputs and background material on which the recommendations are based. This platform is an essential tool in risk assessment and in management and guideline development. (See the Background Report in ***the Annex 2.1.)***

WP2 prepared and published a national case study on current IAQ and respiratory health issues for consideration in the analysis of SINPHONIE data. This case was discussed in the TC meeting in Porto in April 2012.

The WP2 literature review was reported in the SINPHONIE Interim Report (Deliverable 2.1, Background Report in ***Annex 2.1).*** The case study is an additional document on IAQ and health assessment suggested by the WP2 leader for consideration in the SINPHONIE database analysis***. (See the case study in Annex 2.3, and the Peer reviewed article in Annex 2.2)***

The design of the data analysis, prepared by the WP5 leaders, is attached at WP5 in this section.

3.3 Work Package 3: Assessment of the outdoor/indoor school environment

Within **WP3**, IAQ field studies were organised in schools in 23 European countries. Measurements of 31 physical/chemical/biological parameters were carried out using common methodologies.

WP3 was led by JRC and NIEH, and all except three partners (TNO, HVDGM, NILU) participated in the field monitoring for the main study. The leading institutions of the various sub–work packages were:

- WP3.1: Characterisation of school buildings: IDMEC-FEUP, NIEH
- WP3.2: Physical and chemical measurements: VITO, NIEH
- WP3.3. Measurement of biological contaminants: THL, NIEH
- WP3.4: Environmental context and modelling: NKUA, NIEH

School buildings and classrooms were selected according to a set of harmonised and predefined criteria. Two documents defining selection criteria for schools, and for classrooms within each school, were prepared, distributed to all partners and uploaded to the project website.

School and classroom checklists were prepared jointly by the WP leaders and all partners. Several aspects were discussed and efforts were made to integrate all suggestions before the final document was sent to all partners on 13 May 2011. A new annex to the classroom checklist was prepared by WP3.4 leaders, with the goal of collecting information for the modelling work, and this was also sent to all partners.

Information concerning the building/school/classroom characteristics that potentially affect IAQ was gathered via inspections of the school buildings and selected classrooms, and these activities were carried out during the period October 2011 to March/May 2012 (in some countries the field activity was finished in May). The checklists were completed with no major issues arising from the partners. Each partner entered the collected data into the database. The uploading of data on building characterisation to the database was finalised for 310 classrooms belonging to 121 buildings in 112 schools in 22 countries.

The SINPHONIE fieldwork was divided into one main study and four case studies according to different goals. The case studies focused on definite aspects of IAQ in schools. The main study, which aimed to assess indoor exposure in EU schools, was performed in 112 schools in 22 European countries across four clusters (defined according to climatic conditions). Each participating country contributed data on an average 5.2 schools to the main SINPHONIE study.

Case studies were carried out in a limited number of schools and countries in order to prove hypotheses such as the effectiveness of ventilation in enhancing IAQ (VITO, UCL, IDMEC); the influence of seasonal variations on IAQ (THL, UCL, CSTB, IV, UOWM); the effectiveness of abatement measures (VITO, CSTB); and impacts of emissions from consumer products/materials (VITO, IDMEC, UOWM).

The analysis of 18 physical/chemical parameters — including key priority compounds recognised by various international organisations — and 13 biological contaminants — including endotoxins (1 analyte), allergens (5 analytes) and fungal and bacterial DNA (7 analytes) — provides an excellent overview of IAQ in schools across Europe.

The analysis used the measured physical parameters (temperature, relative humidity and ventilation rate) and chemical and biological pollutants of indoor (and related outdoor) air in schools and childcares in all Europe in order to produce new exposure data for an array of pollutants: formaldehyde, benzene, pinene and limonene, naphtalene, nitrogen dioxide, carbon monoxide, carbon dioxide, radon, trichloroethylene, tetrachloroethylene, PAH and BaP, particulate matter (PM10 and PM2.5), allergens in dust and mould and bacteria in dust and the air;

Indoor and ambient air monitoring procedures were harmonised by developing common tools (e.g. sampling protocols, analysis protocols, checklists for sampling in the field, a sample coding system and reporting templates) that were explained and demonstrated in dedicated training sessions and used in fieldwork (measurements of indoor and outdoor air).

Capacity was built via the participation of laboratories with big differences in terms of experience related to IAQ chemical assessment. A quality control and quality assurance strategy, including inter-laboratory trials, was formulated in order to ensure maximum data comparability.

Common methodologies and centralised laboratories were the preferred choice for the analysis of biological contaminants, due to the limited availability of laboratories for biological agents across the European region. In addition, current developments in microbial exposure assessment were carefully considered in the SINPHONIE approach, in that not only viable, but also non-viable microbial compounds were measured, and analyses were performed from long-term integrated dust samples rather than from short-term air samples, as such sample materials are less prone to the short-term fluctuations of microbial levels typically observed in air samples. This ensured that a unique, extensive and highly comparable dataset of biological contaminants in schools across Europe was produced, which will lay the groundwork of, and serve as a reference for, future assessments.

As a result of the successful execution of this WP, datasets containing concentrations of 18 physical/ chemical parameters and 13 biological parameters along with information on the school buildings and classroom characteristics are available for each of the 112 schools that participated in the main study. ***(See Annex 3.6, 3.7, 3.8)***

The collected datasets were uploaded into the database of www.sinphonie.eu. Three verification steps were then applied: 1) data cleaning to obtain datasheets that can be processed in a harmonised way; 2) data validation to exclude incorrect data that cannot be considered an outlier; and 3) reference to quality control to trace data from labs with associated high uncertainty, as proved in the QA/QC strategy.

The influence of external factors such as traffic and climate change was considered using simple methods. A preliminary analysis was carried out of the school building questionnaires, on the basis of which the results of the study modelling the impact of outdoor temperature on indoor temperature could be better explained. However, final conclusions can only be drawn when the merged database becomes available.

Data already made available from a limited number of schools were used in order to study indoor-outdoor air interactions from the point of view of air mass exchange rates and their impact on the levels of traffic pollutants indoors. Moreover, the ability of the European school building stock to "protect" students from increased temperatures occurring as a result of climate change, and from elevated traffic pollutant levels, were a major part of this sub–work package. However, final conclusions can only be drawn when the merged database becomes available.

All deliverables due from this WP3 are listed in *Table 3.* Deliverables were successfully completed and properly reported to the coordination team. Deliverable 3.2.3 are finalised. Deliverables 3.4.1 and 3.4.2 have been reported at the end of the project. In the follow up of the project further data analysis is requested by the WP3.4 leaders. ***(See Annex 3.13, 3.14)***

Review of the impact of the action:

Overall, IAQ auditing in schools across Europe has been successfully performed and for the first time will bring to the public comparable data on IAQ in 295 kindergarten and primary school classrooms in 22 European countries. Exposure levels among 6,904 pupils were assessed.

The organisation of the field campaigns was complex due to the large number of participating partners (in several countries more than one partner per country organised the main study fieldwork) and the very broad range of experience in the field. However, the development of common tools and the organisation of dedicated training sessions proved that harmonised procedures and criteria can coexist with flexibility and capacity building in the various participating labs. Putting in place an appropriate quality control/quality assurance strategy enhanced data comparability.

A unique dataset of biological contaminants in schools in the European region has been produced, using highly standardised sampling approaches and state-of-the-art analysis, also taking into consideration the non-viable but nonetheless health-relevant portion of biological exposure. This dataset will stand as a reference for future assessments of biological agents in the school environment.

(See the report in Annex 3:SINPHONIE Results of the main study and case studies, 3.6 and biological study, 3.7)

WP. 3.4 Environmental context and modelling

The literature review on the impacts of traffic on IAQ was completed. Factors affecting pollutants entering an indoor space can be summarised as follows:

a. the distance of the pollution sources from the building;

b. dispersion processes in the close vicinity of the building;

c. ventilation patterns in the building;

d. the air-tightness of the building; and

e. the physical and chemical properties of the pollutants entering the building (deposition, re-suspension, chemical reactions).

The purpose of this WP 3.4 work was to assess the degree to which traffic-induced pollution affects IAQ in the classrooms monitored in the framework of the SINPHONIE project. The methodology developed was based on the statistical analysis of the measurements of traffic-related pollutants both outdoors and indoors, within the framework of SINPHONIE. This analysis is an integral part of the deterministic approach followed in order to identify the mass exchange flow rates between the indoor and outdoor air that are responsible for the physical transfer of outdoor pollutants indoors and vice versa. The so-called transfer functions that emerge as a result of the above methodology may lead to a reliable and validated prediction model for indoor pollutants for the analysis and theoretical investigation of cases with variable boundary conditions.

Suggestions for guidelines for acceptable IAQ:

The problem of IAQ in spaces of particularly "sensitive" use, such as schools, continues to baffle the scientific community, local environmental authorities, parents and, to some extent, legislative bodies. It has become clear from the sections above that traffic-related pollution is a major source of poor IAQ, while depending on the type of vehicles (diesel or petroleum, trucks or cars, etc.) the amount of fine particles, nitrogen oxides and carbon monoxide emitted may vary. Another important fact is that local climatic conditions more or less impose the ventilation strategy followed by the schools included in this study. On the one hand, schools located in the Southern European quarter rely on natural ventilation and open windows frequently, even during the heating season; on the other hand, those located in the other quarters present a mixed picture — new buildings depend mostly on mechanical ventilation and older ones with no mechanical ventilation simply avoid opening windows altogether as protection from unfavourable weather conditions. To make matters worse, climate change is placing extra pressure on schools because of persistent extreme weather events that have become more frequent, expressed as high temperatures in countries in the south or prolonged periods of cold in the north. This leads school building users either to open windows for longer periods or to rely heavily on HVAC systems. However, simple guidelines on ventilation rates are inadequate if the outdoor environment is not taken into account.

This leads to the conclusion that the battle for acceptable IAQ should focus on two “fronts”:

a) control of the quality of the outdoor air that enters the indoor environment by choosing “pollution-free” zones in which to build schools, or by imposing stricter measures to improve traffic conditions in the close vicinity of schools (e.g. in a radius of 1 km); and

b) adequate ventilation (by natural or mechanical means) in order to reduce pollutants of indoor origin and maintain good comfort conditions. Concerning the former, the quantification of flow rates responsible for the exchange of air between the indoor and outdoor environments proved to be a useful technique in identifying the flows responsible for the transfer of pollutants.

Future work should focus on predicting indoor pollutant levels through the day by taking into account the number of occupants in a room, exchange rates, and outdoor air quality. This can be done initially for CO (and under certain circumstances for NO_2) because it is fairly inert and the levels recorded so far in the SINPHONIE schools have indicated that it originates from traffic since the I/O ratio is below 1.

The work of this WP 3.4 is a logical continuation of the monitoring data analysis process that identifies the mass exchange rates “behind” the observed/measured indoor traffic-related pollutant concentrations. The results presented above make it clear that simple guidelines on ventilation rates are inadequate, since outdoor air quality plays an important role. Moreover, this WP may be thought of as the final piece in the indoor–outdoor relationship puzzle, since the indoor and outdoor environments are connected systematically and quantitatively. The deterministic approach adopted here may lead in the future to the creation of a handy and easy-to-use tool for “knowing” acceptable indoor air concentrations and actually achieving them by forcing the desirable ventilation patterns.

The sample study “Climate Change Impact on the Risk of Overheating in European Schools” for London has also been completed as part of the general study on all schools from the geographic clusters set up at the beginning of the project. The study used the prediction of the UK CIP09 climate model, indicating rising outdoor temperature for the future. The study showed that external and internal temperatures are directly related for all school types: with an increase in external temperatures in the future there will be an increased risk of overheating in school buildings.

For an assumption of the impact of climate change for other schools representing different climatic regions in Europe, climate models from the ENSEMBLE project were used. Predictions of the change in frequency of hot days was investigated for Hungary by studying 20 climate models from the ENSEMBLE project. The models predict future change with great variety.

(See the reports in Annex 3.13, 3.14)

3.4 Work Package 4.: Assessment of health outcomes

The are two sub-packages of the W4: WP 4.1. Clinical field survey and WP4.2 - Clinical tests and noninvasive biomarkers.

3.4.1 The clinical field survey

As leader of WP4, CNR Palermo (in collaboration with CNR Pisa) developed and finalised questionnaires for the assessment of children's and teachers' respiratory health and their perception of IAQ in the school building/classroom for the evaluation of risk factors related to IAQ and confounders regarding children's domestic lifestyles.

To this end, five questionnaires were prepared (See Annex 4.1):

- Questionnaire for Pupils
- Questionnaire for Parents
- Questionnaire for Teachers
- Questionnaire about the School
- Questionnaire about the Classroom

All the tools were developed using as a background the standardised questionnaires from the ISAAC II and ECRHS studies and capitalising on the experiences of the HESE and SEARCH studies. The questionnaires were finalised for the field investigation after accepting, or eventually refusing with justifications, all comments received from the other partners. Having managed the questionnaire arrangements, CNR Palermo (in collaboration with CNR Pisa) also provided documents, comments and expertise for the variable encoding and for the value input, in order to support the work of WP5 and the subsequent data analyses.

CNR Palermo (in collaboration with CNR Pisa) elaborated the attention/concentration test and provided a document for the variable encoding and data entry in order to harmonise the fieldwork for subsequent statistical analyses.

In collaboration with the National Institute of Environmental Health, Hungary, CNR Palermo (in collaboration with CNR Pisa) produced the protocol and form for the attention/concentration test and the tool for absenteeism assessment (register of absenteeism).

CNR Palermo (in collaboration with CNR Pisa) administered all data collection tools for selected participants and provided data to WP5 by uploading to the SINPHONIE website and coordinated activities for the organisation of WP4 partners, particularly Italian partners (organisation of local web meetings, networking activities among Italian and European participants, file/document sharing etc.).

As a participant in WP4.1 Clinical field survey and WP4.2 Clinical tests and non-invasive biomarkers, CNR Palermo (in collaboration with CNR Pisa) supported Università degli Studi di Siena (USiena) during the development of the spirometry protocol. It also completed the field survey and provided data to WP5 by uploading to the SINPHONIE website.***(See in Annex 4)***

Although the questionnaire form for the assessment of teachers' health was expected to be completed within month 8 (D 4.0.1.), some revisions were carried out in order to make the document consistent with the project's master protocol. The intervention was necessary in order to insert questions about familiarity with allergic diseases, dietary habits, current home exposure and knowledge of asthma management in the school.

In order to harmonise the questionnaire encoding with the strategy adopted by WP5 for the database structure, all the developed questionnaires had to be modified and re-sent to the coordination team after the initial deadline.

Review of impact of the action:

The huge amount and variety of collected data enhances current knowledge about IAQ and its links with health in schools and childcare settings and makes it possible to assess the status of IAQ management across Europe. This will contribute to making an effective and fruitful set of proposals leading to new policies, new guidelines and new practices.

An analysis of the situation worldwide and the integration of multiple areas of expertise will help in the elaboration of guidelines on remedial measures in the school environment and in the dissemination of these guidelines to stakeholders that have responsibility to take action.

The questionnaires elaborated to assess children's and teachers' respiratory health and perceptions of IAQ, school and classroom environment characteristics, and the school principals' knowledge of IAQ issues, will be a useful tool that will help school administrators to manage IAQ in the future.

The teachers' questionnaire alone is an innovative tool, elaborated to address the lack of this kind of information in the scientific literature.

The data of questionnaires are analysed in the WP5.

3.4.2 Results of the clinical health checks of the children

The following results are the summary of the report of clinical health check in Annex 4.12.The number of figures bellow follows the numbering in the clinical health check report.

Not all partners performed all checks. But for a range of health parameters the project could collect valuable and comparable data from a wide range of European countries. For a direct comparison differences in the age of the children have to be considered (figure 1). Among other parameters also height is certainly influenced by the age of children (figures 2 and 3). Also weight affects spirometry (figure 4). In fact both very slender and very fat children tend to have poorer lung function. So also the square root of weight (centered around the mean value) was calculated.

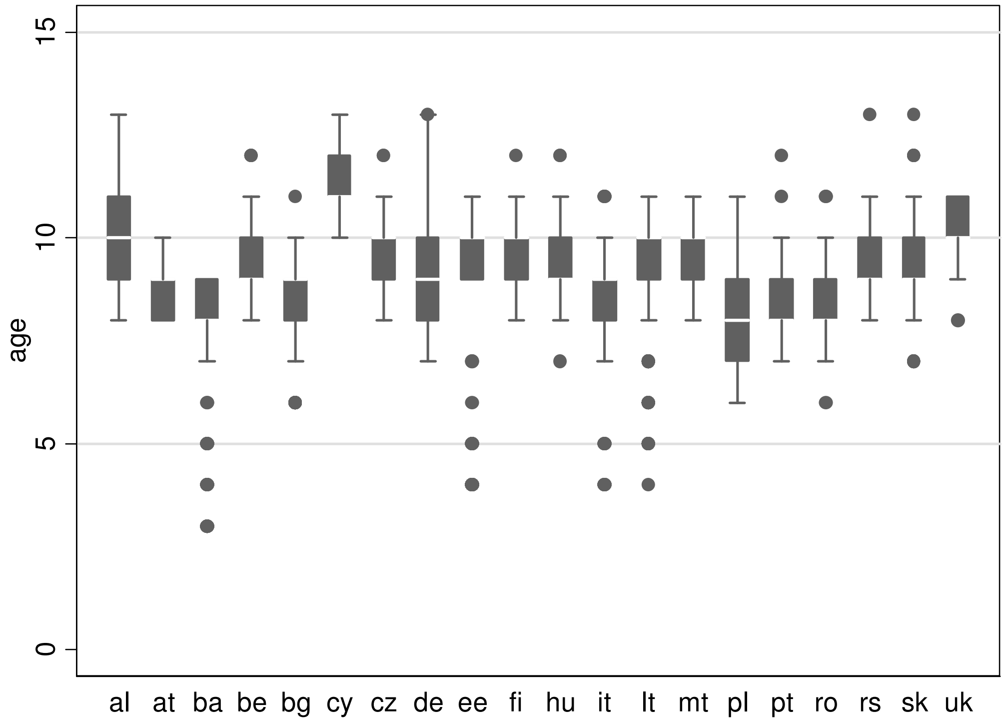


Figure 1: Age distribution of children per country

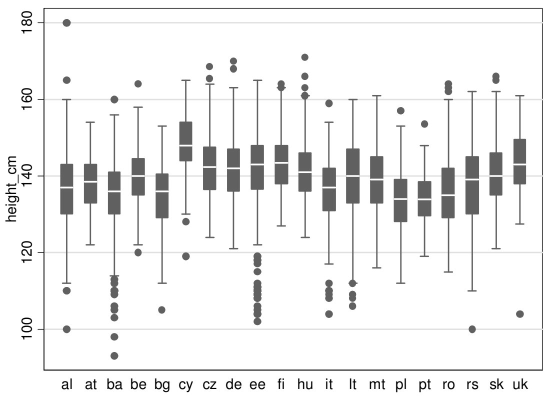


Figure 2: Height distribution of children per country

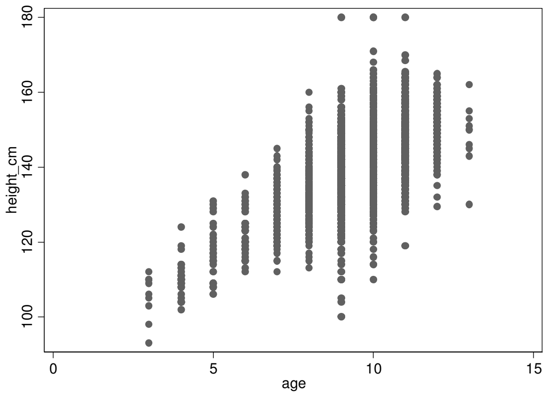
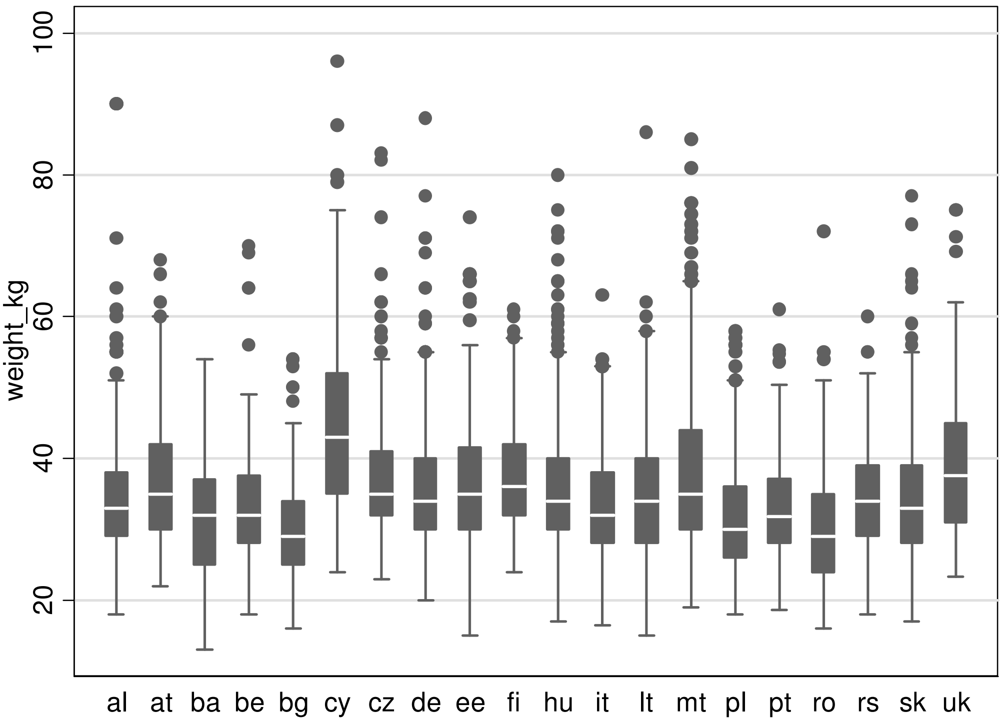


Figure 3: Height by age (all countries included)



<u>Figure 4:</u> Weight distribution of children per country

<u>Skin prick test</u>

Only few countries participated in the skin prick test and not all countries analyzed exactly the same set of allergens. Therefore it does not make sense to compare country results for single allergens. Instead allergenicity of a child was defined as the maximal wheel diameter of all allergens tested. (The diameter was calculated as the arithmetic mean of the largest and smallest diameter of each wheel.)

In total 314 children from 4 countries (it, pl, pt, se) were examined. In all children there was no reaction on the saline negative control. The wheel diameter for the histamine positive control ranged from 2.5 to 10 mm (mean and median about 5 mm).

Variable	Obs	Mean	Std. Dev.	Min	Max
negative	314	0	0	0	0
histamine	314	5.095541	1.097679	2.5	10
max	314	1.786624	3.07193	0	16

Summary statistics of the skin prick test:

The maximal wheel diameter ranged from 0 mm (in about 70% of children) up to 16 mm (table 2). Hence about 30% of children displayed a reaction against at least one of the allergens tested. In about 20% this reaction was stronger than against the positive control (histamine).

Lung function

In order to control for the influence of age, height, weight (and weight squared), and sex a linear regression was performed for each lung function parameter. All data (including those rated as poor quality or poor collaboration) were included (table 3) in the Annex 4.12.

The following box-plots (figure 5) display the raw data for each lung function parameter per each country (black) and the residuals from the regression analyses in grey. Under the assumption that there are no systematic differences between the countries all residuals should center around zero and be fairly normally distributed (with the exception of the Tiffenau parameter). As it can be seen from the box plots this is not the case for all parameters and for all countries either indicating a systematic measurement error or real differences between countries that should be examined further.

Figure 5: Box plots of the lung function parameters (black) per country and of the residuals of each linear regression (grey)

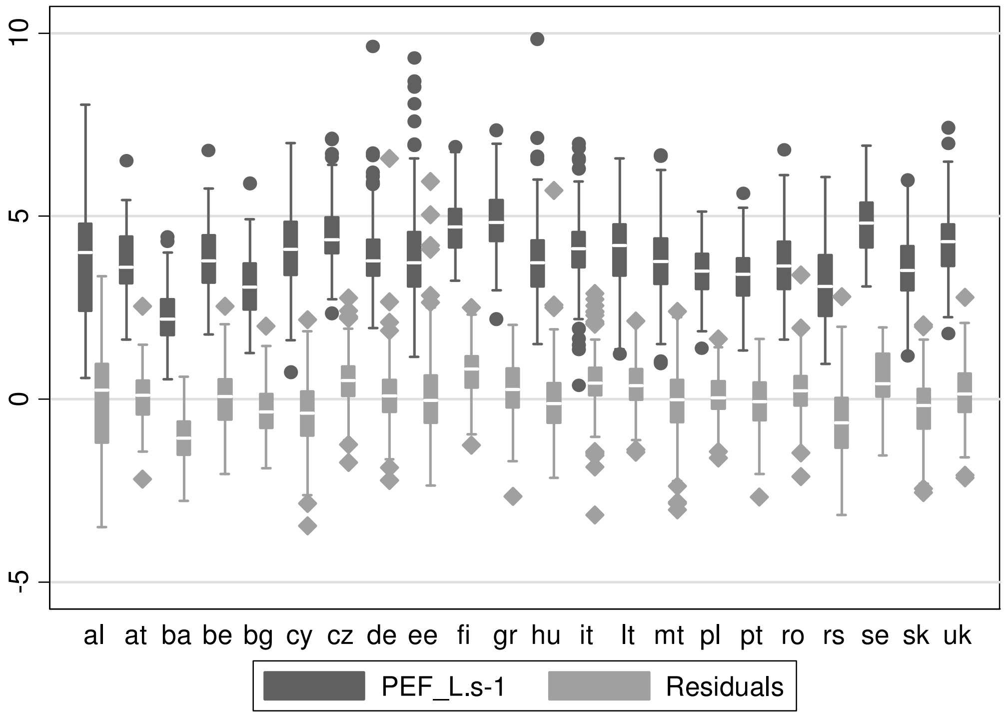
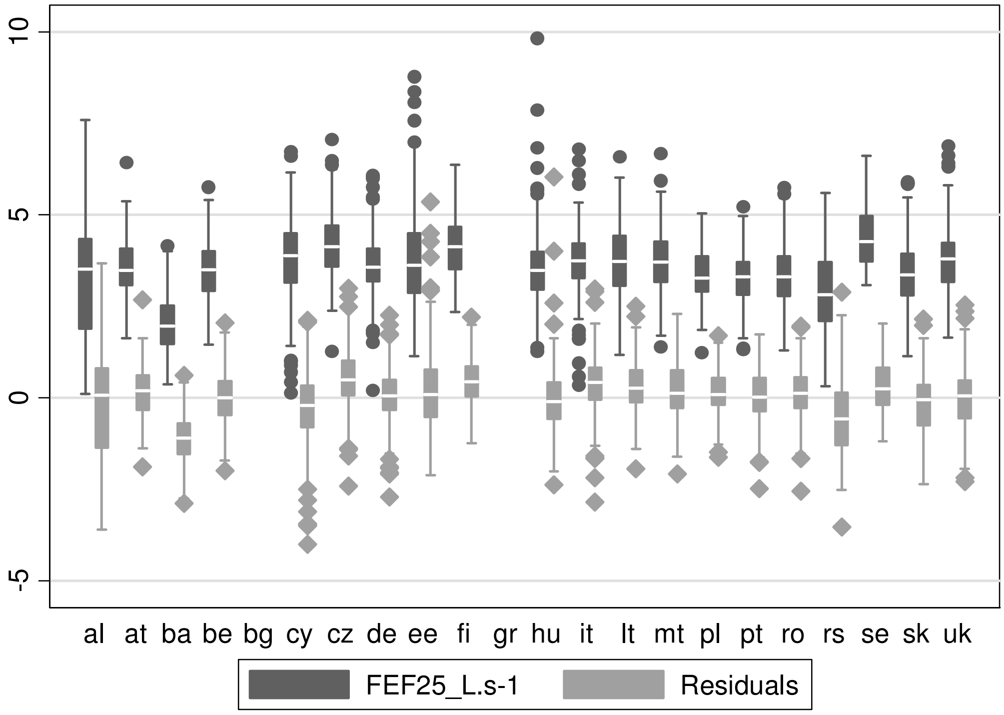


Figure 5 (continued): Box plots of the lung function parameters (black) per country and of the residuals of each linear regression (grey)



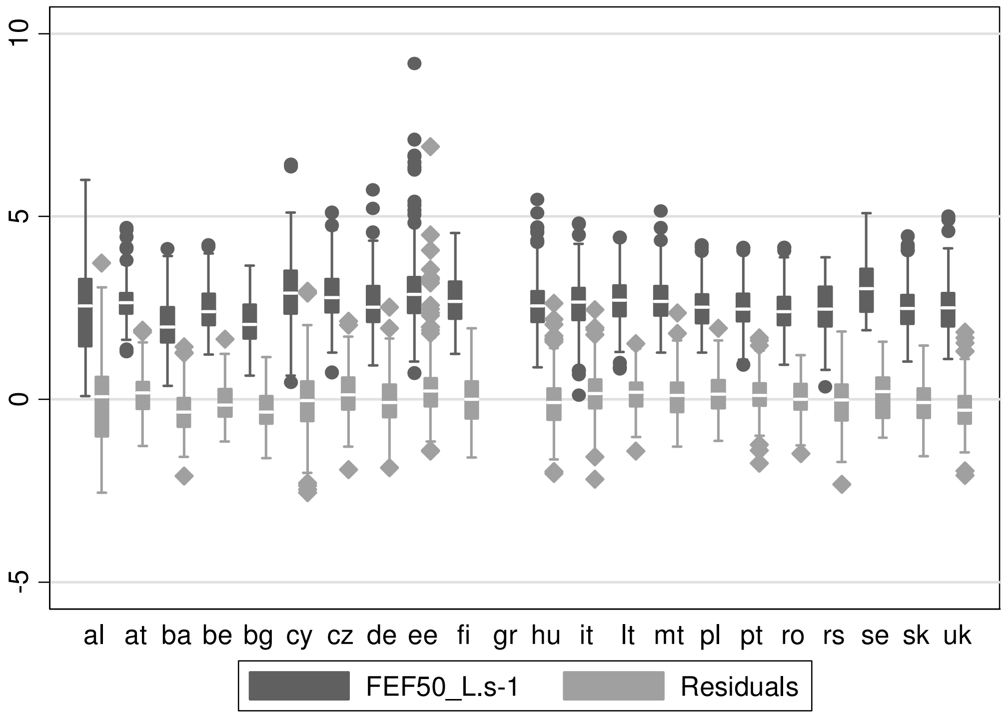
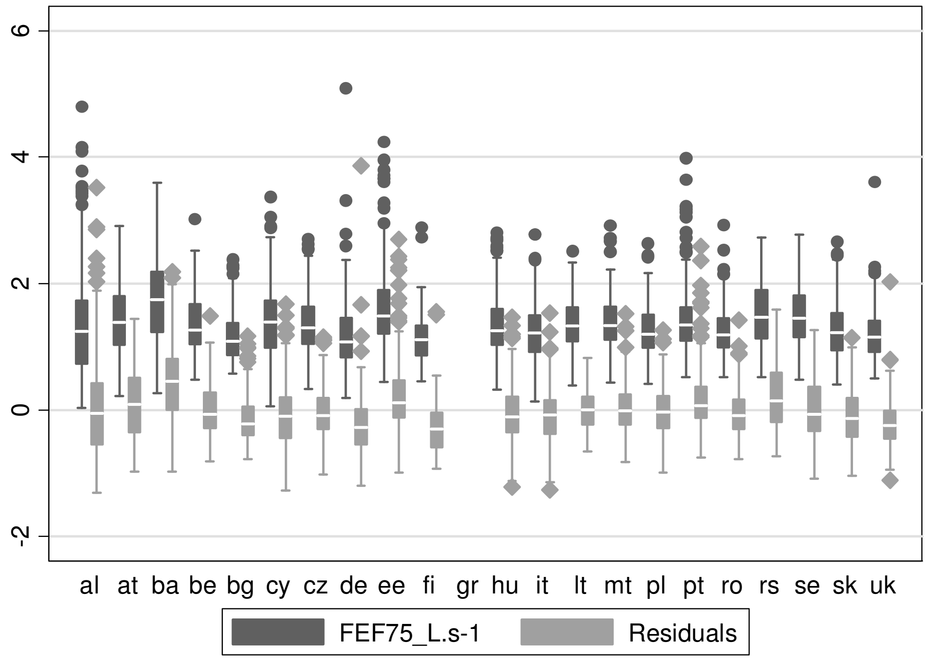
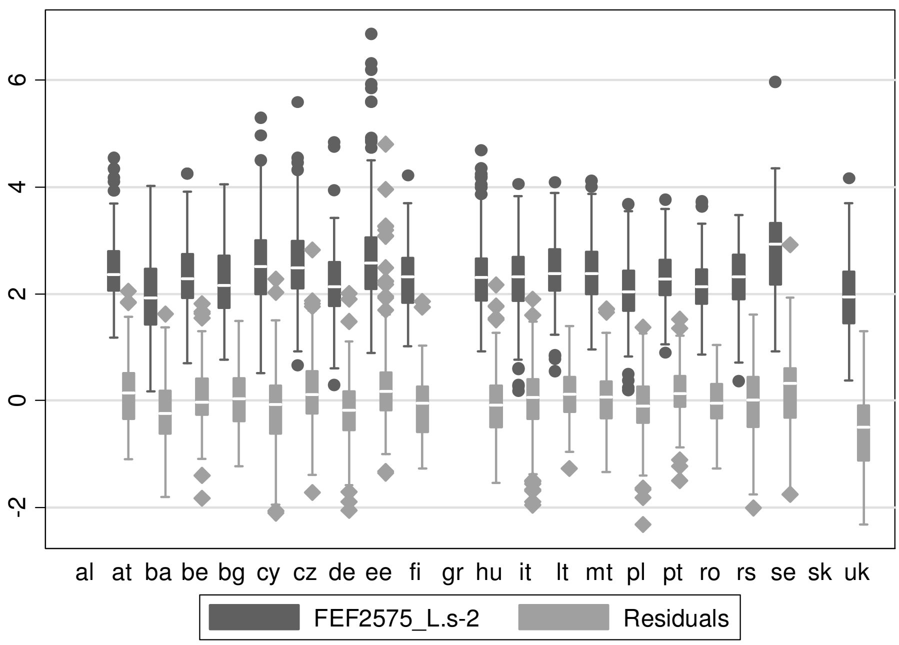


Figure 5 (continued): Box plots of the lung function parameters (black) per country and of the residuals of each linear regression (grey)





<u>Figure 5 (finished):</u> Box plots of the lung function parameters (black) per country and of the residuals of each linear regression (grey)

Rhinometry

Only few countries performed rhinometry and most of the participating partners were not very experienced with this technique. Figure 6 describes the results in box-plots.

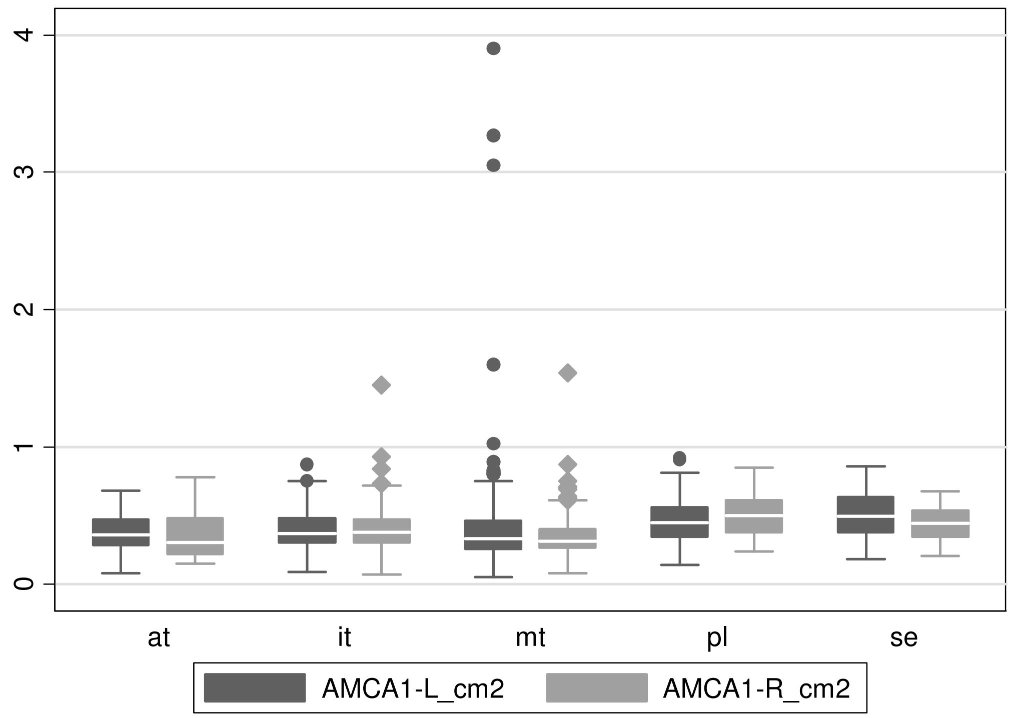
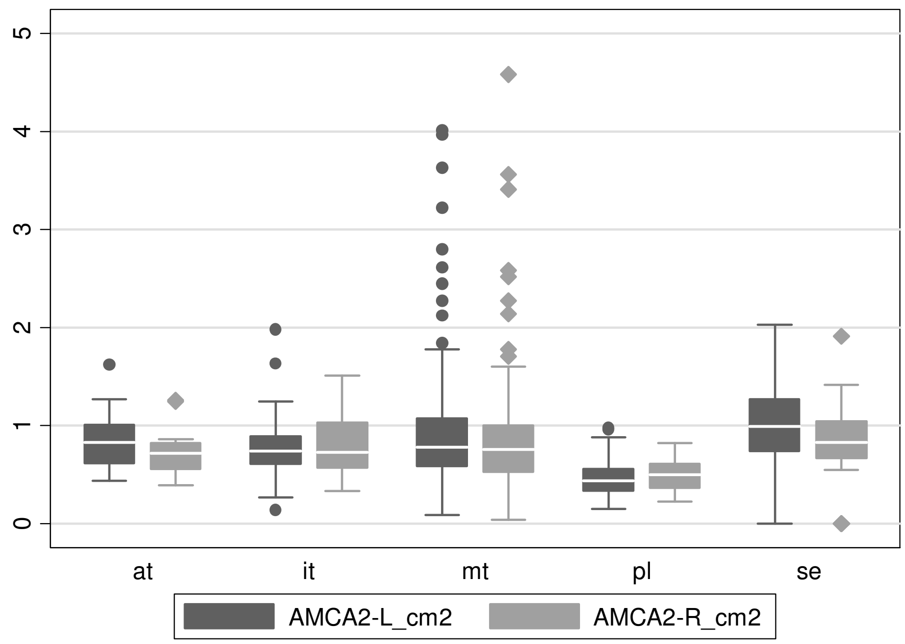
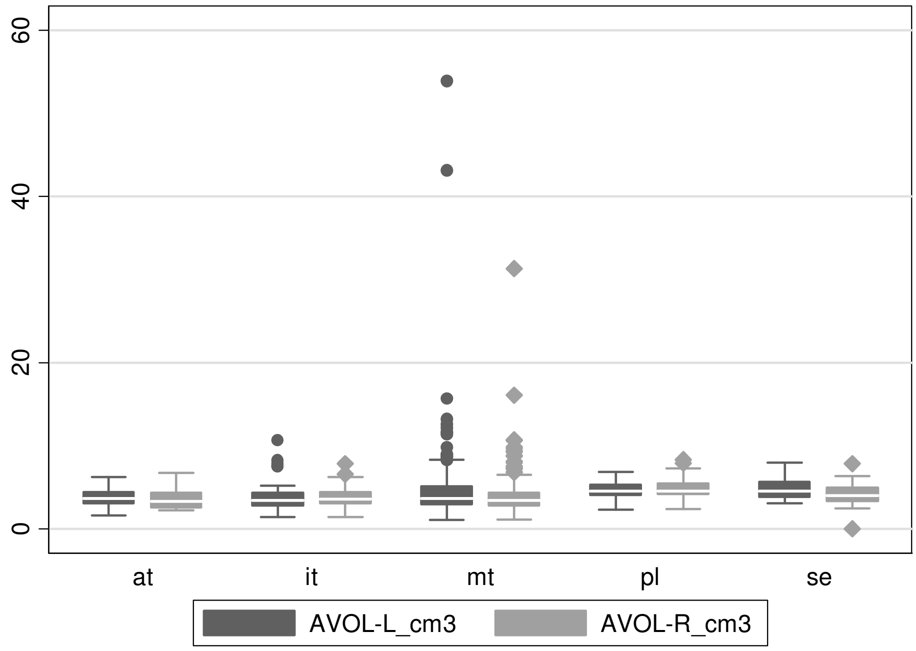


Figure 6: Box plots of the rhinometry results. Left and right nose per country, diameter at first and second narrowing of the nasal canal (AMCA1 and AMCA2) plus nose volume (AVOL).





<u>Figure 6 (continued):</u> Box plots of the rhinometry results. Left and right nose per country, diameter at first and second narrowing of the nasal canal (AMCA1 and AMCA2) plus nose volume (AVOL).

Only one country (pl) also performed rhinometry after decongestion.

<u>Other test results</u>

While the results of the nasal lavage were not ready for the preparation of this descriptive report and will be reported centrally, here a short description of the outcomes regarding break-up time (BUT), exhaled NO, and exhaled CO will be provided.

Exhaled CO was only determined by 3 countries (at, it, mt) and the results differ so much between these 3 countries that this can only be explained by the use of different methodologies that are not entirely comparable.

BUT was measured 3 times by most of the countries that performed that test. Only rs reported only 2 consecutive per child. As can be seen from figure 7 there was no clear trend from the first to the third taking of the test. Therefore it is reasonable to use the average over the 3 tests (respectively 2 tests in the case of rs) for each individual child (figure 8).

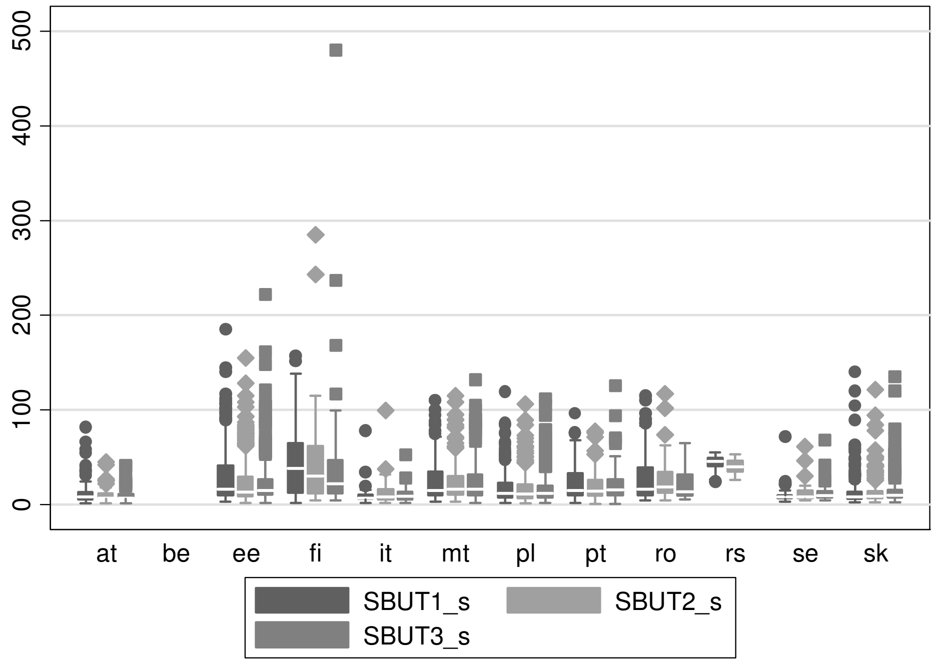


Figure 7: Box plots of the BUT results (in seconds). 3 consecutive tests per child.

Exhaled NO was assessed in the same way by all the partners. The results can be easily compared between countries (figure 9) and schools or classes. The variability is sufficient to study possible environmental influences. The limit of detection (LOD) of the method is given as 5 ppb. Only one partner (fi) reported some children to have exhaled NO below LOD and these values are set to zero in this descriptive analysis.

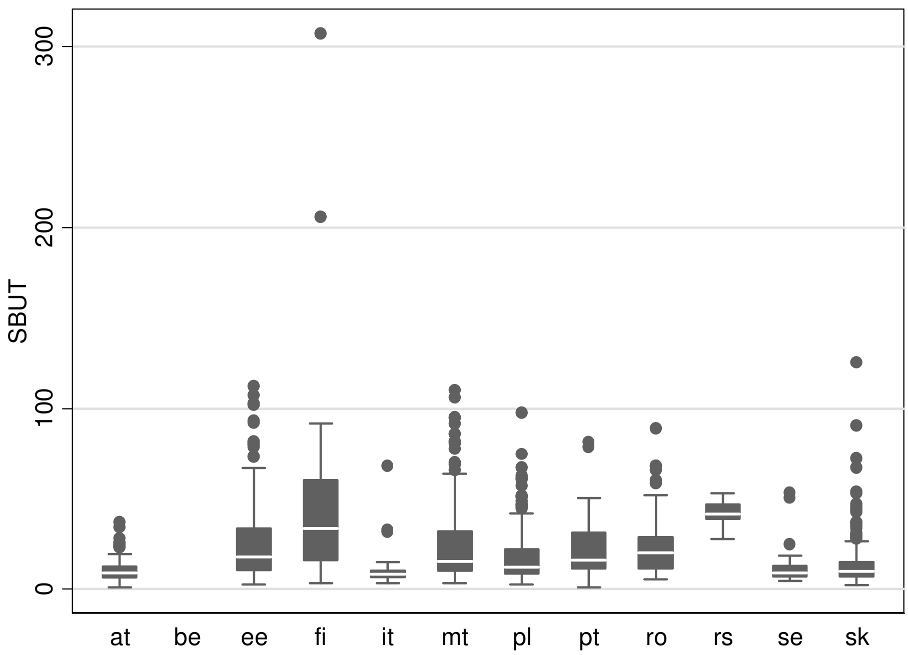


Figure 8: Box plots of the BUT results (in seconds). Averages across 3 consecutive tests per child.

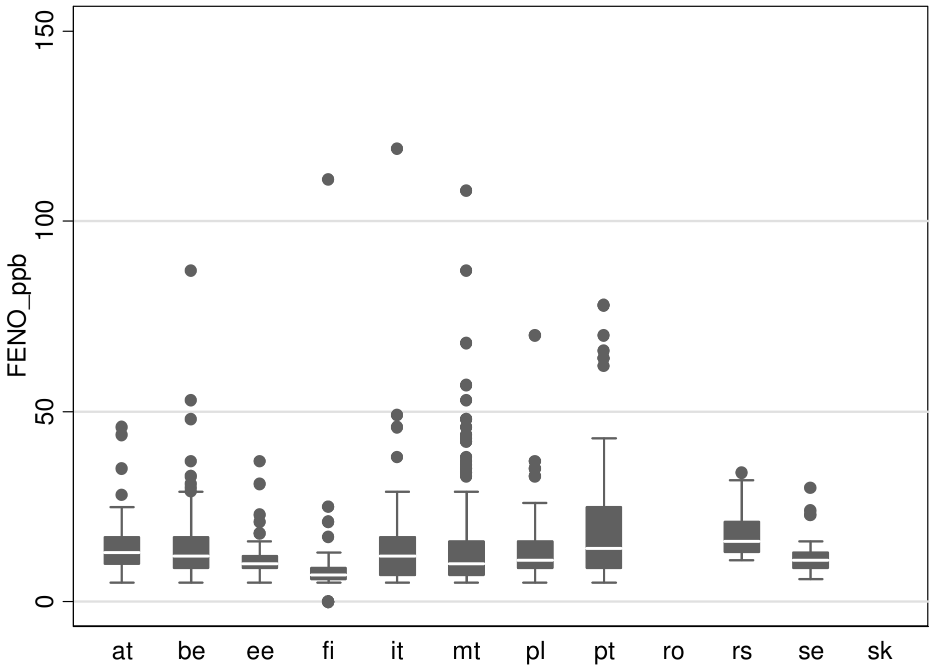


Figure 9: Box plots of the exhaled NO results (in ppb) per country.

3.5 Work Package 5: Data management, cross analysis and database

3.5.1 SINPHONIE Results: Database Structure

This deliverable comprised the definition of a global database structure for the health-related school information collected and analysed in the SINPHONIE project. The selected description/storage mechanism was structured Microsoft Excel sheets (Microsoft Office Excel 2003).

Information was collected on five "item types":

1. Countries: 23 participating countries.

2. Schools (primary schools and day-care institutions), meaning one or two school buildings: an average of four to five per country (total of ~100 schools).

3. Rooms: three classrooms and one outdoor space for each school (total of 492 rooms).

4. Children: maximum 30 per classroom (two exceptions: for uk-s3-r3: 44; and for pl-s1-r2: 44) (maximum total of 11,070+2*14 children).

5. Teachers: maximum 50 per school (maximum total 6,150 teachers).

Five methods of investigation were used to obtain data:

- Given, for factual information on countries.
- Obtained via checklists, for factual information on both schools and rooms.[1]
- Obtained via measurements for rooms, both physical/chemical and biological.
- Obtained via tests of children: 1) both general and clinical (for a subset) health tests; and 2) attention tests.
- Obtained via questionnaires for:
    - school administrators on their schools
    - teachers on the classroom(s) in which they teach
    - teachers on their own health
    - parents on their children and their children's school and home
    - children[2] on their own health and school
- Obtained via registers for
    - (class)rooms (number of absent children) anonymously

[1] Here physically combined into one checklist
[2] In the presence of a health operator

- children (absenteeism) not anonymously

The final unstructured methods of investigation (exact files) are provided in Appendix A.

Identification schema

Countries are identified by a country code (e.g. “be” for Belgium)[3]. Schools are identified by a school code (e.g. “s3” attached to the relevant country code: “be-s3”). Rooms (classrooms and outdoor spaces) are identified by a room code attached to the school identification code (e.g. “al-s1-r2”, meaning room 2 in school 1 in Albania). Children are identified by a child code (e.g. “it-s5-r2-c4”). Teachers are identified by a teacher code (e.g. “gr-s1-t3”).

According to the plan we assumed 24 countries, three to six schools per country (depending on the country), four rooms per school (one outdoor space and three classrooms), a maximum of 30 children per classroom (except for uk & pl: 44) and a maximum of 50 teachers per school.

Interrelationships

Each school sheet contains a column “buildingCode”, in which each school has two predefined rows: one for building1 and one for building2. Next, each school has a column “inCountry” to model its location precisely. Each room sheet has a column “ofSchool”, and each child and teacher sheet has a column “inRoom”. So we “model” the links between the entities in more than one place. Because all IDs are predefined, this does not present any problems.

Types of sheet involved

We have one prefilled country Excel sheet with the countries and leading institutes[4].

We have the following 19 structured but empty (in the sense of no content) Excel sheets:

1. school-cl-h.xls, which will contain all school checklist info (for one or two buildings) for the heating season
2. school-cl-nh.xls, which will contain all school checklist info (for one or two buildings) for the non-heating season
3. room-cl-h.xls, which will contain all room checklist info for the heating season
4. room-cl-nh.xls, which will contain all room checklist info for the non-heating season
5. room-mpc-h.xls, which will contain all room measurements (physical/chemical) info for the heating season
6. room-mpc-nh.xls, which will contain all room measurements (physical/chemical) info for the non-heating season

[3] According to http://en.wikipedia.org/wiki/ISO_3166-1_alpha-2 in lower case
[4] Other institutes are assumed to be locally involved/managed via the country’s ‘leading institute’.

7. room-mb-h.xls, which will contain all room measurements (biological) info for the heating season

8. room-mb-nh.xls, which will contain all room measurements (biological) info for the non-heating season

9. child-tg.xls, which will contain all child test (general) info

10. child-tc.xls, which will contain all child test (clinical) info

11. child-ta1.xls, which will contain all child test (attention) info

12. child-ta2.xls, which will contain all child test (attention) info, as alternative variant

13. child-qp.xls, which will contain all child questionnaire info provided by the parents related to both the school and home situation

14. child-qc.xls, which will contain all child questionnaire info provided by the child related to both health and the school environment

15. school-q.xls, which will contain all school questionnaire info (for one or two buildings) provided by the school administrator

16. room-q.xls, which will contain all classroom questionnaire info provided by the teachers

17. teacher-q.xls, which will contain all teacher health info provided by the teachers

18. room-r.xls, which will contain the anonymous number of children absent

19. child-r.xls, which will contain the actual children absent

Actual file set (total #20 files)

All these files have their attributes in the first row, where the columns have the right validation rules defined for them. All cells are formatted as "General" except for the first row and column, which are formatted as "Text" to be more easily automatically recognisable by Excel as the "non-attribute data" row and "own ID" column respectively.

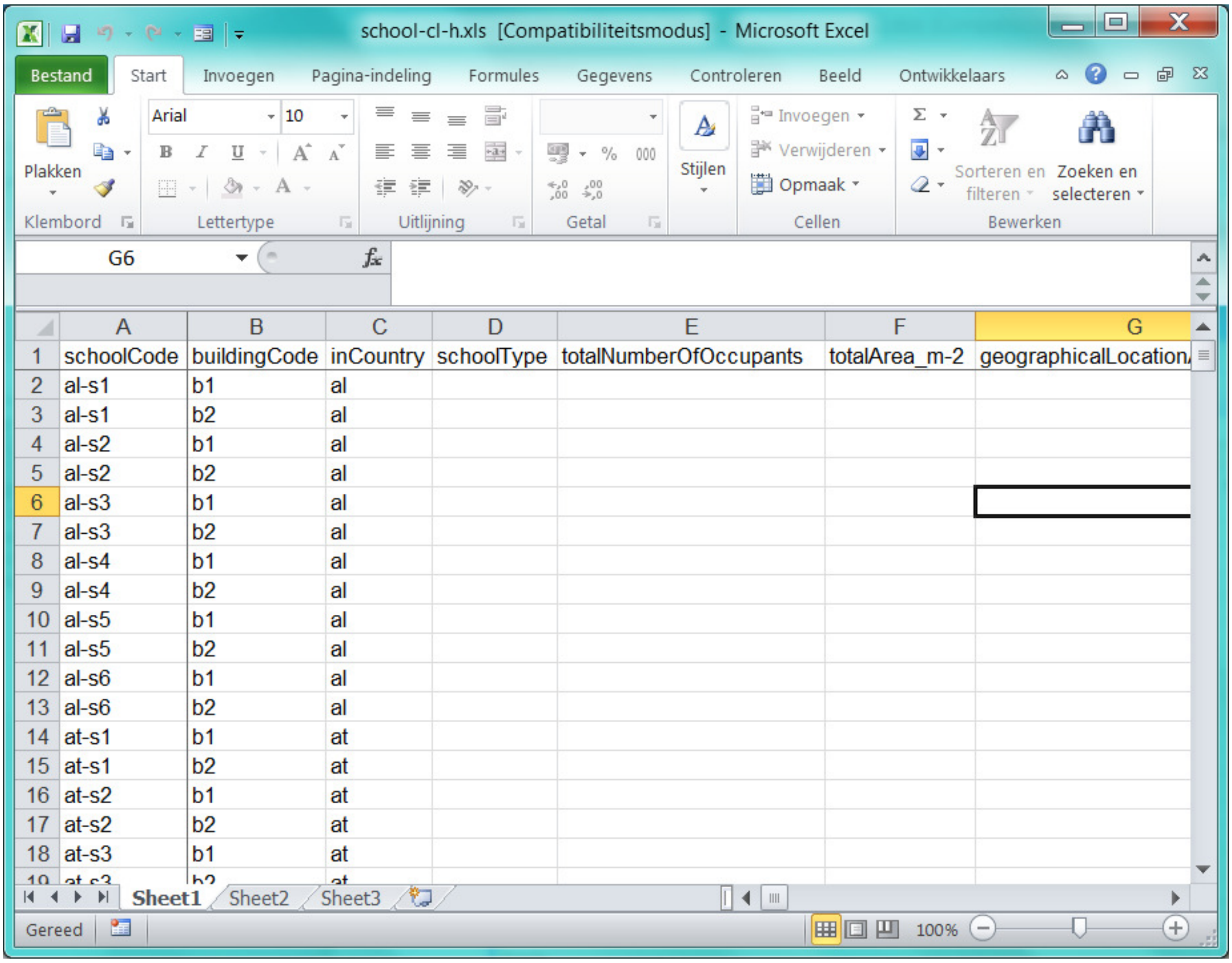
All attributes are in lower case using a dash as name part separator when needed. The units are included in the name after an underscore. These units are kept as clean as possible:

Not: "mic1_cells.mg-1" but: "mic1-cells_mg-1". Algebraic combinations are, for example "L.s-1", thus combined with a full stop (.).

For school and room level there will be two variants of the cl, mpc and mb data: for the heating season (-h) and non-heating season (-nh). The main study is the heating season, but for a subset of schools and for a subset of rooms per such school, additional non-heating season data are gathered. For cl and mpc, the non-heating variant will be a subset of the structure (columns). For mb it will be a subset of the structure plus some additional structure/data (the measurements "_m-3"). That extra structure is also in the variant for the heating season but will not be filled in there. Looking at it from a data (rows) perspective, the data for the non-heating season will always be a subset of the heating season.

For the cl files (for school and room level) there will be some known/accepted duplication (for the static info).

(The detailed WP report is in Annex 5.3)



	A	B	C	D	E	F	G
1	schoolCode	buildingCode	inCountry	schoolType	totalNumberOfOccupants	totalArea_m-2	geographicalLocation
2	al-s1	b1	al				
3	al-s1	b2	al				
4	al-s2	b1	al				
5	al-s2	b2	al				
6	al-s3	b1	al				
7	al-s3	b2	al				
8	al-s4	b1	al				
9	al-s4	b2	al				
10	al-s5	b1	al				
11	al-s5	b2	al				
12	al-s6	b1	al				
13	al-s6	b2	al				
14	at-s1	b1	at				
15	at-s1	b2	at				
16	at-s2	b1	at				
17	at-s2	b2	at				
18	at-s3	b1	at				
19	at-s3	b2	at				

Figure 1 Example Excel sheet content for school-cl-h.xls (row 1 denotes attributes)

For the health test (general/clinical) data, we kept acronyms as attribute names. Explanations can be found in Appendix C.

Once these files are all complemented with relevant details in the form of attributes ("columns") and their underlying validation rules, we will automatically split the school and room files per country and the child and teacher files per country/school-combination. Generated files are collected in country folders, zipped and provided via the SINPHONIE website. The file naming convention hereby is straightforward:

- school-cl-h_xx.xls, where xx stands for the country code; and
- child-q_xx-yy.xls, where xx stands for the country code and yy for the school code

(the same for file types other then "-cl" and "-q").

Specific examples: school-cl-h_be.xls resp. child-q_al-s2.xls.

Attention tests

Typically, one attention test is chosen: ta1 or ta2. These sheets were added late in the process at a time when both were already in use. In the tests themselves, amounts of "good" answers are specified. In the sheets, these results are collected as percentages of questions with good answers.

When data input is completed (per country or per country/school combination), these files can be automatically merged back to the original files (over the countries and/or over the countries/school combinations)

Empty lines (beside predefined codes) are automatically taken out. When merged, validation rules are not kept, just the values. Thus merged files should not be used as a source for changes!

Data validation support

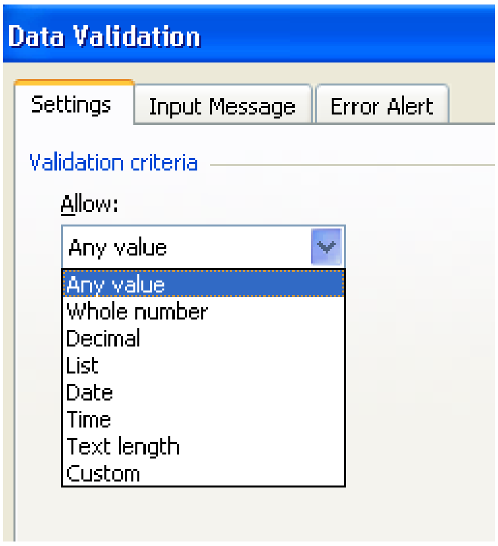


Figure 2 Cell validation types Excel

We apply two available cell validation mechanisms from MS Excel:

- Lists: enumeration data types with allowed textual values, separated by commas in Excel
    - Always including (as last item) "." as valid value
- Custom: examples:
    - Texts: =ISTEXT(D2)
    - Numbers: =OR(D2="."; ISNUMBER(D2))

"Custom" is used for most "non-list" cases. To be able to deal with the "." value for numbers we have to allow it explicitly. Dates are validated as strings. If special tokens are part of such strings, such as '- ' or '/', they must start with a ' ' ' (that is hidden when given).

For the first row of (‘text’-formatted) attributes, we always clear the validation.

For strict validation we always use ‘Errors as’ “error-alert” (and not “warnings” or “information”).

For numbers (‘general’-formatted as all other cells), we use a comma as decimal separator.

For the explicit modelling of “unknown”, “not given” or “unspecified” (i.e.: “explicitly missing value”), we use a full stop (“.”). Only if the whole ‘record’ is not relevant (i.e. there is no child number 28 or higher in a classroom) can the cells stay empty (besides the predefined codes).

Cell protection

For all sheets, all predefined cells (code columns and first attribute row) are locked and protected. All other cells can be selected by the user. First, all cells are unlocked (note that by default all cells are locked, which has no effect until the sheet is explicitly protected). Next, the predefined code columns/first row are selected and locked. Finally, the sheet is protected with “Allow all users of this sheet to: ‘Select unlocked cells’ only”. This protection is achieved without a password merely to prevent accidental changes. In this way we prevent the deletion/changing of predefined fixed data.

Cell freezing

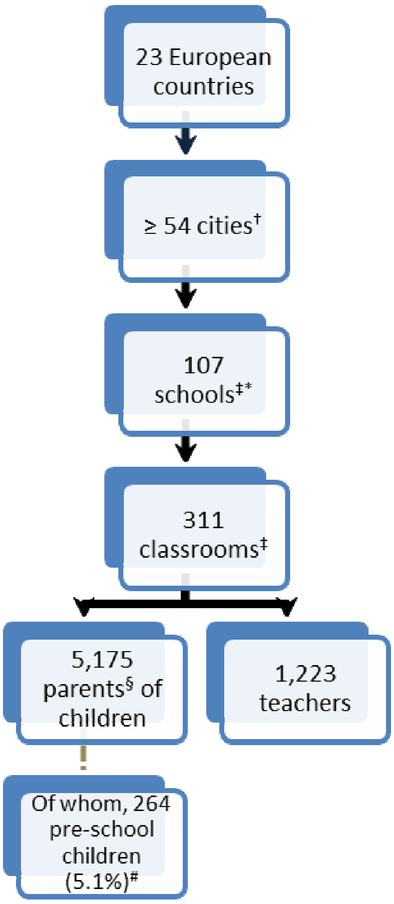
All first rows and columns are frozen via “View/Freeze Panes” for overview during instantiation.

3.5.2 *SINPHONIE results: DATA analysis*

3.5.2.1 Characteristic of the SINPHONIE data

The chart below shows the SINPHONIE data in numbers in terms of country, cities, schools, children and teachers. the plan of analysis According to the plan of analysis, this data base was used for the comprehensive SINPHONIE data analysis.

SINPHONIE Study flowchart



† Many missing data; *: kindergartens in the case of pre-school children

‡ Considering children only from the "parent questionnaire"; otherwise, physico-chemical and biological measurements were also made in some other classrooms from which no children were enrolled in the study

§ Father and/or mother together as a single unit replying to the parent questionnaire

Pre-school children aged between 3 and 5 years, from 10 countries

Remark: children signify both school-age children & pre-school age children (*i.e.*, pre-school children)

In the next figures, the following codes are used for the countries:

AL	**Albania**
AT	Austria
BA	Bosnia-Herzegovina
BE	Belgium
BG	Bulgaria
CY	Cyprus
CZ	Czech Republic
DE	Germany
EE	Estonia
FI	Finland
FR	France
GR	Greece
HU	Hungary
IT	Italy
LT	Lithuania
MT	Malta
PL	Poland
PT	Portugal
RO	Romania
RS	The Republic of Serbia
SE	Sweden
SK	Slovakia
UK	The United Kingdom

Source: ***Annex 5. 1.***

3.5.2.2 The plan of data analysis:

The plan of data analysis, which was discussed in Porto at the TC meeting, is the basis for the analysis of SINPHONIE database. ***(See Annex 5.7)***

The theoretical pathways of the statistical analysis carried out are the followings (Isabella Annesi-Maesano, MCurie Paris):

- Description of classroom/school (kindergarten) characteristics
- Description of environmental "hazards" in classrooms/schools and exposure to such environmental hazards among schoolchildren (pre-school children) /teachers
- Description of socio-demographic, geographic, health (i.e. vulnerability to disease) characteristics of schoolchildren (pre-school children)/teachers
- Description of [health outcomes] in schoolchildren (pre-school children)/teachers
- Relationship between [exposure to environmental hazards] and [health outcomes] in schoolchildren (pre-school children)/teachers
- Risk assessment (with Paolo Carrer)
- Others (see research questions below)

All the above use adapted models (including meta-analysis), adjusting for potential confounders and stratifying by gender, WHO region, season, family history of asthma and allergies.

For the report, ***NIEH*** analysed the descriptive statistics of classroom characteristics and links between classroom characteristics and children's health (Peter Rudnai, NIEH).

The analysis was carried out in order to answer the following research questions:

- How can the school (kindergarten) environment be described in terms of school characteristics and air quality?
- What are the "dangers" in the school (kindergarten) environment in terms of school characteristics and air quality? How many people in the school or kindergarten are exposed to these dangers?
- To what extent is the health of schoolchildren (pre-school children)/teachers impaired during their lifetime, in the past year, and in the past 3 months?
- What are the links between the school environment and the health of schoolchildren (pre-school children)/teachers during their lifetime, in the past year, and in the past 3 months?
- Quantification of risk assessment
- Other questions:

- Are children/teachers with allergies more vulnerable to the effects of air pollutants?

- What are the links between air quality and attention test results, taking ventilation into account.

3.5.2.3 Data analysis: SINPHONIE Results I:

I.. The following tables and graphics show the descriptive results of the SINPHONIE data analysis. The full reports are in the Annex 5, 5. 1 and 5.2.

The number of tables and graphics reflect to the numbering of the report of data analysis, the result reports are ***in the Annex 5.1 and 5.2.*** The SAS program was used for the data analysis.

Table 3: **Socio-demographic and environmental characteristics** of the **children**

(N_{max} = 5,175)

Table 4: **Socio-demographic and environmental characteristics** of the **teachers**

(N_{max} = 1,223)

Table 5: Descriptive statistics for **chemical air pollutants and comfort parameters in children** (excluding pre-school children)

Table 6: Descriptive statistics for **chemical air pollutants and comfort parameters in pre-school children**

Table 7: Descriptive statistics for **chemical air pollutants and comfort parameters in teachers**

Table 8: Descriptive statistics for **bio-contaminants in children** (excluding pre-school children)

Table 9: Descriptive statistics for **bio-contaminants in pre-school children**

Table 10: Descriptive statistics for **bio-contaminants in teachers**

Figure 3a-b: Distribution of **major chemical and biological air pollutants by country**

(formaldehyde, benzene, naphthalene, limonene, NO2, PM2.5, O3, endotoxin, other allergens)

Figure 4: Distribution **comfort parameters, CO2, temperature, RH by country**

Figure 6: Doctor-diagnosed asthma – prevalence, Asthma in schools – prevalence by country

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Table 3: Socio-demographic and environmental characteristics of the **children** (N_{max} = 5,175)

Parameters		Female		Male		Overall	
Characteristics	Categories	**N**	**%**	**N**	**%**	**N**	**%**
Age-group†	Child	2,446	94.7	2,423	95.0	4,890	94.9
	Toddler	136	5.3	128	5.0	264	5.1
Ethnic group	Asian	43	2.0	32	1.5	75	1.7
	Black	38	1.7	38	1.7	76	1.7
	Caucasian	1,764	80.9	1,839	84.2	3,608	82.5
	Middle-Oriental	56	2.6	28	1.3	84	1.9
	Other	280	12.8	247	11.3	529	12.1
Father's occupational status	Disabled	14	0.6	14	0.6	28	0.6
	Fully employed	1,973	84.6	1,996	85.2	3,989	84.9
	Part-time employed	140	6.0	139	5.9	283	6.0
	Pensioner	28	1.2	20	0.9	48	1.0
	Unemployed	178	7.6	173	7.4	353	7.5
Mother's education level	College / university	1,054	41.8	1,096	44.0	2,158	42.9
	Completed primary school	209	8.3	189	7.6	406	8.1
	Less than primary school	48	1.9	52	2.1	102	2.0

	Secondary school	894	35.5	866	34.8	1,768	35.1
	Vocational school	315	12.5	287	11.5	602	12.0
Breast fed	Yes, but also water	953	37.9	975	39.7	1,942	38.8
	Yes, exclusively	1,045	41.6	984	40.0	2,036	40.7
	No	517	20.6	500	20.3	1,022	20.4
	Yes	296	11.6	294	11.6	596	11.7
Dwelling type	Apartment	1,294	51.0	1,232	48.9	2,539	50.0
	Farm	57	2.2	64	2.5	121	2.4
	Other	53	2.1	40	1.6	94	1.8
	Semi-detached house	266	10.5	295	11.7	567	11.2
	Single family house	867	34.2	887	35.2	1,761	34.7
Dwelling¶	New	1,586	72.2	1,536	70.3	3,137	71.3
	Old	610	27.8	650	29.7	1,265	28.7
Dwelling location from traffic	Far away from traffic	493	19.6	543	21.8	1,045	20.7
	Medium traffic	1,372	54.5	1,292	51.8	2,676	53.1
	Plenty of traffic	652	25.9	661	26.5	1,318	26.2
Dwelling near pesticides spraying	No	2,132	85.0	2,133	85.4	4,286	85.2
	Yes	375	15.0	365	14.6	746	14.8

Fireplaces for heating in the dwelling	No	1,955	76.9	1,957	77.8	3,931	77.3
	Yes	586	23.1	559	22.2	1,153	22.7
Air conditioner in the dwelling	No	1,852	72.9	1,823	72.5	3,696	72.7
	Yes	690	27.1	690	27.5	1,386	27.3
Exposed to passive smoking at home	No, never	1,881	73.6	1,856	73.5	3,755	73.5
	Yes, often	372	14.6	372	14.7	746	14.6
	Yes, sometimes	302	11.8	298	11.8	607	11.9
Dwelling decorated <12 months	No	1,619	64.1	1,626	65.2	3,263	64.7
	Yes	906	35.9	866	34.8	1,781	35.3
Carpets in the child's bedroom	No	865	34.3	798	32.1	1,670	33.2
	Yes	1,654	65.7	1,690	67.9	3,363	66.8
Domestic pets	No	1,601	62.7	1,615	64.0	3,233	63.4
	Yes	951	37.3	908	36.0	1,869	36.6
Dampness in dwelling <5 years	No	1,932	76.3	1,914	76.2	3,868	76.3
	Yes	601	23.7	598	23.8	1,204	23.7

[†] Toddler: pre-school age (3-5 years), child: school age (6-14 years)

[‡] Chained question

[¶] New/old: built after/before 1970

Table 4: Socio-demographic and environmental characteristics of the **teachers** (N_{max} = 1,223)

Parameters		Female		Male		Overall	
Characteristics	**Categories**	**N (or mean)**	**% (or SD)**	**N (or mean)**	**% (or SD)**	**N (or mean)**	**% (or SD)**
Age, years (mean, SD)		43.5	10.0	42.7	11.0	43.4	10.1
Dwelling location from traffic	Area far away from busy traffic	124	16.0	22	20.2	148	16.6
	Area with small traffic	401	51.6	61	56.0	465	52.2
	Near busy traffic	252	32.4	26	23.9	278	31.2
Dwelling near pesticides spraying	No	721	89.0	98	87.5	824	88.9
	Yes	89	11.0	14	12.5	103	11.1
Fireplaces for heating in the dwelling	No	642	79.5	86	76.8	731	79.0
	Yes	166	20.5	26	23.2	194	21.0
Air conditioner in the dwelling	No	625	76.5	87	77.7	716	76.7
	Yes	192	23.5	25	22.3	218	23.3
Mechanical ventilation in the dwelling	No	623	78.9	72	64.9	699	77.2

	Yes	167	21.1	39	35.1	207	22.8
Humidifier in the dwelling	No	701	88.5	99	88.4	805	88.6
	Yes	91	11.5	13	11.6	104	11.4
Type of cooker in the dwelling	Coal / wood fire oven	13	1.6	4	3.6	17	1.8
	Gas cooker	457	56.9	49	44.1	510	55.5
	Only electric	333	41.5	58	52.3	392	42.7
Exposed to tobacco at home	No, never	578	70.9	76	67.9	659	70.7
	Yes, daily	124	15.2	20	17.9	144	15.5
	Yes, often	23	2.8	3	2.7	26	2.8
	Yes, sometimes	90	11.0	13	11.6	103	11.1
Type of heating system in the dwelling	Electric	115	14.6	19	17.3	135	14.9
	Floor heating	24	3.0	0	0.0	24	2.7
	Gas heater / gas stove	78	9.9	12	10.9	92	10.2
	Radiators	525	66.5	65	59.1	592	65.4
	Tiled clay / iron stove	43	5.4	13	11.8	56	6.2

	Wall heating	5	0.6	1	0.9	6	0.7
Domestic pets	No	579	71.5	89	80.9	673	72.8
	Yes	231	28.5	21	19.1	252	27.2

† Chained question

Table 5: Descriptive statistics for **chemical air pollutants and comfort parameters in children** (excluding pre-school children)

Air Pollutant	Total no. of kindergartens	Mean	Median	SD	Min	Max	CV%
Formaldehyde[1]	300	15.1	12.0	10.1	1.3	66.2	67.1
Benzene[1]	300	4.1	2.0	5.7	0.0	38.0	140.9
Naphthalene[1]	240	2.2	0.0	4.8	0.0	30.8	223.2
Limonene[1]	300	38.1	9.3	80.5	0.0	671.6	211.1
NO_2[1]	300	13.6	11.3	9.9	0.1	87.8	72.9
$PM_{2.5}$[1]	285	44.2	37.0	34.6	3.6	250.1	78.2
Ozone[1]	279	8.2	3.2	16.6	0.0	141.7	202.0
CO[2]	297	0.9	0.2	7.1	0.0	121.8	814.7
T3CE[1]	284	3.4	0.0	14.4	0.0	126.2	419.1
T4CE[1]	284	1.2	0.0	5.4	0.0	81.2	435.9
Radon[3]	236	205.2	100.9	670.8	0.0	9186.0	326.8
Relative humidity[4]	298	43.1	41.6	13.7	6.0	98.3	31.7
Temperature[5]	298	20.2	21.0	3.9	-7.7	30.0	19.4
Ventilation rate[6]	289	0.7	0.4	0.7	-0.2	4.3	112.2
CO_2[2]	296	1433.3	1257.2	817.2	269.4	4957.0	57.0

SD: Standard Deviation; CV: Coefficient of Variation; T3CE: Trichloroethylene; T4CE: Tetrachloroethylene

[1] $\mu g/m^3$

[2] ppm (parts per million)

[3] Bq/m^3

[4] %

[5] °C

[6] /hr

Table 6: Descriptive statistics for chemical air pollutants and comfort parameters in pre-school children

Air Pollutant	Total no. of kindergartens	Mean	Median	SD	Min	Max	CV%
Formaldehyde[1]	25	15.2	12.7	9.6	6.3	38.4	63.4
Benzene[1]	25	4.0	2.8	4.2	0.6	20.7	106.0
Naphthalene[1]	23	2.8	0.0	4.8	0.0	14.7	168.1
Limonene[1]	25	43.8	20.7	79.7	0.1	330.1	182.0
NO_2[1]	25	16.1	13.4	8.1	5.1	31.5	50.4
$PM_{2.5}$[1]	23	55.6	45.5	37.5	14.4	162.9	67.4
Ozone[1]	23	5.9	6.0	4.2	0.0	16.2	71.1
CO[2]	25	0.4	0.2	0.5	0.0	2.1	132.6
T3CE[1]	23	2.5	0.0	5.7	0.0	20.5	222.5
T4CE[1]	23	1.0	0.0	2.2	0.0	6.4	219.7
Radon[3]	20	579.1	68.3	2184.0	32.0	9854.0	377.2
Relative humidity[4]	25	44.6	43.1	12.5	22.7	80.4	28.1
Temperature[5]	25	20.9	21.1	2.1	14.2	23.8	10.0
Ventilation rate[6]	22	0.8	0.4	0.9	0.0	3.5	112.5
CO_2[2]	25	1308.7	1065.0	823.0	394.0	3531.0	62.9

SD: Standard Deviation; CV: Coefficient of Variation; T3CE: Trichloroethylene; T4CE: Tetrachloroethylene

[1] $\mu g/m^3$

[2] ppm (parts per million)

[3] Bq/m^3

[4] %

[5] °C

[6] /hr

Table 7: Descriptive statistics for **chemical air pollutants and comfort parameters in teachers**

Air Pollutant	Total no. of schools	Mean	Median	SD	Min	Max	CV%
Formaldehyde[1]	106	15.2	12.7	9.3	4.1	46.4	61.3
Benzene[1]	106	4.0	2.3	4.9	0.0	23.9	124.1
Naphthalene[1]	85	2.2	0.0	4.5	0.0	27.0	207.7
Limonene[1]	106	38.2	11.3	71.3	0.4	511.3	186.5
NO_2[1]	106	13.9	11.8	9.3	0.6	60.1	66.8
$PM_{2.5}$[1]	104	43.4	36.8	31.5	3.9	185.4	72.7
Ozone[1]	99	8.1	3.6	15.7	0.0	133.3	193.8
CO[2]	106	0.8	0.4	4.0	0.0	41.8	481.8
T3CE[1]	100	3.4	0.0	11.6	0.0	85.2	344.9
T4CE[1]	100	1.2	0.0	3.8	0.0	30.8	311.2
Radon[3]	89	231.4	99.1	808.2	0.0	7608.3	349.3
Relative humidity[4]	106	43.1	40.8	12.2	6.5	72.7	28.3
Temperature[5]	106	20.3	21.1	3.2	7.7	25.3	15.7
Ventilation rate[6]	105	0.7	0.4	0.7	-0.2	3.0	106.0
CO_2[2]	106	1414.2	1310.8	762.6	364.1	4128.3	53.9

SD: Standard Deviation; CV: Coefficient of Variation; T3CE: Trichloroethylene; T4CE: Tetrachloroethylene

Remark: pollutants' concentrations were assessed using school means

[1] $\mu g/m^3$

[2] ppm (parts per million)

[3] Bq/m^3

[4] %

[5] °C

[6] /hr

Table 8: Descriptive statistics for **bio-contaminants in children** (excluding pre-school children)

Bio-contaminants	Total no. of classrooms	Mean	Median	SD	Min	Max	CV%
Endotoxin[1]	281	10080.1	7114.0	9635.9	496.0	59000.0	95.6
PenAsp cells[2]	278	726149.3	63154.5	2774222.4	1143.0	24739120.0	382.0
Avers cells[2]	278	378.0	0.0	3526.1	0.0	55671.0	932.8
Tviri cells[2]	278	301.2	10.0	4339.1	0.0	72308.0	1440.6
Cherb cells[2]	278	923.5	268.5	4305.2	0.0	69322.0	466.2
Aaltr cells[2]	278	39.2	8.0	268.1	0.0	4406.0	684.0
Strep cells[2]	278	42252.7	16914.0	100577.7	0.0	1268072.0	238.0
Myco cells[2]	278	147504.4	51191.0	442424.2	0.0	6401677.0	299.9
Cat allergen[3]	292	86.5	0.0	211.1	0.0	1762.0	244.1
Dog allergen[3]	291	103.5	0.0	222.8	0.0	1745.0	215.2
Horse allergen[3]	98	80.3	0.0	400.1	0.0	2630.0	498.5
Derp1 allergen[3]	99	4.9	0.0	36.9	0.0	337.0	751.5
Derf1 allergen[3]	99	2.8	0.0	20.1	0.0	167.0	713.7

SD: Standard Deviation; CV: Coefficient of Variation

[1] units/m^2

[2] units/mg dust (qPCR)

[3] units/g dust

Table 9: Descriptive statistics for **bio-contaminants in pre-school children**

Bio-contaminants	Total no. of kindergartens	Mean	Median	SD	Min	Max	CV%
Endotoxin[1]	25	7358.0	7956.0	3158.0	2565.0	12768.0	42.9
PenAsp cells[2]	25	88074.0	34830.0	148737.4	2621.0	622039.0	168.9
Avers cells[2]	25	21.2	0.0	66.2	0.0	320.0	312.0
Tviri cells[2]	25	29.4	2.0	78.3	0.0	296.0	266.4
Cherb cells[2]	25	171.0	37.0	237.0	5.0	807.0	138.6
Aaltr cells[2]	25	6.7	0.0	10.9	0.0	40.0	163.3
Strep cells[2]	25	23856.3	6859.0	48573.6	1556.0	227616.0	203.6
Myco cells[2]	25	81163.6	32155.0	139865.6	4735.0	580782.0	172.3
Cat allergen[3]	25	90.6	0.0	261.6	0.0	1285.0	288.8
Dog allergen[3]	25	70.0	0.0	130.1	0.0	468.0	185.7
Horse allergen[3]	7						.
Derp1 allergen[3]	6						.
Derf1 allergen[3]	6						.

SD: Standard Deviation; CV: Coefficient of Variation

[1] units/m^2

[2] units/mg dust (qPCR)

[3] units/g dust

Table 10: Descriptive statistics for **bio-contaminants in teachers**

Bio-contaminants	Total no. of schools	Mean	Median	SD	Min	Max	CV%
Endotoxin[1]	106	10160.9	7660.0	8100.2	576.0	39565.0	79.7
PenAsp cells[2]	102	672290.7	75055.0	2273164.5	4173.0	14830440.0	338.1
Avers cells[2]	102	345.0	2.5	2028.7	0.0	18567.0	588.0
Tviri cells[2]	102	276.6	12.0	2396.4	0.0	24213.0	866.2
Cherb cells[2]	102	871.0	317.0	2766.9	4.0	27209.0	317.7
Aaltr cells[2]	102	36.7	8.0	149.4	0.0	1480.0	406.6
Strep cells[2]	102	40250.9	19486.5	66342.9	1927.0	466939.0	164.8
Myco cells[2]	102	148561.6	70108.5	289466.3	2088.0	2417766.0	194.8
Cat allergen[3]	104	85.3	35.5	140.2	0.0	683.0	164.3
Dog allergen[3]	104	100.3	9.0	162.1	0.0	790.0	161.6
Horse allergen[3]	102	77.1	0.0	392.4	0.0	2630.0	508.9
Derp1 allergen[3]	102	4.8	0.0	36.4	0.0	337.0	762.9
Derf1 allergen[3]	102	2.7	0.0	19.8	0.0	167.0	724.5

SD: Standard Deviation; CV: Coefficient of Variation

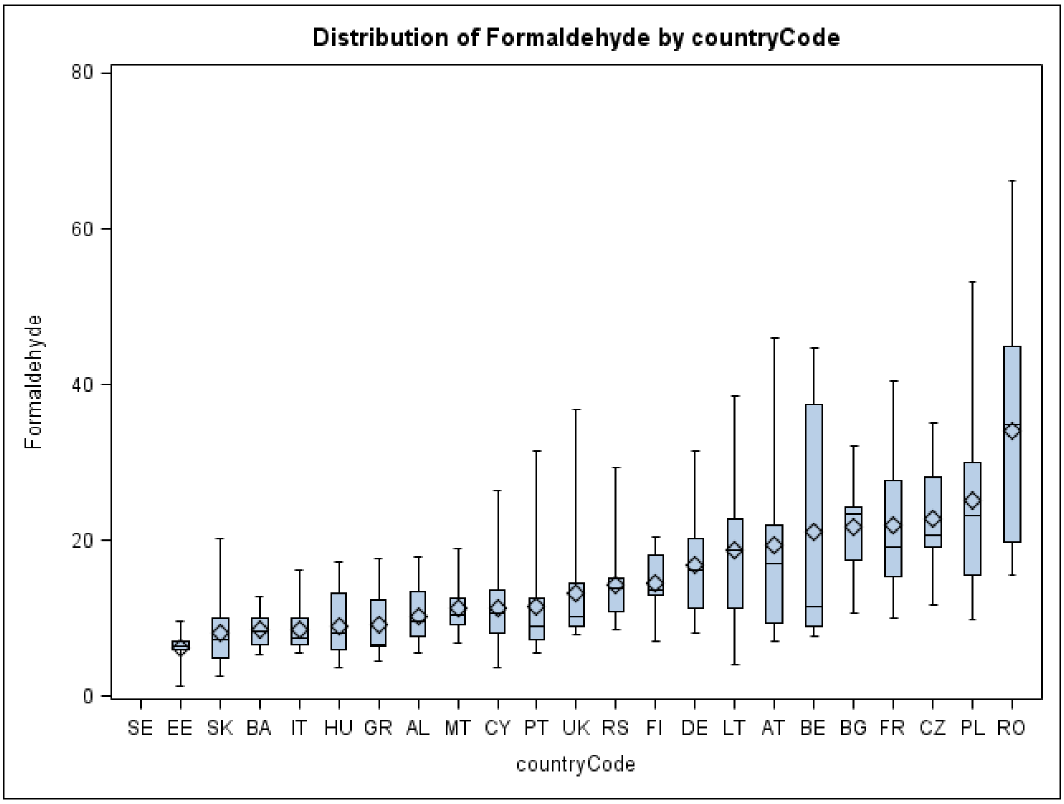
Remark: biocontaminants' concentrations were assessed using school means

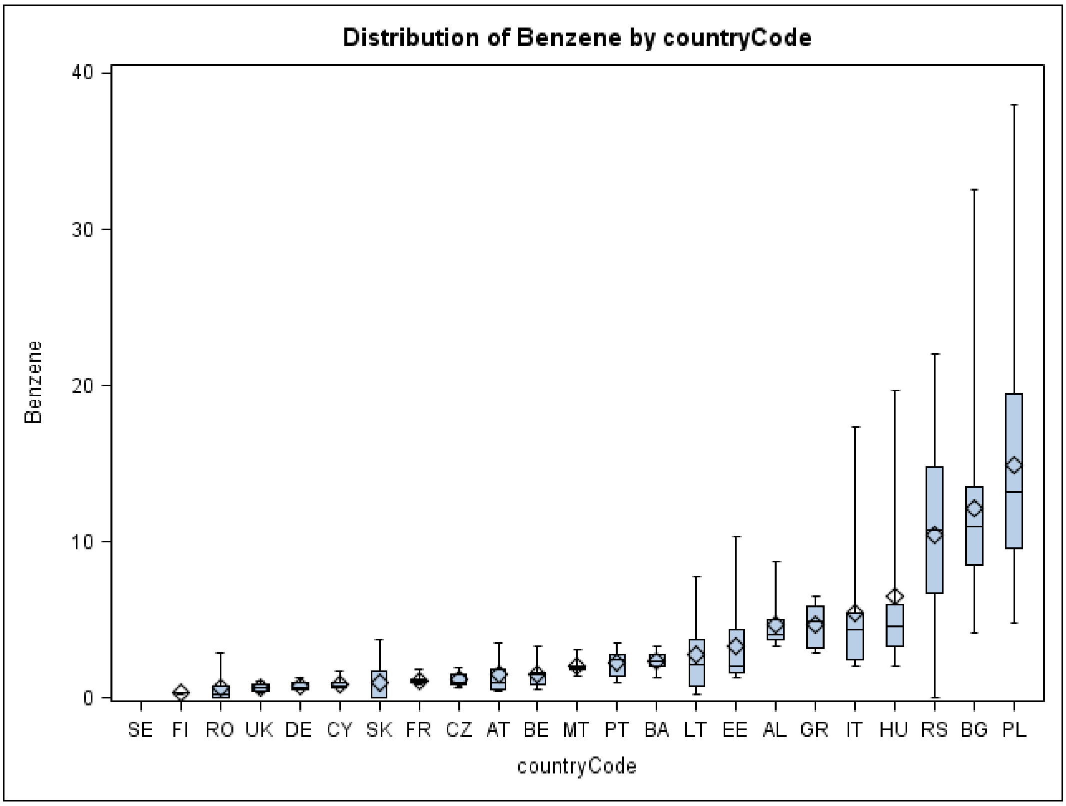
[1] units/m^2

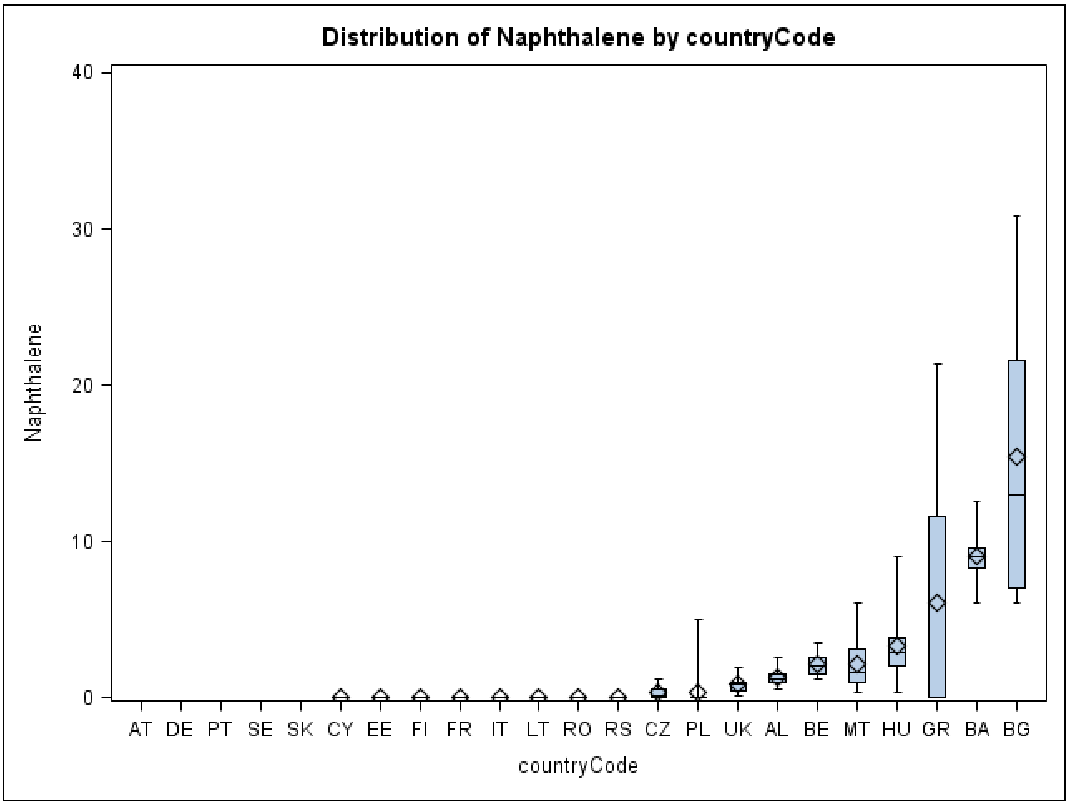
[2] units/mg dust (qPCR)

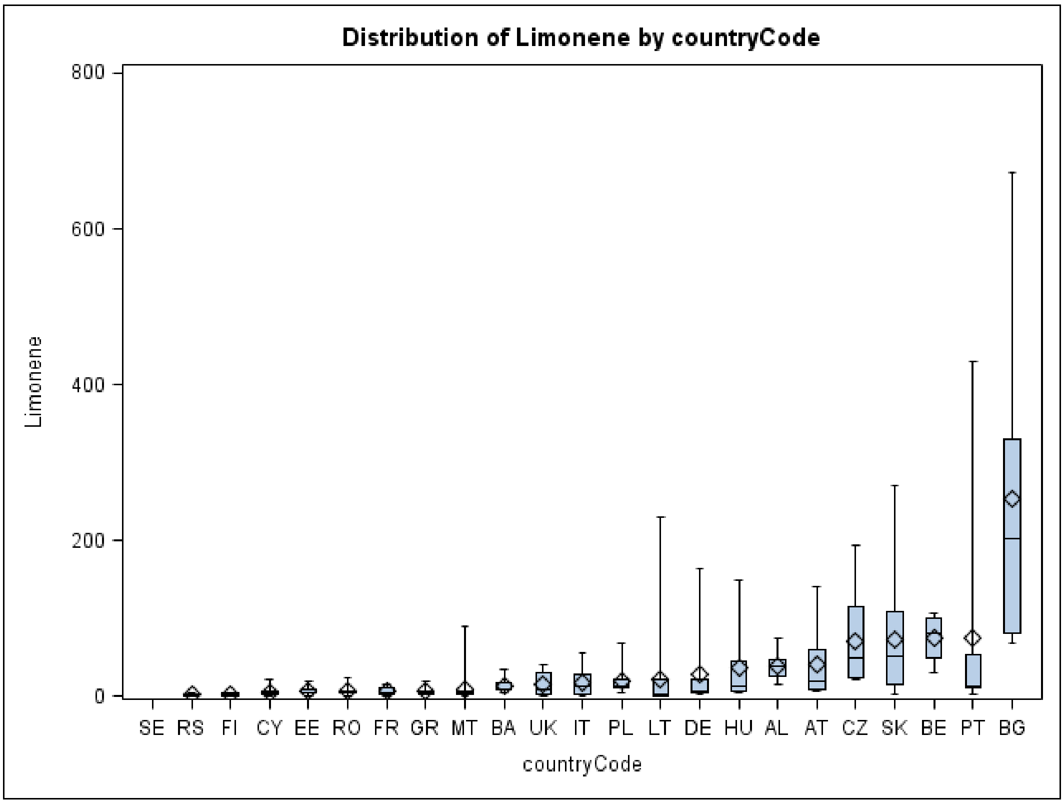
[3] units/g dust

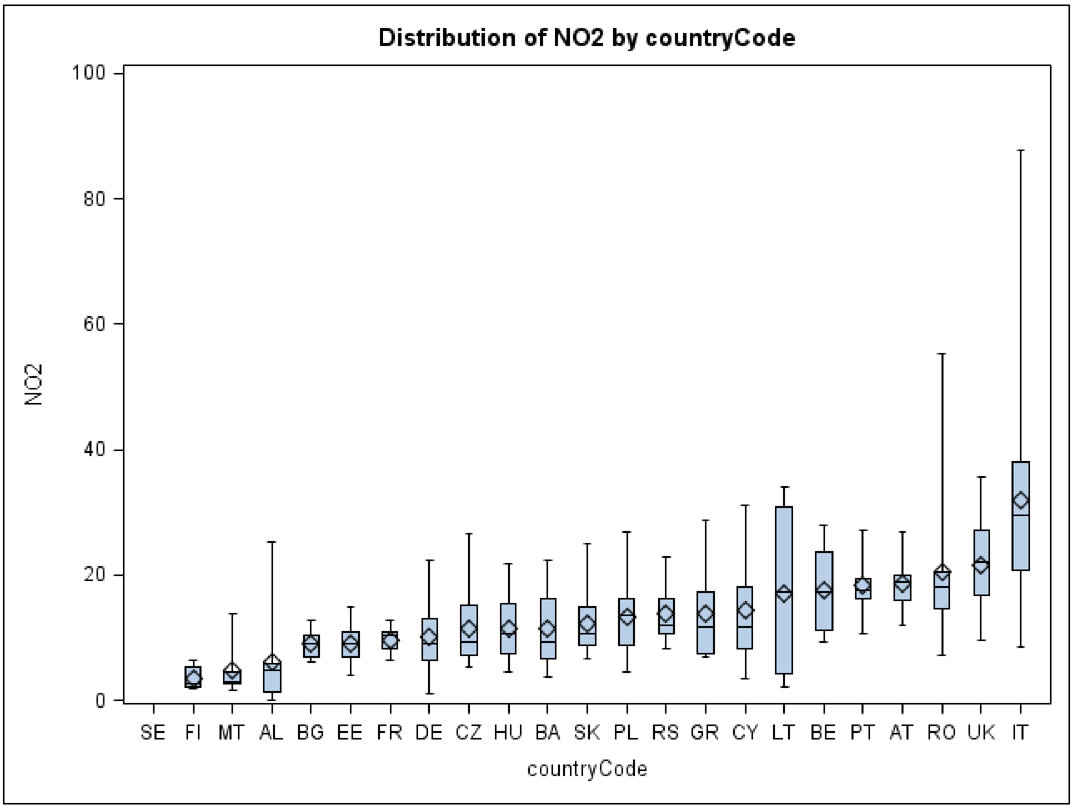
Figure 3a: Distribution of major chemical air pollutants by country



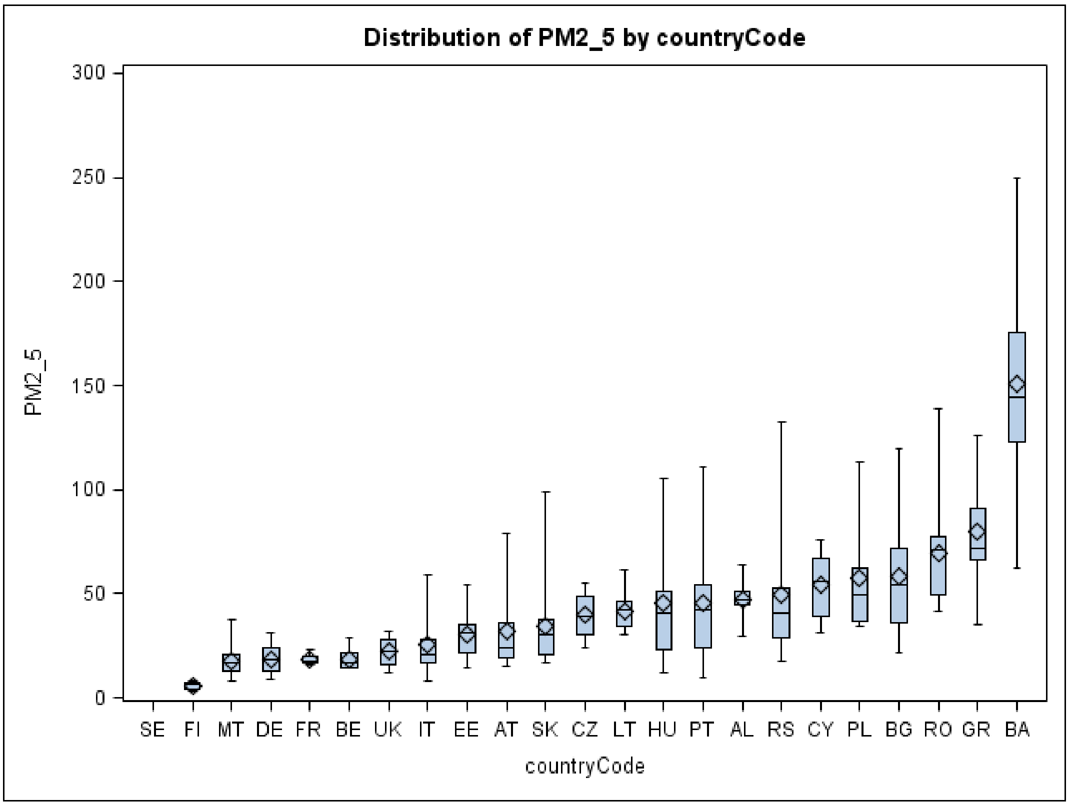



Distribution of Naphthalene by countryCode
Naphthalene
0
10
20
30
40
AT DE PT SE SK CY EE FI FR IT LT RO RS CZ PL UK AL BE MT HU GR BA BG
countryCode

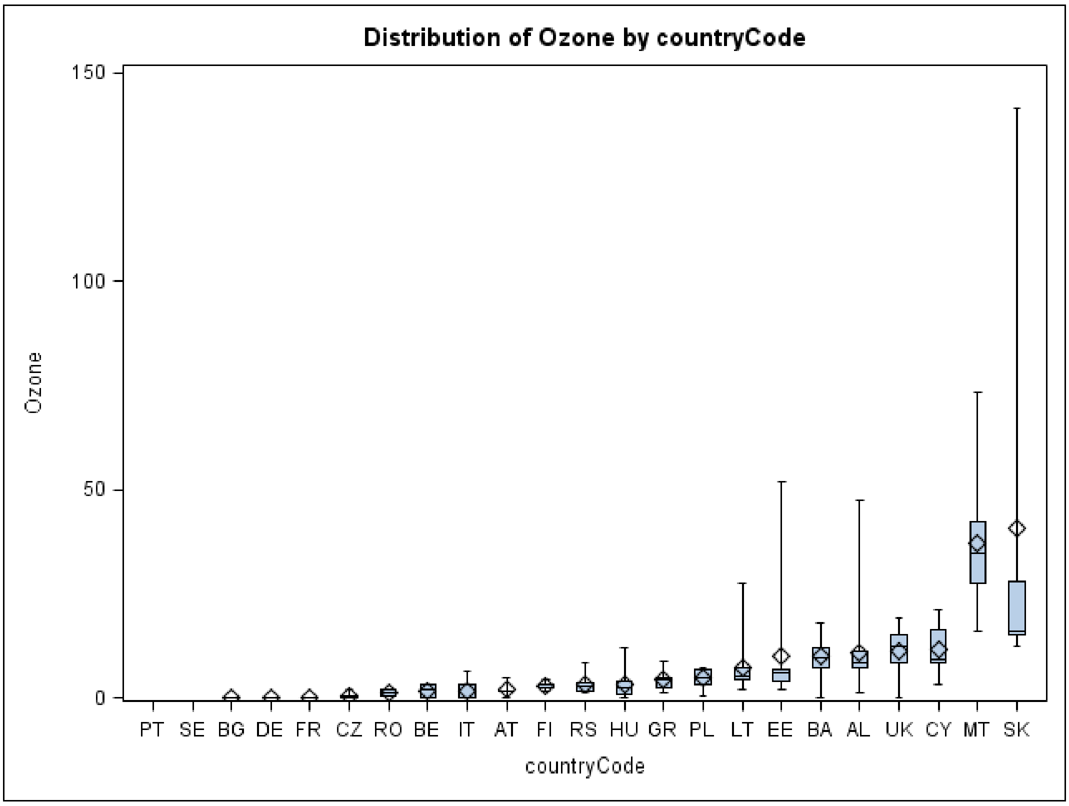

Distribution of Limonene by countryCode
Limonene
0
200
400
600
800
SE RS FI CY EE RO FR GR MT BA UK IT PL LT DE HU AL AT CZ SK BE PT BG
countryCode



Distribution of NO2 by countryCode
100
80
60
40
20
0
NO2
SE FI MT AL BG EE FR DE CZ HU BA SK PL RS GR CY LT BE PT AT RO UK IT
countryCode



Distribution of PM2_5 by countryCode
300
250
200
150
100
50
0
PM2_5
SE FI MT DE FR BE UK IT EE AT SK CZ LT HU PT AL RS CY PL BG RO GR BA
countryCode

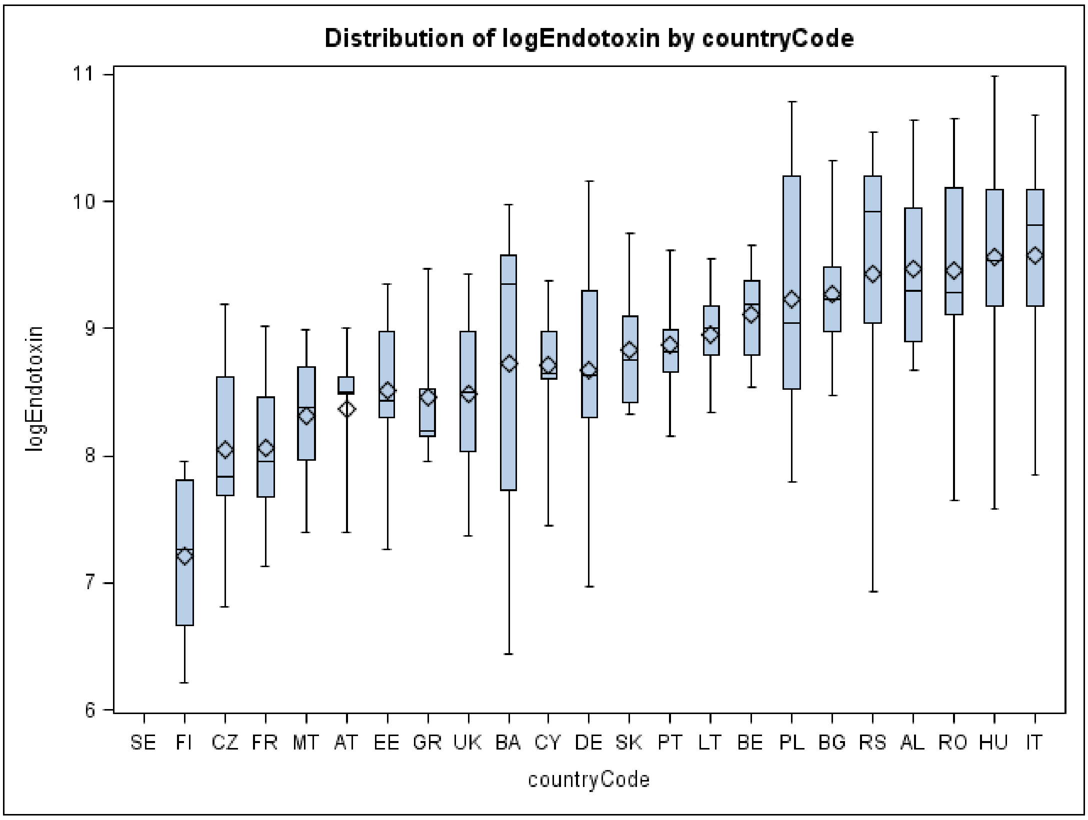


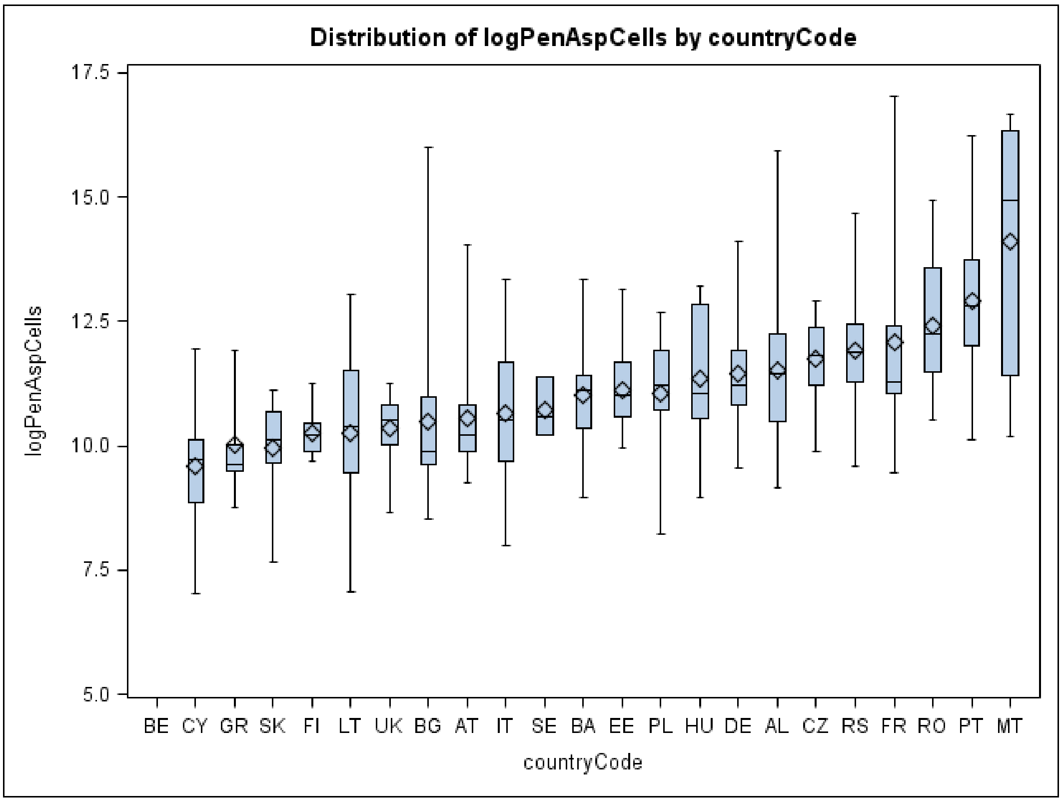
Concentrations in µg/m^3.

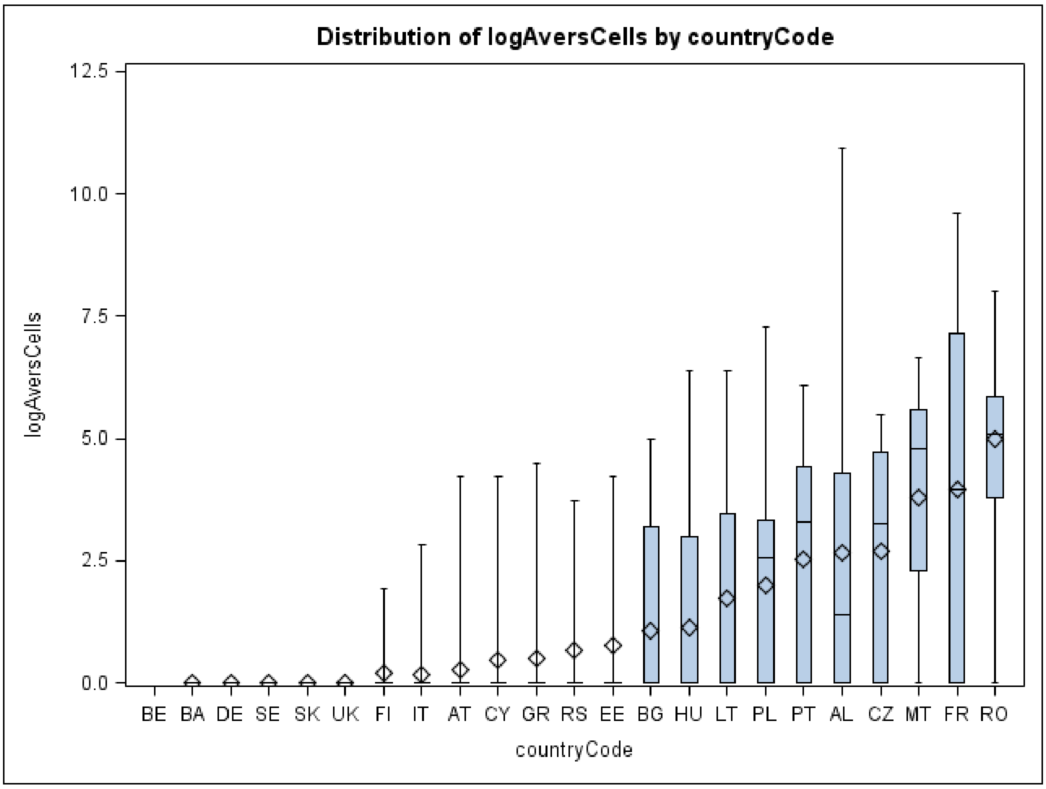
The boxplots are sorted by ascending order by their country specific mean values.

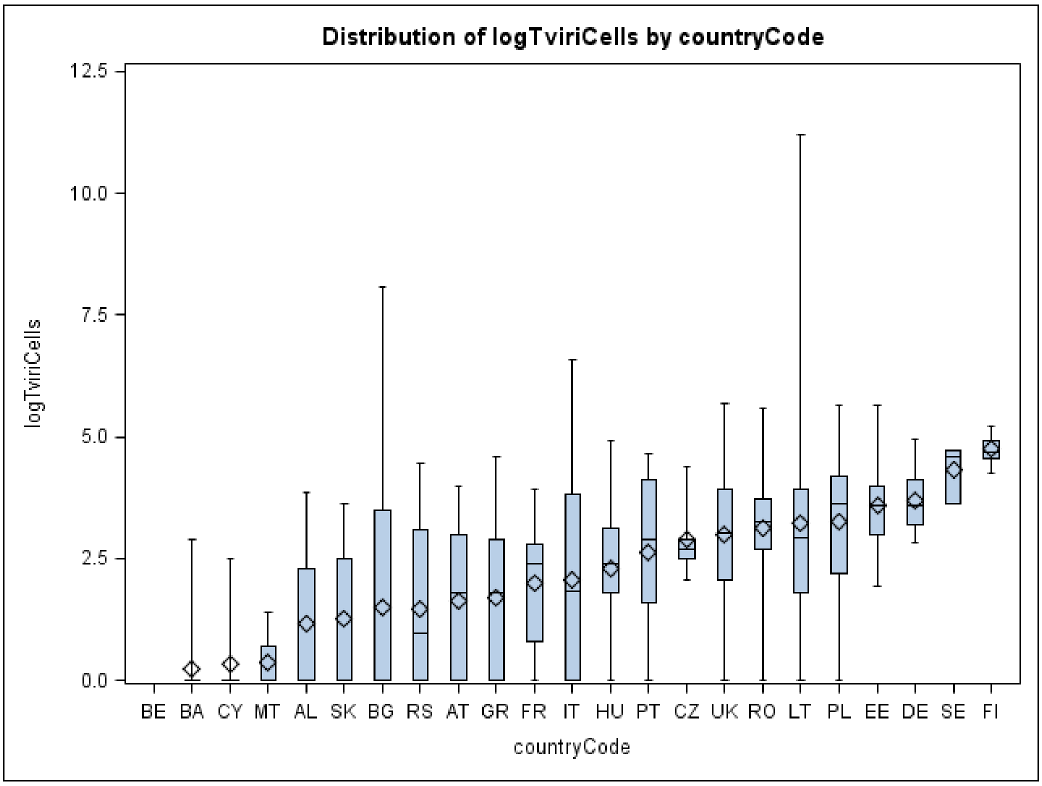
The lozenge shapes in the boxplots are the means, and horizontal bars are the medians of the distribution

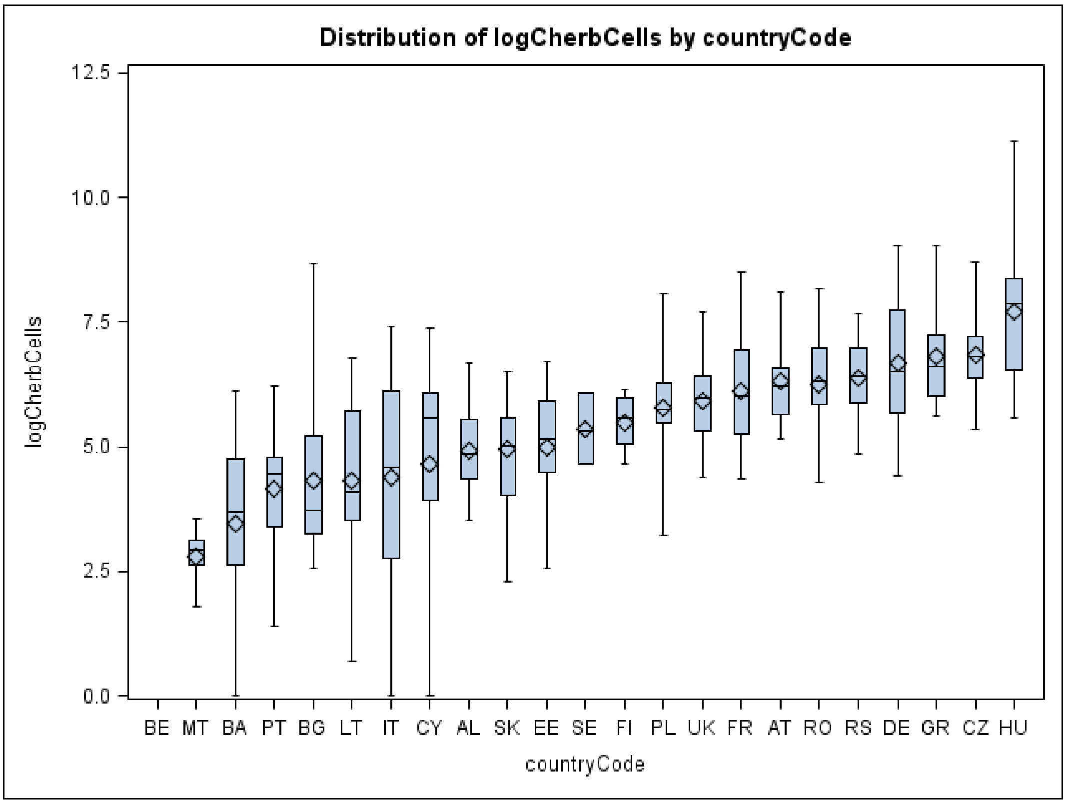
Figure 3b: Boxplots of log-biocontaminants (endotoxin (units / m^2); PenAsp cells, Avers cells, Tviri cells, Cherb cells, Aaltr cells, Strep cells, Myco cells (units / mg dust); cat allergen, dog allergen (units / g dust)) for the participating countries

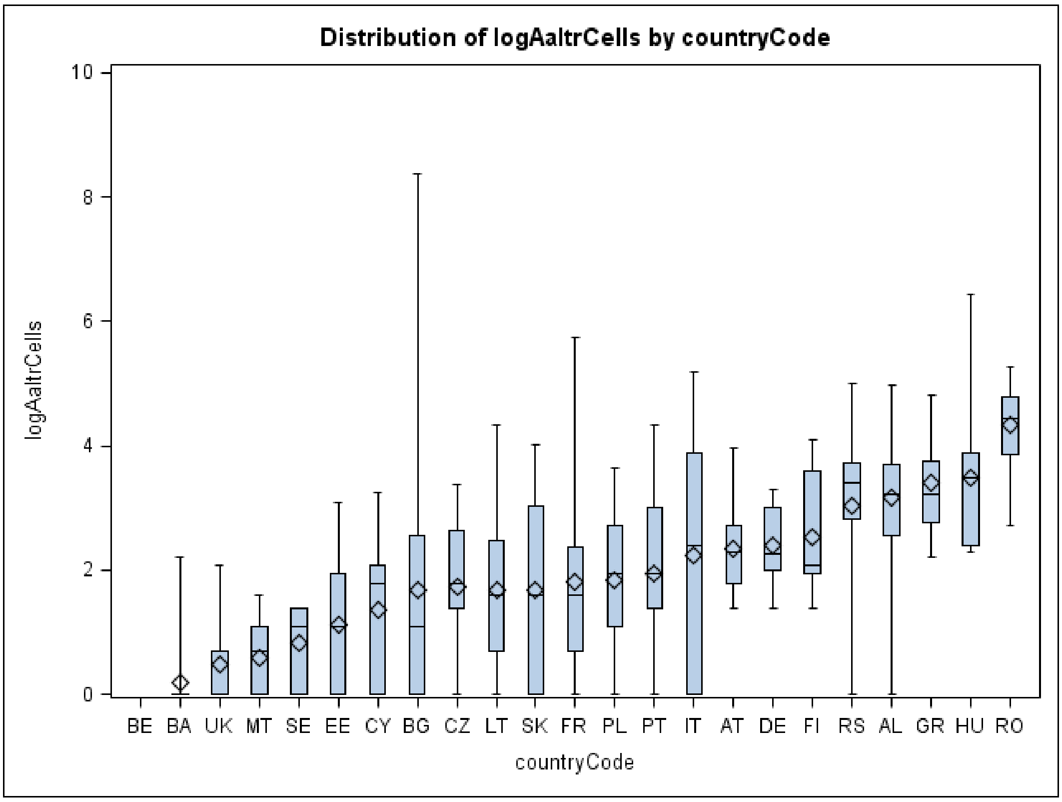


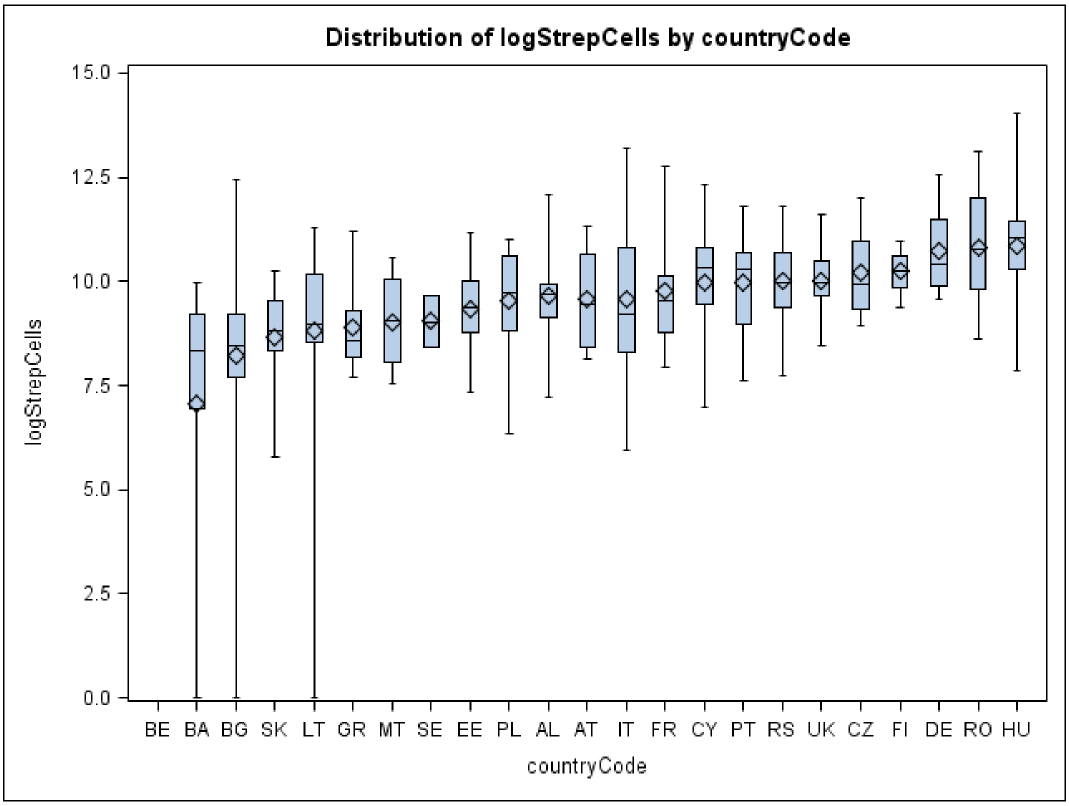


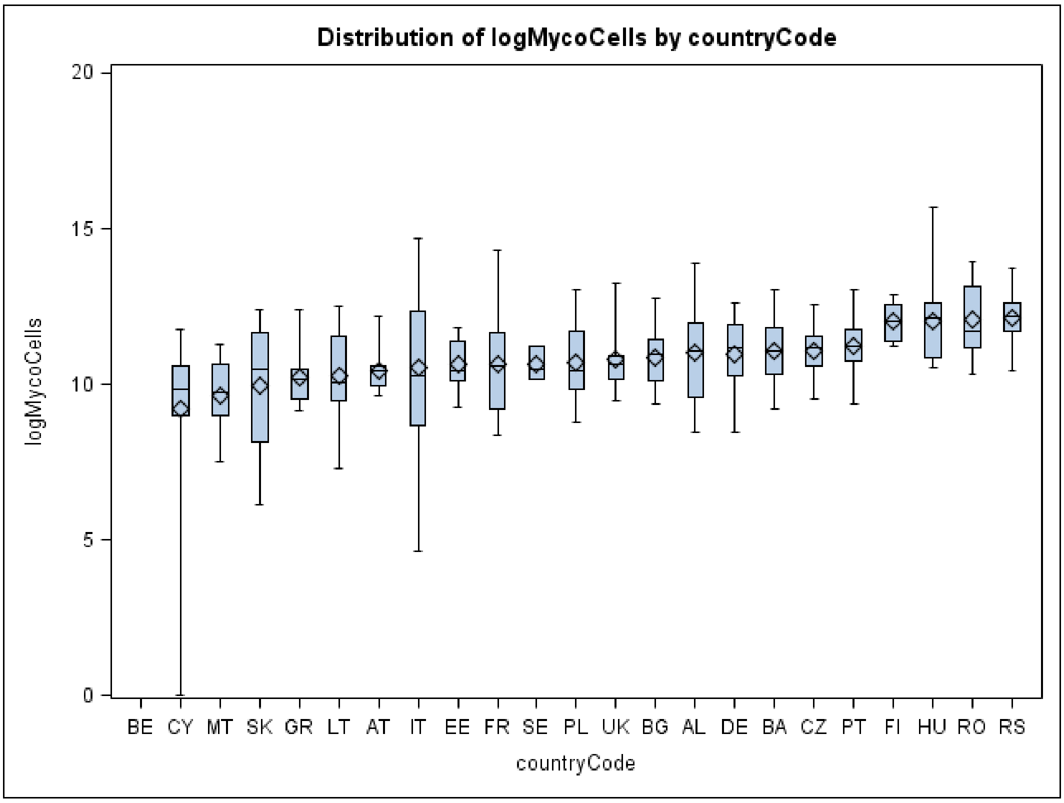

Distribution of logAversCells by countryCode
logAversCells
countryCode
12.5
10.0
7.5
5.0
2.5
0.0
BE BA DE SE SK UK FI IT AT CY GR RS EE BG HU LT PL PT AL CZ MT FR RO

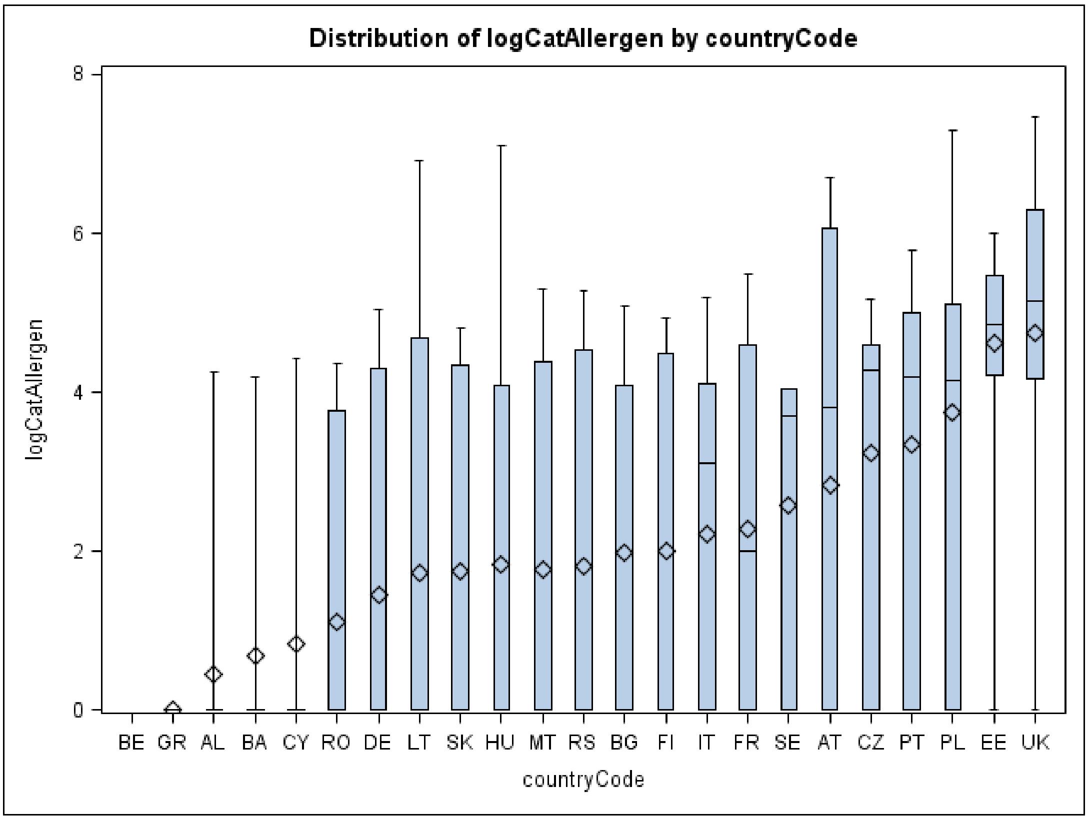

Distribution of logTviriCells by countryCode
logTviriCells
countryCode
12.5
10.0
7.5
5.0
2.5
0.0
BE BA CY MT AL SK BG RS AT GR FR IT HU PT CZ UK RO LT PL EE DE SE FI

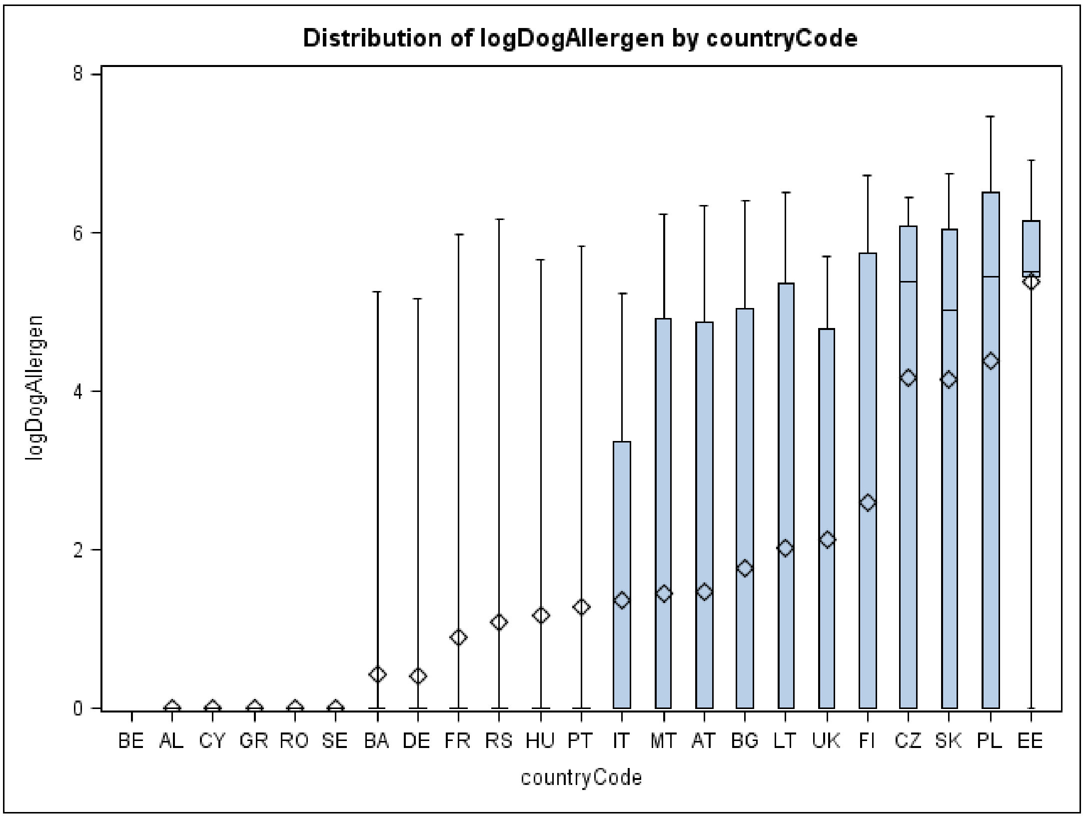

Distribution of logCherbCells by countryCode
logCherbCells
0.0
2.5
5.0
7.5
10.0
12.5
BE MT BA PT BG LT IT CY AL SK EE SE FI PL UK FR AT RO RS DE GR CZ HU
countryCode


Distribution of logAaltrCells by countryCode
logAaltrCells
0
2
4
6
8
10
BE BA UK MT SE EE CY BG CZ LT SK FR PL PT IT AT DE FI RS AL GR HU RO
countryCode


Distribution of logStrepCells by countryCode
logStrepCells
15.0
12.5
10.0
7.5
5.0
2.5
0.0
BE BA BG SK LT GR MT SE EE PL AL AT IT FR CY PT RS UK CZ FI DE RO HU
countryCode

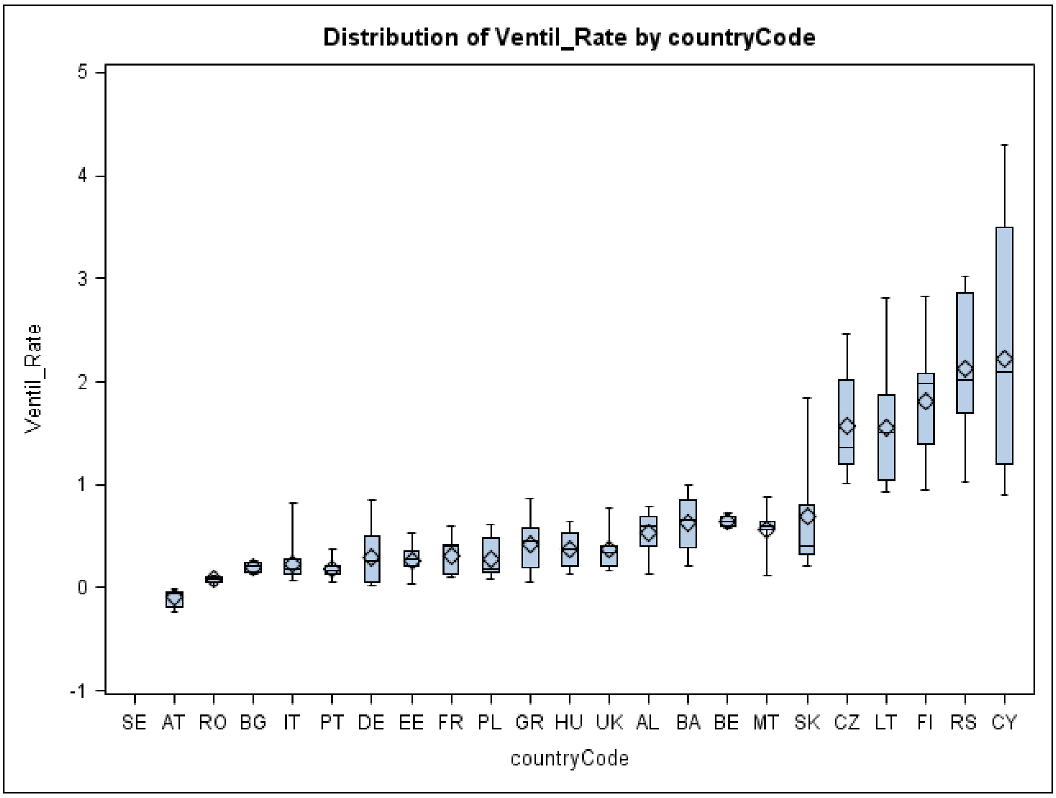

Distribution of logMycoCells by countryCode
logMycoCells
20
15
10
5
0
BE CY MT SK GR LT AT IT EE FR SE PL UK BG AL DE BA CZ PT FI HU RO RS
countryCode





Note: the boxplots are sorted by ascending order by their country specific mean values

Figure 4: Distribution of comfort parameters by countries (% for relative humidity, ppm for CO_2, /hr for ventilation and °C for temperature)



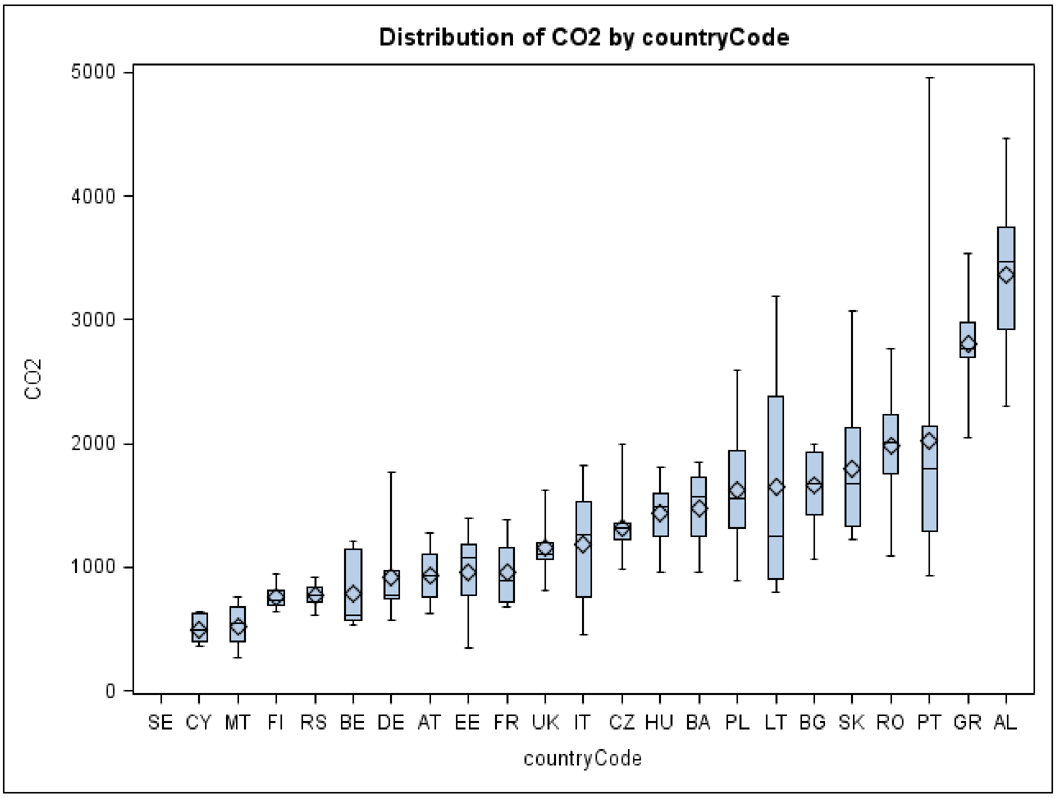
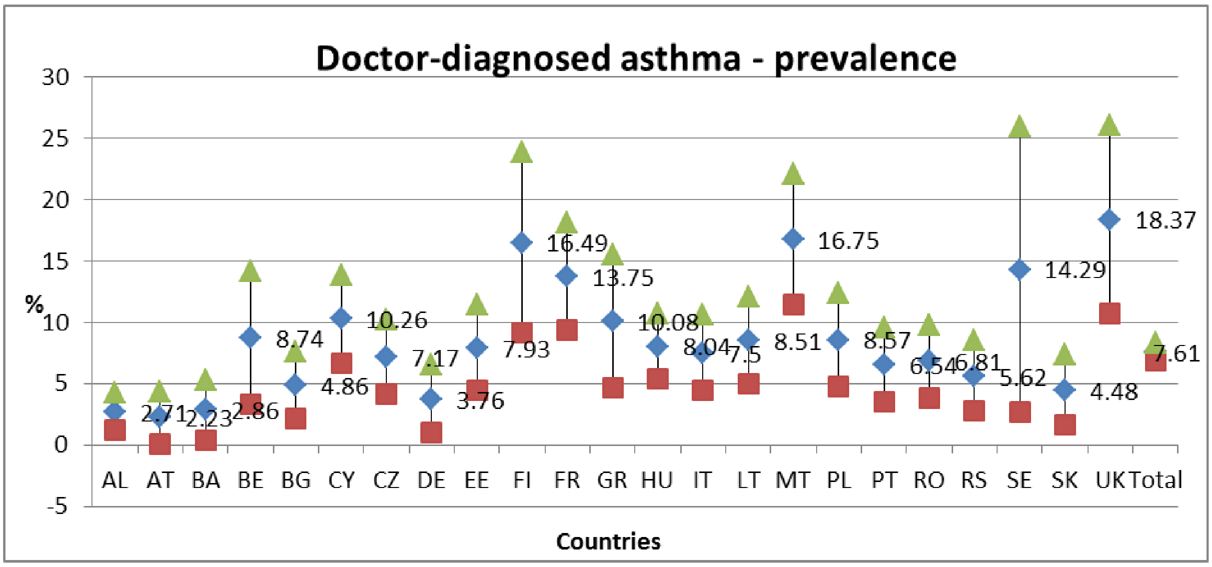
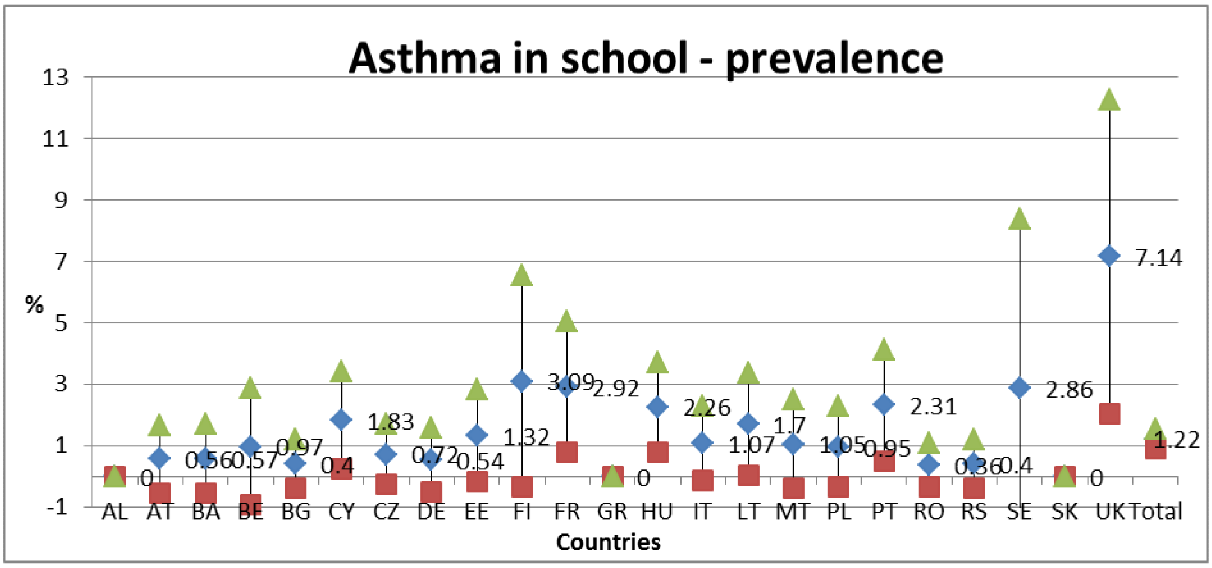


Figure 6: Country-wise prevalence rates (%) ± 95% CIs of ISAAC symptoms in children as reported by their parents for the participating countries, and a pooled estimate using meta-analytic techniques (inverse variance-weighted method) at the right end of each figure





What is the impact of air quality in European schools and kindergartens on the health of children, pre-school children and teachers?

3.5.2.4 The results of the SINPHONIE data analysis:

RES 1: In the random sample, air quality in classrooms was poor, varying significantly among the schools and cities in the 23 European countries that participated in the SINPHONIE survey.

RES 2: According to existing guidelines a big proportion of schoolchildren, pre-school children and teachers were highly exposed to air pollutants and bio-contaminants.

RES 3: Exposure to elevated concentrations of particulate matter and gases as well as bio-contaminants which were found in classrooms and kindergartens was significantly related to symptoms and diseases currently observed in schoolchildren, pre-school children and teachers.

RES 4: More than 2% of children were reported suffering from asthma at school.

RES 5: Further investigations are needed to better assess the health burdens to people present in schools due to exposure to the air of the school environment.

RES 6: Existing standards for monitoring and evaluating the health burden associated to exposure indoor/outdoor air pollutants and bio-contaminants in the school environment are currently inadequate.

RES 7: Further investigations are needed to better assess the burdens associated with the school environment in individuals present in schools.

REC 8: Standards for air pollutants and bio-contaminants are currently inadequate.

THE KEY FINDINGS:

The results of the SINPHONIE project are greatly relevant to public health. Significant number of schoolchildren is exposed to health threats due to inadequate indoor/outdoor air quality in European schools, with childhood asthma and allergies being among the most widespread health effects.

(More details are in ***Annex 5.1 and 5.2*****)**

3.5.2.5 Data analysis: SINPHONIE results II:

The STATA program was used for the analysis of the SINPHONIE data for SINPHONIE results II. The modification of the data base is explained in the Annex 5.1.

A. Association between classroom characteristic and children's health

Floor level of the classroom

- Children in classrooms on the 0 level had the **most health problems**. ($p < 0.05$) The higher floor the classroom was situated the fewer children's parents thought that their children suffered from some serious health problems.

- Prevalence of children with **sneezing at school during the last 7 days** significantly ($p<0.001$) increased with increasing number of floors on which the classroom was situated. This association remained significant even after adjustment ($p < 0.01$).

- Prevalence of children with **bleeding nose at school during the last 7 days** significantly ($p < 0.001$) increased with increasing number of floors on which the classroom was situated, especially if windows were oriented towards the school-yard. After adjustment this association remained statistically significant ($p = 0.05$).

- Prevalence of children with **breathing difficulties at school during the last 7 days** significantly ($p < 0.05$) increased with increasing number of floors if the classrooms' windows were oriented towards the school-yard. After adjustment this association lost statistical significance ($p = 0.11$).

<u>Crowdedness (< 2m^2/child) in the classroom</u>

- Children with **nasal obstruction during the past 3 months** was found significantly more frequently in crowded classrooms than in those with more space. This association remained significant even after adjustment for the most important confounders.

<u>Orientation of the classroom: street</u>

- Prevalences of children with **cough with phlegm** on most days of the week or **feeling tired** during the last 3 months were found significantly ($p<0.05$) higher in classrooms facing the street than those facing the school-yard. After adjustments these associations also lost the statistical significance. ($p<0.1$)

- In the classrooms facing the street **nasal allergies, allergic rhinitis, allergy to cats and dogs, as well as to food** (all confirmed by a physician) were significantly more frequent than in classroom oriented to the school-yard. However, after adjustments most of these associations lost statistical significance ($p<0.1$), with the exception of doctor-diagnosed allergy to dogs ($p<0.05$).

<u>Plastic floor in the classroom</u>

- Plastic floor material in the classroom had multiple significant associations with the various **<u>allergic</u> <u>symptoms</u>** of the children reported by their parents**,** like **sneezing** or **runny** or **blocked nose** during the past 12 months, doctor-diagnosed allergic **rhinitis** or **allergy to cats, dogs** or **pollens.** With the exception of allergy to dogs, all of them remained statistically significant even after adjustments to the most important confounders.

- In accordance with the symptoms mentioned in the previous paragraph, some **allergic symptoms** reported by the pupils themselves were also strongly associated with the plastic floor material like **runny nose, sneezing, dry cough and sore throat** at school during the past week. All of them were significantly associated after adjustments, too.

- **Fatigue** experienced by the children at school during the past week was also found significantly more frequently in classrooms with plastic floor than in those with other floor materials. This association was even stronger after adjustments.

<u>Wall paints used in the classroom</u>

- **Water-soluble paints** were significant risk factors for **asthma attack** ever at school, s**kin rash on hands or forearms, itching hands or forearms** in past 3 months**,**

allergic rhinitis confirmed by a physician, doctor-diagnosed **allergy to cats** and **breathing difficulties** at school in the past week. **Allergy to cats** had an even stronger association with water-soluble paint if it was used *within 1 year*.

- **Feeling of getting a cold** was significantly associated with **white wash** even after adjustments.

- Prevalence of children with **ear-ache** or **otitis** in the past 12 months and feeling of **tiredness** in the past 3 months was significantly associated with **wallpaper** in the classroom and it remained so even after adjustments.

Air conditioner in the classroom

- **Doctor-diagnosed allergies to cats, pollen and food** as well as **itchy rash** during the past 12 months were significantly associated with the presence of air conditioners in the classroom. With the exception of pollen allergy these associations lost their statistical significance after adjustments for the most important confounders.

- Though statistically not significant ($p<0.1$), it may be worth mentioning the association between the presence of air conditioner and the prevalence of **red eyes** at school in the past week.

In the heating period windows opened 2-3 times/day or less

- **Dry throat** at school in the past week and **skin rash** on the hands or forearms during the past 3 months were significantly associated with opening the windows 2-3 times a day or less frequently but both associations lost significance after adjustments.

Classroom cleaning once a day or less frequently

- **Asthma attack** ever at school happened significantly more frequently in classrooms cleaned once per day or less frequently (4.1%) than in those cleaned twice a day (2.2%). This association remained statistically significant after adjustments, too.

- **Eczema** in the past 3 months and **itching hands or forearms** at school were associated with cleaning frequency of once a day or less but these associations lost statistical significance after adjustments ($p<0.1$).

Classrooms cleaned in the morning before school time

- This kind of cleaning regime was significantly **advantageous** from the point of view of **headache** in the last 3 months and it remained so after adjustments, too.

- **Allergies to pollen and food** were also less frequent in classrooms cleaned in the morning but these associations lost significance after adjustments.

- On the other hand, prevalence of children with **dry cough at school** was significantly higher in classrooms cleaned in the morning than in other times of the day and this association was significant after adjustments, too.

Classrooms cleaned in the evening after school time

- This kind of cleaning regime proved to be **disadvantageous** from the children's health point of view. **Runny nose or phlegm** as well as **tiredness** experienced by the children in the last 3 months were significantly associated with evening time cleaning of the classrooms. These associations remained statistically significant even after adjustments.

- Prevalence of children with **allergy to cats** or **pollen** was significantly higher in classrooms cleaned in the evening but these associations lost statistical significance after adjustments.

Vacuum cleaner used for classroom cleaning

- Statistically significant increase of risk for **several symptoms appearing at school** in the past week were demonstrated in classrooms cleaned by vacuum cleaner: **itching or irritated nose, sneezing, stuffy or blocked nose, bleeding nose, dry throat, headache, fatigue and wheezing in the chest.** These associations remained statistically significant even after adjustment.

- **Wheezing during or after exercise** in the past 12 months and **itching eyes** at school in the past week were significantly associated with the use of vacuum cleaner in the classroom but these associations lost significance after adjustments.

- The only advantageous sign was a significant decrease of risk for doctor-diagnosed allergic rhinitis but after adjustments the statistical significance disappeared.

Broom used for classroom floor cleaning

- **Nausea** during the last 3 months was experienced significantly **less frequently** in classrooms cleaned with brooms and this advantageous effect remained significant even after adjustment.

- On the other hand, prevalence of children with **eczema, itching face or neck** or **runny nose** was significantly lower in classrooms cleaned with brooms but after adjustments these associations turned around and broom use became significant determinants of these symptoms.

Mop used for classroom floor cleaning

- Prevalences of children with **important health problems, eczema** in the past 3 months, **food allergy** confirmed by a physician, **skin rash on hands or forearms** or **dry throat** at school in the past week and **asthma attack at school** ever were significantly associated with mop use for classroom cleaning and these associations remained statistically significant even after adjustments.

Mop with bleach used for cleaning classroom floor

- Risk for **asthma attack ever at school**, **eczema** and irritative cough during the past 3 months was significantly ***lower*** in classrooms cleaned with mop with bleach and these associations were also statistically significant after adjustments.

- On the other hand, risk for **dry cough at school** during the past week was found significantly increased in relation to mop use with bleach and it remained so even after adjustments.

Open windows during cleaning

- The **favourable effect** of open windows during cleaning could be demonstrated by the significantly decreased risk of **wheezing ever**, **difficult breathing with wheeze** at school, **dry throat** and **sensation of sand in eyes** at school in the past week, which remained statistically significant even after adjustments.

Furniture installed within 1 year

- **Nasal allergies** confirmed by a physician, **allergies to cats** and **eczema** ever and in the last 3 months were found significantly more frequently in the classrooms with furniture installed within one year compared to those where furniture was installed earlier, though after adjustment most of the associations became borderline significant.

Black board with chalk

- Use of blackboard with chalk was strongly associated with increased risk of doctor-diagnosed **allergic rhinitis** and **allergy to cats,** which remained statistically significant even after adjustments.

White board with alcohol based markers

- Statistically significant **advantageous effect** of white board with alcohol-based markers was found from the point of view of **doctor-diagnosed allergic rhinitis** in both the unadjusted and the adjusted model.

Children use products with irritant smell

- In the classrooms where children use products with irritant smell significantly increased risk for **sore throat** and **dry cough** at school in the past week was found which remained statistically significant after adjustments, too.

Classrooms with mouldy odour

- In classrooms with mouldy odour significantly increased risk for **wheezing** ever and in the past week at school was found and this association was statistically significant even after adjustments for the most important confounders.

B. Association between classroom characteristic and absenteeism of children

Description of recording absenteeism

Absenteeism of the children was recoded for 4 months between 01.11.2011 and 29.02.2012, either in a personalised way (the child was present or absent, day by day) or, where the school or the parents did not give their consent, by class level (daily number of absent children per class).

Descriptive results of absenteeism

In order to include as many classes as possible the statistical evaluation was done by class level. Absenteeism was evaluated for a total of 202 classes from 16 countries. Two parameters were evaluated: 1.) percentage of absent children per day per classroom, and 2.) percentage of days with any absenteeism per class. The descriptive results of these two parameters are presented in the tables (see the full report in Annex 4.2).

Associations between classroom characteristics and absenteeism

Regression coefficients of the associations between the classroom characteristics and the absenteeism were evaluated by linear regression without (b1) and with adjustments (b2) for country. Lower and upper 95% confidence levels (LCL 95% and UCL 95%) of the regression coefficients are also presented in the Table of Results as a background information, independently whether the association was significant or not. The statistically significant and reasonable associations are discussed below.

Wall paints used in the classroom

According to both the crude and the adjusted association, children were significantly more frequently absent in wall-paper covered classrooms than in those with some other paints (13.6% vs. 5.4% mean absenteeism per day and the days with any absenteeism: 84.9% vs.50.4%)

Classrooms cleaned in the morning before school time

Average absenteeism was significantly higher in classrooms cleaned in the morning (after adjustment for country) – but this is explained later: vacuum cleaners are preferably used in the morning (i.e. not the time but the means of cleaning can be regarded important)

Means of classroom cleaning

Use of vacuum cleaner for cleaning the classrooms was highly significantly associated with absenteeism of the children.

Many other aspects were investigated, but we found no significant associations (See in the report, Annex 5.1)

C. Association between classroom characteristic and the attention test results

Description of the Attention tests

The test consisted of two parts: the first one was a series of simple mathematical tests. Percentage of the right answers (score1a) was evaluated. The second part was a logical test with 119 elements to be solved within 120 seconds. Again, percentage of the right solution (score 1b) was scored.

These two parts had to be completed during the first lesson of the day and repeated during the last lesson of the day (score2a and score 2b). The difference between the two trials was expected to reflect the decreased attention and concentration capacity at the end of the teaching day, influenced by various factors of the school environment.

Scores observed in the morning and in the afternoon as well as their differences (Diff 2a-1a and 2b-1b) were analysed separately in association with the various classroom characteristics.

Descriptive results of the Attention tests

Altogether 12 countries used the attention tests. 2909 children completed all the 4 tests, while some more of them completed one or the other.

OVERALL RESULTS

	Score1a	**Score1b**	**Score2a**	**Score2b**	**Diff 2a-1a**	**Diff 2b-1b**
N	3080	3294	3062	3269	3055	3263
Mean	80.1	39.6	79.2	42.8	-0.83	3.24
Min	0	0	0	0	-68	-64.7
25% percentile	69	29	68	31	-6	-2.52
Median	88	35.3	88	41	0	3.40
75% percentile	97	46	96	50	4.16	10.09
Max	100	100	100	100	62.5	79

In general, the mathematical test results were somewhat better in the morning than in the afternoon, while the logical tests results of the second trial (i.e. by the end of the teaching hours) were significantly better than those of the first trial (2b-1b), which may be explained by a so-called "learning effect".

MEAN VALUES BY GENDER, AGE AND COUNTRY

	n	**Score1a**	**Score1b**	**Score2a**	**Score2b**	**Diff 2a-1a**	**Diff 2b-1b**
Boys	1483	80.2	38.4	79.1	41.9	-1.19	3.65
Girls	1426	79.9	39.9	79.3	42.8	-0.51	2.81
8 years	473	75.3	31.9	76.1	33.8	0.62	1.79
9 years	1079	80.7	38.2	80.3	42.3	-0.20	4.14
10 years	1003	82.5	41.4	80.5	44.6	-1.95	3.15

11 years	281	80.7	48.0	78.4	49.1	-2.25	1.29
AL	504	86.6	34.9	84.6	35.0	-2.0	0.82
BA	125	71.5	32.6	71.9	35.5	0.62	2.95
BE	107	65.6	33.8	64.5	44.1	-1.42	10.16
CZ	298	87.8	52.6	87.1	49.4	-0.74	-3.16
EE	188	85.9	73.2	85.3	77.9	-0.36	4.01
FR	234	77.6	41.8	74.1	46.6	-3.06	4.91
GR	95	27.5	50.4	29.0	57.6	1.60	7.37
HU	196	82.9	34.0	82.1	43.9	-0.26	9.97
IT	262	84.6	35.0	88.1	44.0	3.41	8.94
LT	218	88.0	45.1	88.7	49.5	0.68	4.38
PT	227	72.2	32.5	77.8	39.1	5.75	6.61
RS	495	79.5	28.7	73.8	25.5	-5.69	-3.19

There was no significant difference in the mathematical test results between the two genders but the girls' logical tests results were statistically significantly better than those of the boys, especially in the morning ($p<0.001$), even after adjusting for age.

The logical tests, performed either in the morning or in the afternoon, showed significant increase with age. The mathematical test results also increased with age with the exception of the 11 year old children but this latter group consisted only from a relatively small number of children.Both the mathematical and logical test results of the countries differed significantly from each other.

Associations between attention test results and classroom characteristics

Regression coefficients of the associations between the classroom characteristics and the attention test results were evaluated by linear regression without (b1) and with adjustments (b2) for age, gender, education of the mother, environmental tobacco smoke and country. Lower and upper 95% confidence levels (LCL 95% and UCL 95%) of the regression coefficients are also presented in the Table of Results as a background information, independently whether the association was significant or not. **The statistically significant and reasonable associations are discussed below.**

Floor level of the classroom

- Both the mathematical and logical test results in the morning were significantly better in classrooms situated higher than the ground floor but after adjustments these associations lost their significance and what's more, the morning mathematical test results were even significantly ($p<0.05$) better in the ground floor classrooms than in those in higher floor levels.

- The difference between the results of the second and the first trials of the logical test (i.e. tiredness) was significantly bigger among children in classrooms of the ground floor than among those in classrooms situated in higher floors but these associations also lost their significance after adjustment to the most important confounders.

Crowdedness (< 2m2/child) in the classroom

- In crowded classrooms the children performed the logical test both in the morning and the afternoon significantly more poorly than in classrooms with more space but this associations lost their significance after adjustments.

Plastic floor in the classroom

- The difference between the results of the afternoon and the morning mathematical tests was significantly higher in classrooms with plastic floor than with other floor materials but slightly lost its statistical significance after adjustments.

Wall paints used in the classroom

- Children in classrooms with *water resistant paints* performed the logical tests significantly poorer both in the morning and, especially, in the afternoon than in classrooms with other wall paints. These associations remained statistically significant ($p<0.001$) even after adjustments for the most important confounders.
- On the other hand, children in classrooms painted with water soluble paints performed the logical tests both in the morning and in the afternoon significantly better than those in classrooms with other wall coverings and these associations remained statistically significant ($p<0.001$) even after adjustments.

- However, in the classrooms painted with water soluble paints *within the last 12 months* the results showed opposite directions: the results of both the mathematical and the logical tests were significantly poorer in the afternoon than in the morning (indicating greater tiredness of the children). These differences were significantly bigger than in classrooms painted earlier and remained significant even after adjustments ($p<0.001$)

- In classrooms painted with *white-wash during the last 12 months* the children performed both the mathematical and the logical tests better in the afternoon than in the morning and these differences significantly differed from the performance of children in classrooms with other paints.

- The mathematical test results in the morning were significantly ($p<0.001$) better in classrooms with wall-paper than with other wall coverings and this association remained significant ($p<0.05$) even after adjustment. On the other hand, the difference between the results of the afternoon and the morning logical tests (i.e. the tiredness) was found after adjustments significantly ($p<0.01$) higher in classrooms with ***wall-paper*** than with other wall coverings.

Ventilation in the classroom

- Children in classrooms with an **air conditioner** completed the mathematical tests in the morning significantly ($p<0.05$) better than those in classrooms without an air conditioner. However, the afternoon test results proved to be very poor, therefore the differences between the morning and the afternoon test results became significantly worse (even after adjustments) than in other classrooms, indicating that the attention and concentration capacity of these children significantly decreased.

- **Mechanical ventilation** in the classrooms was associated with good logical test results both in the morning and in the afternoon but after adjustments they became significantly poorer results than in other classrooms.

In the heating period windows opened 2-3 times/day or less

- Logical test results, especially in the afternoon, were significantly poorer in classrooms where the windows were opened only 2-3 times or less in contrast to the classrooms which were better ventilated. This association remained statistically significant even after adjustments.

- In harmony with the above mentioned finding, the difference between the afternoon and the morning results of the logical tests was significantly bigger than in classrooms with other ventilation regime, indicating that the children's attention capacity decreased in these classrooms.

Classroom cleaning once a day or less frequently

- After adjustments, children in less frequently cleaned classrooms performed both the mathematical and the logical tests poorer than in the morning and these negative differences were significantly bigger than in more frequently cleaned classrooms.

Classrooms cleaned in the morning before school time

- Significant decrease of the children's attention and concentration capability could be observed in the classrooms cleaned in the morning before school time: the afternoon results of both the mathematical ($p<0.05$) and the logical tests ($p<0.001$) were poorer than the morning ones and after adjustments these differences were significantly larger than those in other classrooms.

Classrooms cleaned in the evening after school time

- The mathematical test results both in the morning ($p<0.001$) and in the afternoon ($p<0.01$) were significantly poorer than in classrooms cleaned other times but evening after school time. These associations were significant even after adjustments.

- On the other hand, the logical test results in the afternoon were significantly ($p<0.001$) better in classrooms cleaned in the evening after school time than in classrooms cleaned in other times. Accordingly, the positive difference between the afternoon and the morning logical test results was significantly ($p<0.001$) better than in other classrooms.

Means of classroom cleaning

- In classrooms where vacuum cleaner was used for cleaning, the afternoon logical test results were better than the morning ones and after adjustments this difference was significantly ($p<0.001$) bigger than in classrooms cleaned by other means.

- In classrooms cleaned with broom the morning logical test results were, after adjustments, significantly ($p<0.01$) better than in the case of other means of cleaning.

- In classrooms cleaned with mops the afternoon logical test results were significantly poorer than in classrooms cleaned with other means and this association remained significant even after adjustment.

- Mop with bleach used for cleaning classroom floor was associated with significantly poorer results of both the mathematical and the logical tests in the morning than in the case of other means of classroom cleaning.

Measured concentrations

- After adjustments for the most important confounders, both the morning and the afternoon mathematical test results were in a significant inverse association with both the **formaldehyde** and the **benzene** concentrations measured in the classrooms.

- Similar inverse associations were found between the measured **pinene** concentrations and both the morning and the afternoon mathematical test results as well as with the difference between the afternoon and the morning logical test results indicating increased tiredness of the children by the end of the school day with increasing concentrations of pinene.

- The difference between the afternoon and the morning logical test results indicating increased tiredness of the children by the end of the school day was significantly associated with increasing concentrations of **ozone** as well.

- The morning logical test results and the measured **tetrachlorethylene** and **naphthalene** concentrations were in a significant inverse association.

- No significant associations between the measured **trichlorethylene, benzo(a)pyrene,** **$PM_{2.5}$** and **limonene** concentrations and the attention test results were found after adjustments.

- The morning logical test results were in a significant inverse association with **CO_2** concentrations measured in the classroom and it remained significant even after adjustments.

- After adjustments for the most important confounders, the afternoon logical test results were in a significant positive association with the **ventilation rate.**

Conclusion: the school environment and the IAQ has significant effect on the performance of children during the teaching period. All listed aspects of exposure of children above should be avoided to have better performance of children in the European schools.

3.6 Work Package 6: Health and risk assessment

In line with the work plan, this activity started in month 13.

Indoor air quality in schools has been far less studied than IAQ in other buildings (e.g. offices and other workplaces). Consequently, little attention has been given to IAQ in these buildings, the related health impacts, and the effectiveness of remedial measures in European schools.

Our aim, based on the literature background (WP2), the results of the field studies (WP3 assessment of outdoor/indoor school environment; WP4 assessment of health outcomes) and data management and modelling (WP5 data management, cross analysis and modelling) was to estimate the potential impact of IAQ in classrooms on children's health, giving particular attention to inhalation exposure, irritation symptoms and respiratory diseases (airway allergic reactions).

The evaluation of IAQ and the health risk assessment of IAQ were planned to identify research needs for policy development.

Implementation (status of deliverables):

Based on the results of field studies (WP3), after the preparation of the database (WP5) the evaluation of health risk assessment of IAQ in schools began. Assessments of the impact of indoor air in classrooms on children's health were carried out based on the results of the field studies, with particular attention to inhalation exposure, irritation symptoms and respiratory diseases in order to define priorities for policy development.

Risks and related adverse effects were identified based on the literature background (WP2).

Exposure assessment was carried out based on the mean concentration of chemical pollutants in the four regions defined in the framework of the SINPHONIE project. Inter-regional variability was assessed. A detailed assessment of variability is carried out by the end of the project and described in the Final Report and in the "Report on the scientific basis for risk assessment in schools and childcare settings".

Risk characterisation is carried out by the end of the project and communicated in the Final Report and in the "Report on the scientific basis for risk assessment in schools and childcare settings" for estimation of the incidence and severity of the adverse effects likely to occur due to risk exposure.

The results of this WP, described in the "Report on the scientific basis for risk assessment in schools and childcare settings", will be useful in order to define priorities for policy development and to identify the main specific IAQ problems and gaps in the body of knowledge. Related research needs for policy development will be proposed, in particular in relation to IAQ audits and epidemiological and clinical studies.

(See the detailed report in Annex 6.1: Report Health risk assessment)

Indoor air quality in schools is very important because:

- many subjects are involved;
- schools are at risk from indoor air pollution; and

- children are at particular risk from indoor air problems.

During the 2010 academic year there were slightly more than 108 million students in the European Union, including about 15 million pupils in nursery schools, about 28 million pupils in primary schools, and about 44 million students in secondary schools. In most countries, students attend school five or six days a week and spend between 700 and 900 hours a year in class.

The studies conducted show that schools frequently have IAQ problems; various air pollutants can be found in classrooms sometimes in elevated concentrations:

- *Carbon monoxide*: with the exception of one classroom, in which very elevated indoor levels of CO were observed (121.8 ppm), all children were exposed to low levels of less than 6 ppm (the WHO 2010 guideline value for 24 hours).

- *Nitrogen dioxide*: in seven classrooms, elevated indoor levels of NO_2 were observed.

- *PM2.5*: 70% of children were exposed to higher levels than 25 µg/m^3 (WHO ambient guideline as 24-hour average) and more than 90% to higher levels than 10 µg/m^3 (WHO ambient guideline as annual average).

- *Formaldehyde*: indoor formaldehyde measurements in schools in the framework of the SINPHONIE project ranged from 1.3 to 66.2 µg/m^3, with large differences between participating countries. Indoor formaldehyde levels in schools in western and eastern countries (European regions 2 and 3) were significantly higher than in northern and southern countries (European regions 1 and 4). More than 50% of children were exposed to formaldehyde in schools at more than 10 µg/m^3, a figure proposed by ***AFSSET (2007***) as a long-term formaldehyde guideline value for indoor environments (this guideline value was not confirmed by WHO 2010).

- *Benzene*: in SINPHONIE schools, indoor benzene values were between 0 and 38 µg/m^3, with big deviations between participating countries. Indoor benzene levels in schools from European regions 1 and 2 were significantly lower than in European regions 3 and 4, suggesting that indoor benzene concentrations increase from north to south. About 25% of the children were exposed to benzene in schools at more than 5 µg/m^3.

- *Trichloroethylene*: indoor TCE measurements in SINPHONIE schools showed a large range in school values (0-126 µg/m^3), with large differences between participating countries. Indoor TCE levels in schools in western and northern countries (regions 1 and 2) were significantly lower than in southern and eastern countries (regions 3 and 4). In any case, only 10% of children were exposed to TCE in schools at more than 5 µg/m^3.

- *Tetrachloroethylene*: indoor levels of TCA in SINPHONIE schools were very low (range 0-126 µg/m^3); none of the children were exposed to TCA at more than 250 µg/m^3 (WHO 2010 recommended guideline for year-long exposure); only 10% of children were exposed to TCA in schools at more than 3.3 µg/m^3.

- *Naphthalene:* in SINPHONIE schools, indoor concentrations of naphthalene ranged from 0 to 30.8 µg/m^3. The southern and eastern region (regions 3 and 4) have significantly higher indoor naphthalene concentrations, although all mean values for all four regions are far below the guideline value. About 5% of children (corresponding to 12 classrooms) were exposed to naphthalene at more than 10 µg/m^3 (WHO 2010 recommended guideline for year-long exposure); a large proportion of children were exposed to very low levels of naphthalene (less than 1 µg/m^3).

- *Limonene:* risk assessment related to d-limonene exposure is a complex issue. A long-term exposure limit (EL) of 450 µg/m^3 in the EU INDEX project was suggested, but it was stated that it is not possible to recommend this long-term EL as a guideline value due to the lack of sufficient toxicological data. In SINPHONIE schools, indoor concentrations of limonene ranged from 0 to 671.6 µg/m^3. Except in two classrooms, the majority of children were exposed to very low levels of limonene (less than 100 µg/m^3).

- *Radon:* 50% of children were exposed to more than 100 Bq/m^3 (national residential reference proposed by WHO 2010), but none to more than 300 Bq/m^3 (maximum national reference level suggested by WHO 2010). The southern and eastern regions have significantly higher indoor radon concentrations. Based on mean values, the lowest risk level of 3 x 10^{-2} was shown in northern countries (region 1), and the highest in eastern countries (region 3) at 9.6 x 10^{-2}.

The figures bellow are from the WP6 report, ***Annex 6.1.***

Figure 4.1. Formaldehyde indoor levels (µg/m^3) in schools in the four European regions in heating (H) and Non heating (NH) season

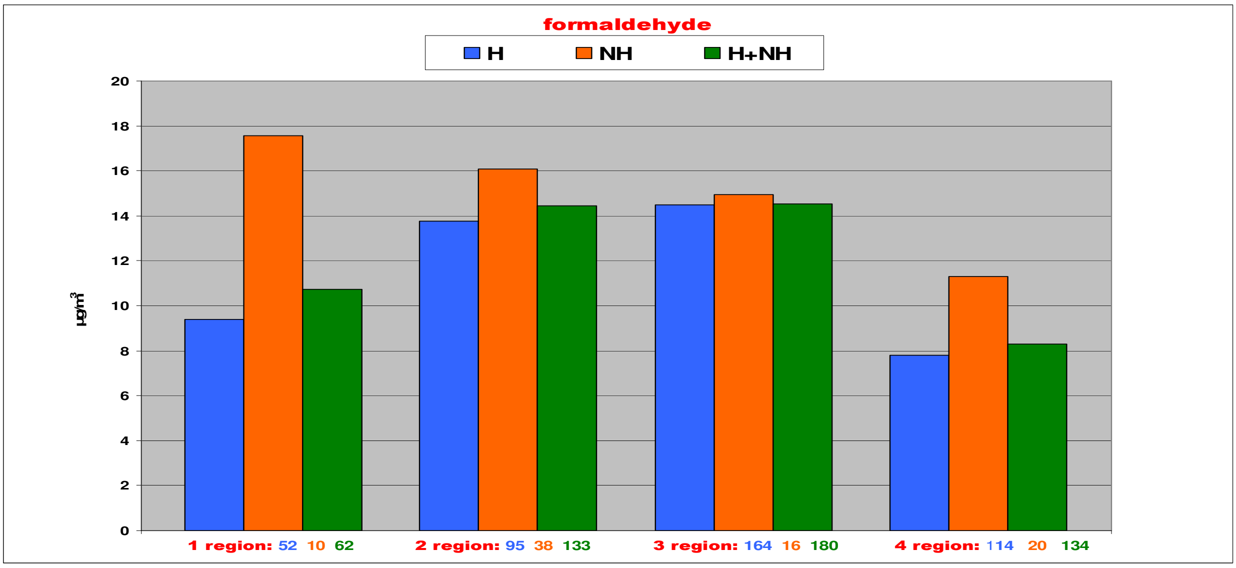


Figure 4.2. Benzene indoor levels in schools in the four European regions in heating (H) and Non heating (NH) season

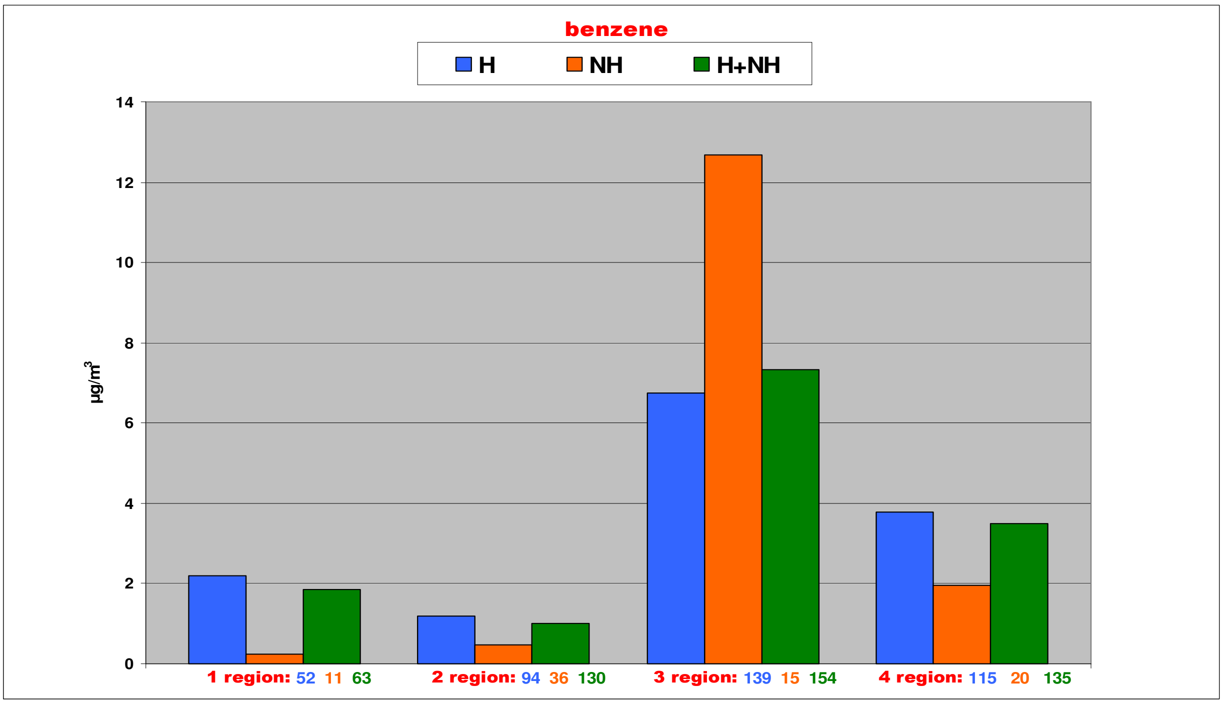


Figure 4.4. Naphthalene indoor levels in schools in the four European regions in heating (H) and Non heating (NH) season

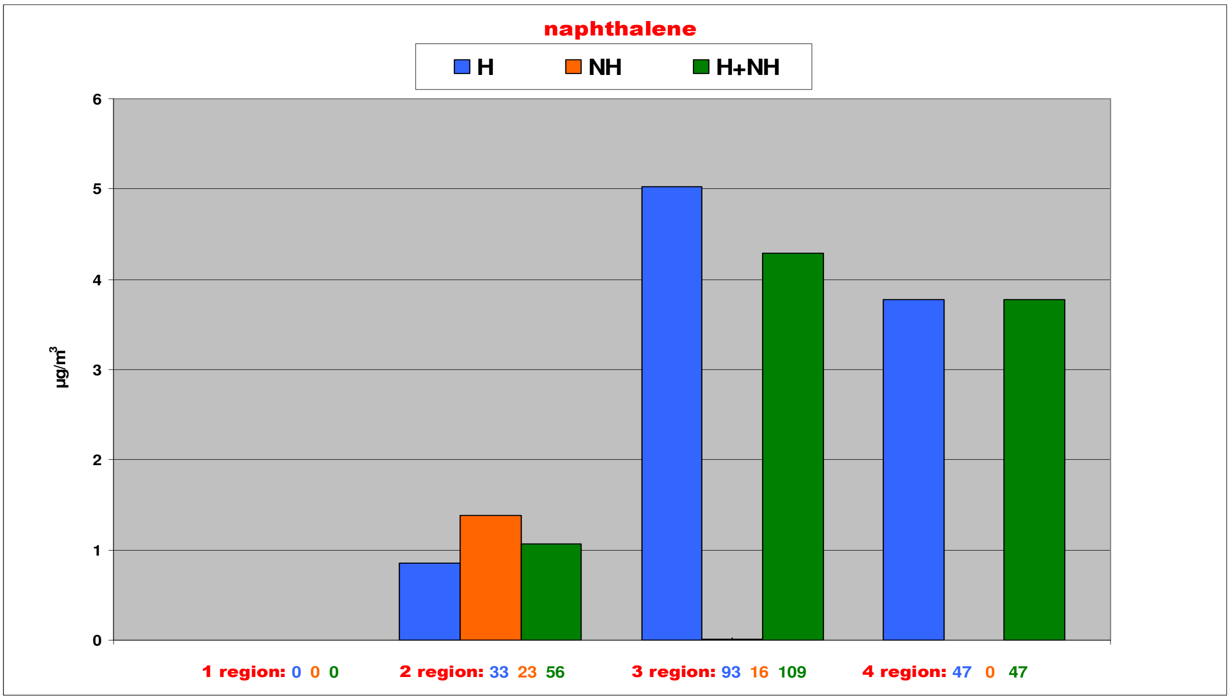


Figure 4.5. Radon indoor levels in schools in the four European regions in heating (H) and Non heating (NH) season

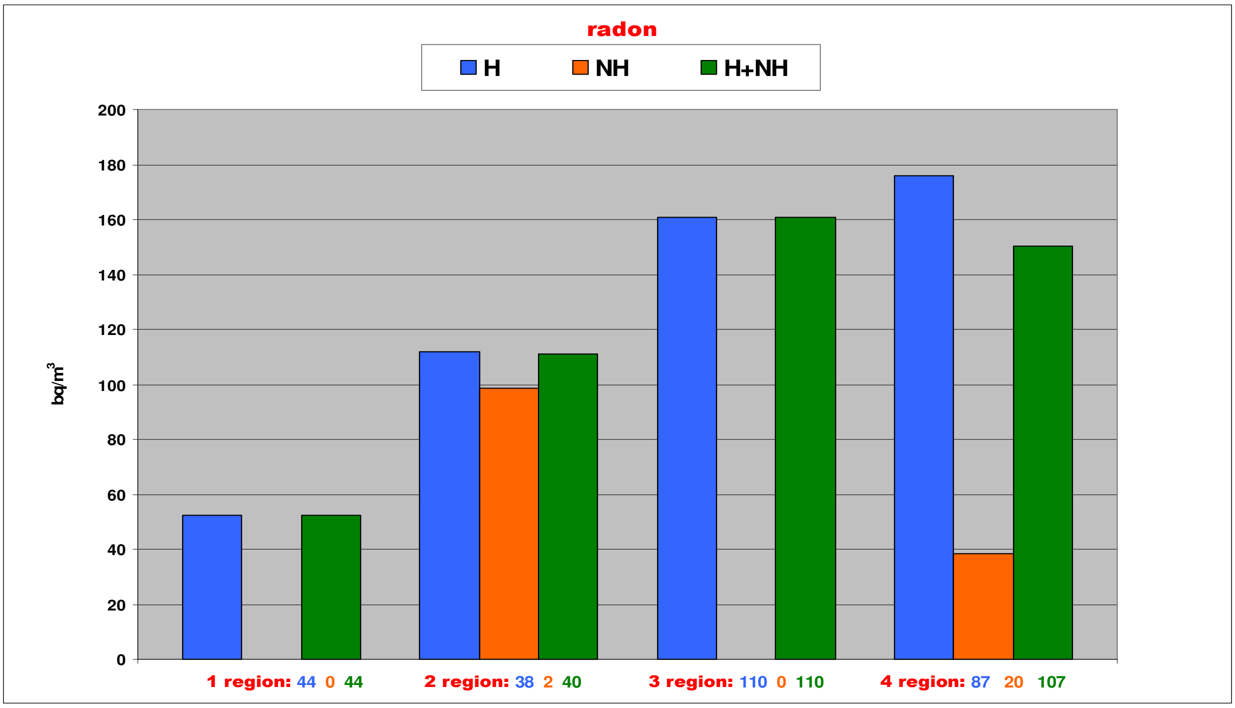
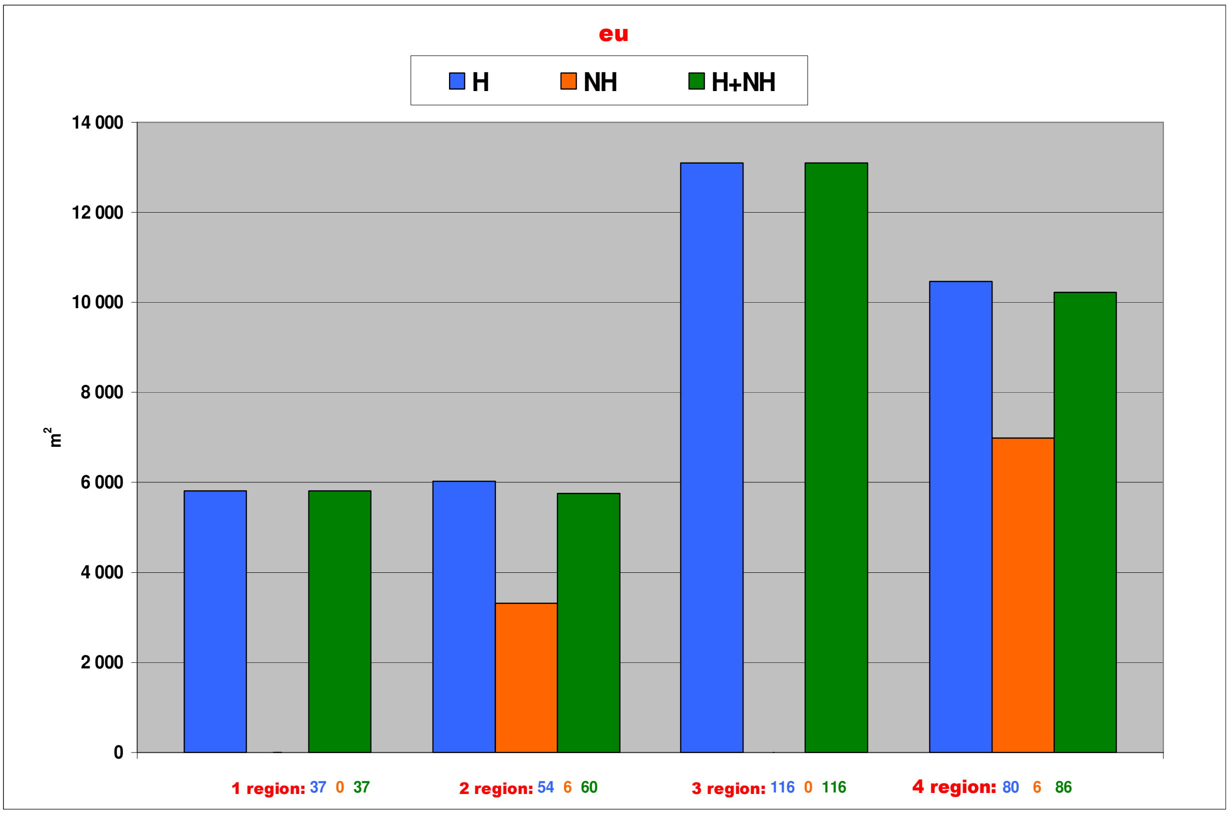


Figure 4.6. Endotoxin indoor levels in schools in the four European regions in heating (H) and Non heating (NH) season



Poor IAQ in schools can:

- cause discomfort, irritation, and various short- and long-term health problems in students, teachers, and staff;
- aggravate health problems, including irritation and respiratory symptoms;
- spread airborne infectious diseases;
- reduce teacher, staff and student productivity; and
- accelerate physical plant and equipment deterioration.

For lung function and exhaled NO parameters, the data collected in the SINPHONIE project showed sufficient variability and are from a sufficiently large number of children to allow further analyses regarding possible environmental causes of the differences.

Indoor air quality in schools should be recognised as a priority topic for public health. A multidisciplinary European programme on IAQ that places particular attention on schools is required with the aim of encouraging and coordinating actions in the fields of prevention, information, education, training, research and legislation.

This multidisciplinary programme should result in the development of initiatives for good indoor school environments and should have an impact in terms of public health. It should promote:

- -avoidance of environmental tobacco smoke;
- avoidance of moisture/mould in buildings;
- avoidance of allergen sources;
- adequate cleaning and maintenance, with the practical shaping of the interior to facilitate cleaning and maintenance;
- good control of heating and ventilation to ensure satisfactory temperature and ventilation in the classroom;
- adequate periodical monitoring of IAQ parameters in schools;
- appropriate training of students, teachers and school staff responsible for management, maintenance and cleaning.

In addition, the multidisciplinary programme should:

- *Promote initiatives*, including legislative initiatives, to regulate school buildings in terms of design, construction, materials used (e.g. carpets and other textiles), safety, cleaning and building maintenance procedures, the avoidance of tobacco smoke and allergens, and ensuring adequate ventilation.
- *Promote awareness-raising campaigns and training* aimed at children and their families, school staff, professionals, policy makers and the public.
- *Promote research* to develop sustainable measures aimed at improving indoor air quality in school buildings.

In particular, research is required in the following areas:

- The implementation of epidemiological methodology:
    - *Indoor air quality audits* in schools, using the principal measurements of IAQ (CO2, VOCs, allergens, ventilation) in combination with an evaluation of building characteristics and building use.
    - *Standard questionnaires, medical visits and some objective tests* to establish a system for the medical surveillance and screening of schoolchildren; this system could be an important complement to environmental measurements in order to identify specific IAQ problems and gaps, and to evaluate the impact of poor air quality on the health of the student population.
- Studies of the impact of IAQ in schools on health, learning and children's lifestyles.
- Studies to develop healthy school buildings (building construction, operation, maintenance and monitoring).

3.7 Work Package 7: Risk management and development of guidelines/ recommendations

According to the work plan, activities in this work package will start in month 19.

The deliverable **Risk management and development of guidelines and recommendations** (WP 7, D.7.1) provides an overview of existing policy measures on indoor school environments, including measures on IAQ in schools in European countries. In addition, criteria are described on which national guidance, guidelines and recommendations are evaluated for their suitability to become generic international recommendations issued by the European Commission. The concept behind generic international recommendations is that national authorities are free to further tailor the recommendations, taking into account local geography, climate and socioeconomic conditions in order to find the best way to incorporate the recommendations into national policies. The recommendations are directed to relevant stakeholders such as policy makers, designers, school building managers and school building users, and in particular to teachers and students.

Setting up generic guidelines for national and local implementation: The harmonisation of national policy measures on an international scale is only possible at a generic level. This would allow all EU-27, accession countries and WHO region countries to take certain actions, while at the same time providing them with sufficient freedom to implement measures according to their specific national and local conditions. After reviewing the national initiatives described in Annex I, Germany and France issued comprehensive guidelines on hygienic requirements for schools; measures to control specific indoor air pollutants; structural and indoor climate requirements; and procedures for tackling and remediating problems related to the indoor environment. France foresees mandatory auditing of IAQ in schools on a periodical basis. Each section of the German guidelines ends with generic guidelines/recommendations on indoor hygiene in school buildings. These generic guidelines are considered suitable to form the basis of generic guidelines issued by the European Commission on IAQ in schools. The way these generic guidelines are set up is considered to provide sufficient freedom to other countries to implement custom-based guidelines tailored to their national and local situations. An overview of the guidelines in Germany and France is given in Annexes II and III respectively. Ideally, these general recommendations could eventually be combined with other topics related to the building environment, such as energy saving, school surroundings, noise disturbance etc.

Guidance on the implementation of generic international guidance/recommendations in national policy measures on indoor hygiene in schools.

Measures to improve indoor hygiene in schools require a variety of actions and depend on national and local situations. For example, measures that are suitable for Finnish schools may not be suitable (or possible) for Serbian schools. In order to guide national stakeholders (i.e. policy makers, school building designers, school staff etc.) to make informed decisions about which measures are most suitable for implementation, a strategy was developed in the context of SINPHONIE WP 7 based on criteria that include mechanisms for obtaining a deeper insight into the relationship between the cost and the expected health benefits of a given policy measure.

Criteria available to national stakeholders for the implementation of international guidelines/recommendations in national measures

Several criteria have been set up to help national and local authorities judge which policy measures are best suited to a local or national situation. The main criteria are described below:

1) *Effectiveness*

Effectiveness refers to the estimated expected changes in terms of risks or impacts. In other words, it should be possible to indicate the expected effectiveness of a policy measure in terms of risk reduction capacity. It is important to look at the effect of a certain measure on a particular proportion of a population: that is, a relatively small reduction in risk may still have a large impact when sufficient individuals from that population (in our case schoolchildren) experience health benefits. Known metrics based on this concept include burden of disease estimations based on DALYs (disability-adjusted life years), such as the one presented by the DG SANCO–funded IAIAQ project[5]. In other words, it is important to indicate the impact on a population level, and on a sub-population level such as a more vulnerable group (e.g. asthmatics). Although the division is not strictly possible, it is important to know whether a measure is directed at improving children's health or school performance, or if – as is most often the situation – it is a combination of both (i.e. a healthier child will most probably also perform better at school).

2) *Proportionality*

Proportionality refers to the generation of an overview of the costs against the benefits in terms of health gain. Knowing the costs and the benefits will support national and local authorities in evaluating the measure and better judging their economic feasibility. Greater insight into the costs can be obtained by methods based on cost-benefit analyses, such as those described by Fisk et al. (2011). For this purpose, information about absenteeism due to sickness of teaching staff and pupils is commonly used. Technical feasibility also plays a role, although this criterion is expected to be mainly building specific rather than country specific. Mechanical ventilation systems for improving IAQ in school buildings maybe used, for example. However, a wide array of existing school buildings in Europe have been designed in such a way that a posteriori modification of the building structure to accommodate mechanical ventilation systems is not cost-efficient. This, however, also strongly depends on the selected ventilation options. Some ventilation options, such as controlled exhaust with trickle vents, may be more technically feasible and therefore also more cost-efficient.

3) *Practicability*

Practicability refers to the assessment of the implementability, enforceability and manageability of the guidelines or recommendations. For example, mandatory monitoring of indoor school environments can be implemented in national policies, but in the absence of appropriate enforcement strategies and instructions in the event that certain standards are violated, this is neither practical nor efficient.

[5] Promoting actions for healthy indoor air (IAIAQ): http://ec.europa.eu/health/healthy_environments/docs/env_iaiaq.pdf: description of effects of measures on burden of disease and DALY. Although measures are not specifically directed to schools, the concept is also applicable to schools.

4) Monitorability

Monitorability refers to the assessment of direct (e.g. exposure levels, hygiene standards) and indirect (e.g. health effects such as running nose, cough or longer-term asthma prevalence rates) impacts of the policy measures undertaken, and the generation of an overview of the costs of monitoring.

Recommendations for setting up international guidelines

1. Creation of generic guidelines

It is recommended to create generic guidelines, allowing individual countries to incorporate the recommendations into their own legislation taking into account national and local needs and possibilities. In Annex I, generic German guidelines are presented that could be used as a starting point for countries for setting up their own national policy measures.

2. Harmonisation and integration of children's health-based general living environment into national legislation

As a first step, national legislation could draw particular attention to the planning phase when new school buildings are constructed. It is recommended to include attention to the indoor environment in relation to the prevention of health risks during the planning of location (geographical criteria) and construction (choice of building materials). It is recommended to focus on children's general living environment rather than dividing the focus according to separate guidance based on different laws.

3. Cost–benefit-based prioritisation

Costs and benefits in terms of health protection can be assessed, and this assessment can subsequently be used to draw up criteria for establishing national guidelines. This analysis can be made either qualitatively or, preferably, quantitatively on the basis of four criteria: effectiveness, proportionality, practicality and monitorability.

4. Awareness raising and screening

In general, it is recommended that schools be screened in order to gain an understanding of the scale and state of the buildings, which will indicate the likelihood of and need for measures on ventilation, the use of certain building products (construction materials and furniture), remediation etc.

The starting point could be to raise awareness of the need to improve indoor air in schools.

(See in the attached Annex 7.1)

WP7 Risk management and development of guidelines /recommendations provides recommendations for establishing international guidelines to help national governmental and non-governmental stakeholders to improve the general indoor school environment, with particular attention to health and IAQ. For the European Commission, it is recommended to develop generic guidelines in order to give countries the possibility to develop fit-for-purpose strategies according to the national and local situation.

Many countries in Europe have legislation in place that directly or indirectly aims to improve the health of school children and staff. Many countries, however, do not have legislation in place that is primarily directed to improving IAQ in school buildings. A non-exhaustive overview was carried out of information on the promotion of healthy school environments provided by SINPHONIE partners on (inter)national initiatives. By analysing this information and identifying common aspects and differences, criteria can be established to support the prioritisation of possible measures. These criteria allow stakeholders to gain greater insight into the effectiveness, proportionality, practicality and monitorability of possible measures. An important step supporting this prioritisation process is to carry out cost-benefit analyses prior to the implementation of measures. Possible measures fall into five categories: 1) hygienic requirements for cleaning procedures and frequency; 2) awareness raising; 3) good ventilation practice; 4) the use of products/materials; and 5) technical interventions.

3.8 Work Package 8: Communication and dissemination

This work package focused on the distribution of project results through the organisation of meetings and seminars, the publication of information brochures, and website management. The main objectives of the work package were to:

- develop an information strategy plan for the dissemination of project findings to various target groups;
- develop an internal and external communication strategy and tools for the project, such as website, leaflets, newsletter and press releases;
- disseminate the project results to policy makers, the media, schools and parents via project publications.

The REC was responsible for this WP and coordinated project communication and dissemination activities with the cooperation of the WP co-leader IDMEC-FEUP. Several partners from the consortium also contributed to the various tasks:

- Development of information leaflet and brochure for school staff and children: REC, IDMEC-FEUP.
- Translation of brochures for school staff and children into 19 national languages: all partners.
- Contribution of short articles to the newsletters: REC, IDMEC-FEUP, JRC, NIEH, THL, USiena, UAVR, UPMCParis, TNO, UMalta, UBA-A, IEH, UCL, VITO, CNRPalermo, CSTB, KTU, LGH, NCPHA, UMIL, director of DG Sanco John F. Ryan, AC chair Luciana Sinisi, WHO former head of the Bonn office Michal Krzyzanowski.
- Development of final brochure: REC, IDMEC-FEUP, HVDGM, JRC, NIEH, UMIL.
- Development of website, maintenance and regular updating: REC, Iconica Bt.

3.8.1 Website

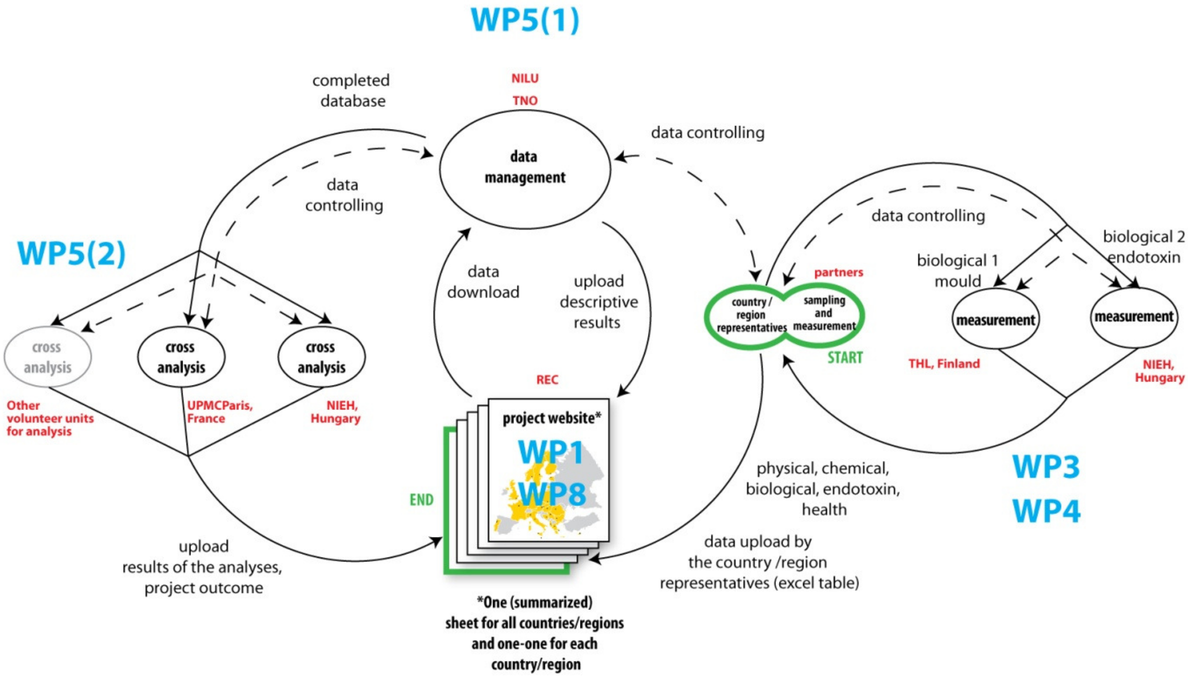
The website is an important and efficient tool for supplying basic project information to the public about the SINPHONIE profile, context, methods and results. The partner area contains information about the work plan and its implementation, allowing access by project partners to internal data. Data entry requires strong cooperation between those responsible for database structure and website management.

Two separated areas:

1. A public area to ensure the visibility of the project (WP8 Communication and dissemination – Objective 1)

2. A restricted partner area: an interactive space for project partners' communication and project management for authorised partners only (WP1 Management and coordination dissemination – Objective 2). WPs, protocols, timelines, data from fieldwork (for uploading and downloading datasheets by country/region), results.

The role of the restricted partner area in data processing



Technical description:

The site was developed in Drupal, an open source content management platform, and hosted by the Regional Environmental Center in Szentendre, Hungary.

The structure of the *public site* follows the general rules for web presence and provides easy navigation and access for all public-related information. The structure of the *restricted partner area* follows the logic of the project design and is divided by WPs, country-related tasks and results and provides resources for partners.

All country coordinators are able to manage their own site, download templates and upload datasheets. Institutes involved in data cleaning, validation and analysis also use the website as the data management platform. The site developer was provided with all kinds of user support (written user guide, personal consultation via email or Skype, or taking over tasks when necessary).

Obstacles:

As to be expected in such a large project, there were minor hitches but, thanks to the careful planning and expertise of the partners, the process went according to plan. Fortunately there were no significant technical problems.

(The detailed website report can be found in Annex 8.9)

3.8.2 Brochures

Project brochures were produced to inform target groups about the importance of IAQ and to provide a summary of the project. Each brochure highlights the importance of collaboration with the target groups, especially during field activities.

- *The* ***promotional brochure*** provides general information about the project, its background and structure, and the importance of the research (published in November 2010).

- *The* ***brochures for children, parents and school staff*** highlight the importance of IAQ in connection to the survey and raise awareness of the topic (published in May 2011).

- *The* ***brochure on project achievements*** disseminates the outcomes of the SINPHONIE project to school staff and parents and motivates them to participate in follow-up actions in European schools and to contribute to better IAQ in schools. An additional two pages for children summarises the most important aspects of the SINPHONIE research in an easily understandable way in order to develop a healthier school environment. (The brochure and insert page were published in January 2013 in 20 languages).

3.8.3 Newsletters

The e-newsletter SinphonieNews provides an overview of project implementation and presents important project milestones.

- ***Issue 1*** reported on the kick-off meeting and the outcomes of the training activities (published in October 2011).

- ***Issue 2*** provided an overview of the current status of the SINPHONIE project, including reports on the school field studies and data management (published in April 2012).

- ***Issue 3***, published for the project closing meeting, provided a basis for the final SINPHONIE project report by analysing the output of the school field activities, data management and analysis (published in September 2012).

3.8.4 Posters

Posters were produced to highlight the most important aspects and milestones of the SINPHONIE project.

Two large and four smaller posters were created, illustrating the geographical scope of the project, presenting the project in numbers, outlining the research design, listing the IAQ projects that served as a background study, and highlighting data management tasks and further research activities.

Review of impact of the action:

The website is a valuable tool for networking and ensuring the exchange of information between project partners. Coordinating and implementing data management among the 23 participating countries through the website proved the effectiveness of the database.

The brochures proved to be effective tools during the field activities in the schools by providing a good overview with easily understandable information about the project and the field measurements.

The newsletters provided important information about project milestones and achievements in an easily accessible format for the public.

The posters were ideal tools for increasing project visibility during dissemination events.

4 Lessons learnt

4.1 Management

The two-year SINPHONIE project brought together the multidisciplinary expertise of 39 institutions from 25 countries. One of its main objectives was to collect information on IAQ and children's health from schools throughout Europe using comparable methodologies. The project partners are now preparing guidelines and recommendations on indoor air quality in schools in order to improve the air that children breathe and to create a healthy school environment. The project outputs will be disseminated to actors involved in the planning and management of school infrastructure; stakeholders and policy makers at European and national level; and local actors (building owners, teachers, pupils and parents).

The high number of institutes and broad expertise of the project partners required intensive project coordination. The project CC and TC created an excellent expert network to implement the WPs successfully.

4.2 Content: lessons learnt from the field work, data management and analysis

For WP3, the successful participation of individual schools in the project was largely dependent on the quality of the information provided to the school staff and managers. The goodwill of the school coordinating board also influenced each school's flexibility and willingness to participate in the SINPHONIE study.

Information on school building/classroom characteristics was gathered using the checklists during inspections and visits that took place after contacting the school managers and staff.

The organisation of the field studies was made complex as a result of the large number of participating partners and the very broad range of experience in the field. However, the development of common tools, the organisation of dedicated training sessions, and the constant assistance available to fieldworkers and lab technicians proved that harmonised procedures and criteria can coexist with flexibility and the capacity building of the various participating labs if appropriate quality control is put in place.

An appropriate sample coding system is essential in order to link all the information related to a particular room or building, and to transfer those data into a centralised database. Various datasets were produced (e.g. information from checklists, concentrations of analytes etc.). An appropriate procedure for data cleaning and validation was the final step before the database was ready for analysis. It was important to define this step clearly in terms of actors and timing.

One of the lessons learnt by WP4 is that when planning a school survey, it is important to bear in mind that a school is a complex whole comprising principal, teachers, staff, plans, lesson scheduling etc., which may be difficult to fit in with. In this context, all activities should be planned well in advance in order to optimise the quality of school staff participation in the fieldwork.

The tools used to collect technical information (checklists) should be streamlined in order to make them user friendly for non-professionals, who might manage them in the future outside the framework of the project.

4.3 Conclusions

Specific conclusion, tools, recommendations

SCL 1. **Technical and logistical support** was offered for the development and implementation of common methodologies for measuring indoor air pollution in all the participating countries.

SCL 2. **New exposure** data were generated, unique in terms of wide European coverage and enhanced data comparability due to the use of harmonised procedures/tools. Related information on school buildings/classroom characteristics was also gathered, making it possible to study interactions between IAQ and pollution sources in the school environment.

SCL 3. The study of the predicted **impacts of climate change** focused on the need to strengthen or initiate measures for improving the heat resilience of school buildings.

SCL 4. **Physical procedures** were identified, such as air exchange rates, which — combined with parameters such as indoor activities, number of occupants, and indoor materials — contribute to the generation of indoor pollution levels. An understanding of the “impact” of exchange rates is essential for IAQ management in sensitive spaces such as classrooms.

SCL 5. When gathering such a variety of data from so many European countries, greater time should be spent initially on the **standardisation of approaches in order to harmonise over the measurement protocols and procedures to be employed.** For instance, the training session should be longer and more comprehensive in content, and a process similar to the Continuous Medical Education process should be implemented.

SCL 6. **Close collaboration** is advisable right from the outset of the study between those in charge of elaborating the questionnaires and those in charge of implementing the project’s database.

SCL 7. In order to **facilitate an efficient data management and subsequent robust data analyses**, great attention should be given to the standardisation of data input gathering and assimilation procedures among the partners.

SCL 8. When planning a huge **multi-centre study such as SINPHONIE**, it is necessary to allocate more time for data cleaning, data validation and data analysis in order to perform robust data analyses and produce meaningful results including the elaborate of fruitful recommendations and guidelines.

SCL 9. Preliminary impressions from the SINPHONIE fieldwork suggest that IAQ in the school environment is a latent but consistent issue. **All the standardised tools developed and used during SINPHONIE represent important outputs that can be further used in similar multi-centre studies, as well as in routine controls.**

SCL 10. The **enormous SINPHONIE database** produced represents an important starting point from the perspective of the long-term monitoring of changes in future IAQ polices related to the EU school environment..

SCL 11. Several countries in Europe have **legislation** in place that directly or indirectly aims to improve hygiene in schools and the health of schoolchildren and staff. Many countries, however, do not have legislation in place that is primarily directed to improving IAQ in school buildings. A non-exhaustive overview was undertaken of information on the promotion of healthy school environments provided by SINPHONIE partners in their countries and also on other international initiatives. By analysing this information and the common aspects and differences, criteria were established to **support the prioritisation of possible measures**. These criteria are available to help stakeholders gain greater insight into the effectiveness, proportionality, practicality and monitorability of possible measures. An important step supporting this prioritisation process is to carry out cost-benefit analyses prior to the implementation of measures. Possible measures fall into five categories: 1) hygienic requirements for cleaning procedures and frequency; 2) awareness raising; 3) good ventilation practice; 4) the use of products/materials; and 5) technical intervention.

SCL 12. Communication and dissemination tools were used to inform the public, stakeholders and decision makers about the project results and achievements. As this research project was very complex, different communication tools were employed to convey the main message of the project to stakeholders and a variety of target groups.

Brochures accustomed for specific target groups were very useful during the implementation of the field activities. School staff, parents and children were very interested in the process and the brochures were served as awareness-raising tools. As the experts had not communicated directly with school staff, parents and children, the brochures helped to explain them the field activities in an easily understandable way.

The Final SINPHONIE brochure for schools provided tips and recommendations for a healthy school environment in Europe in 20 languages (www.sinphonie.eu).

SCL 13. The SINPHONIE project contributes significantly to the implementation of the Parma Declaration of WHO and the achievement of its Regional Priority Goal no 3.

4.4 Main conclusions and further steps

MCL 1. The SINPHONIE project, supported by the European Parliament and run under the Public Health Program of DG SANCO, was the first pilot project to monitor the school environment and children's health in parallel in 23 European countries.

The two-year SINPHONIE project brought together the multidisciplinary expertise of 39 institutions from 25 countries. One of its main objectives to collect information on indoor air quality and children's health from schools throughout Europe using comparable methodologies was successfully reached.

The project partners has started to use guidelines and recommendations on indoor air quality in schools in order to improve the air that children breath and to create a healthy school environment throughout the EU.

The SINPHONIE outcome will be disseminated to actors involved in the planning and management of school infrastructure; stakeholders and policy makers at European and national level; and local actors (building owners, teachers, pupils and parents). The project contributes to the fulfilment of the Parma Declaration commitments in terms of policy development and environmental health actions.

MLC 2. The project partners are envisaging to a following up the SINPHONIE project to fill in the research gaps identified and to contribute in setting up of harmonised guidelines and an inventory of best school practice on IAQ and children's health in Europe.

The results of SINPHONIE put in evidence important aspects concerning the complex pattern of the interrelations between physical, chemical and biological factors, exposures, sources/causes and health impacts on school children. The exposure to a mixture of physical, chemical and biological factors linked to a variety of indoor sources and its relation to the burden of disease observed in school children and staff needs to be further and deeply investigated in order to be able to protect the younger generation from a wide range of respiratory symptoms associated to poor IAQ in the school environment.

As 2013 is the Year of Air for Europe**,** it is an ideal opportunity to promote air quality and health in schools and call for actions at both, EU and MS levels. The outcome of the SINPHONIE project and its envisaged follow-up can greatly contribute in putting in place the aspirations of this important initiative and increase healthy and sustainable lifestyles in Europe.

Overall, SINPHONIE can be considered as a milestone project which provided standardised methodologies and tools and elaborated risk management options and guidelines for healthy air in school environments in Europe, yet it represented a unique opportunity and an excellent vehicle for capacity building for several national institutions mostly in the Eastern and Southern European countries. In this sense, it has been a clear case of 'technology transfer' on indoor air quality and health impact assessment in EU Member States. SINPHONIE's outcome is expected to trigger the need of undertaking further studies aimed at integrating exposures occurring in the school environment with home pollution loads, as children spend more than 60% of their time at home and also to elaborate and implement harmonised guidelines for a healthy school environment in Europe.

5 Annexes to the Final Technical Report

The annexes listed below were prepared by the WP leaders and co-leaders of the project.

Abbreviations used in the table:

PR1= Progress report 1 IR= Interim Report PR3= Progress Report 3

Draft FR= Draft Final Report n.a. = not applicable

Annexes of the Final Report	Annex earlier submitted at
1. Annex 1.: WP1 related documents (Management and coordination)	n.a
1.1. Updated list of submitted deliverables	n.a.
1.2. Reports	n.a.
1.2.1. DELIVERABLE 1.1 – Progress report 1	PR1
1.2.2. DELIVERABLE 1.2 – Interim report	IR
1.2.3. DELIVERABLE 1.3 – Progress report 3	PR3
1.2.4. DELIVERABLE 1.4 - Final report	Draft FR
1.3. Workplan	n.a.
1.3.1. Workplan	in all reports
1.3.2. Timetable of the fieldworks	IR Annex 3.2
1.4. Minutes of meetings	n.a.
1.5. SINPHONIE Consortium Agreement	IR Annex 2.2
1.6. Amendment to the Contract	n.a.
1.6.1. On JRC Status	IR Annex 2.3
1.6.2. On the extension	No
1.7. Cooperation with other projects/ programmes	n.a.
1.7.1. Associated partnership (Belgium)	IR Annex 2.1

Annexes of the Final Report	Annex earlier submitted at
1.7.2. WHO cooperation letter	PR3 Annex 2.4
2. Annex 2. WP2 related documents (Background report)	n.a
2.1. DELIVERABLE 2.1 Background report	IR Annex 4.1
2.2. DELIVERABLE 2.5 Peer reviewed articles	No
2.3. A case study	PR3 Annex 4.
3. Annex 3. WP3 related documents (Assessment of the outdoor/indoor school environment)	n.a.
3.1. DELIVERABLE 3.1.1 School and classroom checklists	IR Annex 5.1
3.2. DELIVERABLE 3.1.2 Data on school and classroom characterization	PR3 Annex 5.2
3.3. DELIVERABLE 3.2.1.a Protocol for physical and chemical measurements	PR1 Annex 4 és IR Annex 5.2
3.4. DELIVERABLE 3.2.1.b Data on physical and chemical measurements	PR3 Annex 5.2
3.5. DELIVERABLE 3.2.2 Motivation document on the school selection	IR Annex 5.3
3.6. DELIVERABLE 3.2.3 Report on the results of the main study and the case studies	Draft FR Annex 5.
3.7. DELIVERABLE 3.3.1.a Protocol biological – main study	PR1 Annex 4. és IR Annex 5.4
3.8. DELIVERABLE 3.3.1.b – Protocol biological – sidestudy	IR Annex 5.5
3.9. DELIVERABLE 3.3.2 Datasets from vacuumed floor dusts	PR3 Annex 5.2
3.10. DELIVERABLE 3.3.3 Datasets from settled dust	PR3 Annex 5.2
3.11. DELIVERABLE 3.3.4 –Datasets from QPCR indoor and outdoor	PR3 Annex 5.2
3.12. Report on WP 3.3. biological study	Draft FR Annex 6.
3.13. DELIVERABLE 3.4.1 – Report on the impact of traffic on IAQ	No
3.14. DELIVERABLE 3.4.2 – Report on the impact of climate change on IAQ	Draft FR Annex 7.
3.15. Reports on QA/QC trials for laboratories	IR Annex 5.9.

Annexes of the Final Report	Annex earlier submitted at
4. Annex 4. WP4 related documents (Assessment of health outcomes)	n.a.
4.1. DELIVERABLE 4.0.1 – Questionnaires	IR Annex 5.6
4.2. DELIVERABLE 4.0.2 – Assessment of absenteeism	No
4.3. DELIVERABLE 4.0.3 – Protocol for spirometry	IR Annex 5.7
4.4. DELIVERABLE 4.0.4 – Protocol for attention/concentration testing	IR Annex 5.8
4.5. DELIVERABLE 4.1.2 – Questionnaire data	PR3 Annex 5.2
4.6. DELIVERABLE 4.1.3 – Lung function data	PR3 Annex 5.2
4.7. DELIVERABLE 4.1.4 – Attention/concentration test data	PR3 Annex 5.2
4.8. DELIVERABLE 4.2.1 – Data on nasal patency	PR3 Annex 5.2
4.9. DELIVERABLE 4.2.2 – Data on break-up time	PR3 Annex 5.2
4.10. DELIVERBALE 4.2.3 – Data on exhaled nitric-oxide	PR3 Annex 5.2
4.11. DELIVERABLE 4.2.4 – Data on inflammatory cytokines in NAL	PR3 Annex 5.2
4.12. Results of the clinical health checks	No
4.13. Results of the attention test analysis	No
5. Annex 5. WP5 related documents (Data management, cross analysis and database)	**n.a**
5.1. DELIVERABLE 5.1 – Report on the relationship between building and IAQ	No
5.2. DELIVERABLE 5.2 – Report on the impact of air quality in schools and health	No
5.3. SINPHONIE database structure	IR Annex 6.1 and PR3 Annex 5.1 and draft FR Annex 8.
5.4. SINPHONIE database functionalities	IR Annex 6.2
5.5. SINPHONIE Variable table final	IR Annex 6.3
5.6. SINPHONIE schools per country table	IR Annex 6.4
5.7. Plan of data analyses	Draft FR Annex 9.

6. Annex 6. WP6 related documents (Health risk assessment)	**n.a**
6.1. DELIVERABLE 6.1 Report on health risk assessment	Draft FR Annex 10.
7. Annex 7. WP7 related documents (Risk management and development)	n.a.
7.1. Risk management & development of guidelines/recommendations (DELIVERABLE 7.1 DELIVERABLE 7.2)	Draft FR Annex 11.
8. Annex 8. WP8 related documents (Communication and dissemination)	n.a.
8.1. DELIVERABLE 8.1 – Information brochures to children, parents and school staff	PR1 Annex 5. and IR Annex 7.1 and Annex 7.2
8.2. DELIVERABLE 8.2 – website	PR1 Annex 5. And IR Annex 7.3 and draft FR Annex 12. (report)
8.3. DELIVERABLE 8.3 – Reports to children, parents and school staff - final brochure	No
8.4. SINPHONIE logo	PR1 Annex 5. and IR Annex 7.4
8.5. SINPHONIE project leaflet	PR1 Annex 5.
8.6. SINPHONIE newsletter	NL1 - IR Annex 7.5 NL2 - PR3 Annex 6.1 NL3-no
8.7. SINPHONIE posters	No
8.8. Data management flowchart	IR Annex 7.6
8.9. Summary of communication and dissemination activities	No

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