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Online Questionnaire as a Tool to Assess Symptoms and Perceived Indoor Air Quality in a School Environment

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Abstract: School environments are a complex entirety where various different exposure factors are related that contribute to the indoor air quality (IAQ) and may affect occupants' health and well-being. Indoor air questionnaires are useful for collecting information about the occupants' experiences and perceptions of the indoor air and for evaluating the results of the measures taken. A common way to implement health questionnaires is to ask the respondents to describe symptoms at certain time points, such as weeks or months. The aim of our study was to develop a short and easy online questionnaire to assess symptoms and perceived IAQ. We also aimed to test the usability of the questionnaire in school buildings and assess the differences between the online measurement data (CO_2, T, and RH) and the IAQ complaints and symptoms reported by the pupils. A total of 105 teachers and 1268 pupils in 36 classrooms at six schools answered the questionnaires over a two-week period. The participants completed the questionnaire always after the lesson in the studied classroom. We received 719 answers from the teachers and 6322 answers from the pupils. The results demonstrated that the teachers reported more IAQ problems and symptoms than the pupils did. Differences between classrooms were observed in both the IAQ problem and reference schools. The most common significant differences (p-value > 0.05) between the classrooms were among humidity, too cold air, and stuffy air, and among symptoms, dry/sore throat, tiredness, headache, and skin symptoms. Maximum values of CO_2 measurements and the highest prevalence of stuffy air were relatively consistent. The testing process demonstrated that such a questionnaire was suitable for adults and children aged at least 12 years. The results of our study suggest that a quick and easy online questionnaire that is completed within a short period may be useful for gathering valuable knowledge about perceived IAQ. It could be used in combination with other indoor environment investigations to produce detailed results and restorative measures.

Keywords: indoor air; health questionnaire; symptoms; pupils; teachers

1. Introduction

Indoor air quality (IAQ) problems are relatively common in school buildings around the world [1–5]. For example, one-half of U.S schools have IAQ problems [6], and in Finland, 75−85% of occupants in school buildings have reported some kind of IAQ problems [7,8]. Poor IAQ can cause health and comfort problems [9–17] and reduce learning performance [1,14,18,19], attendance [9,14],

and ambient comfort among occupants [1,20,21]. Further, school environments are particularly complex, and involve many different interconnected factors that can affect occupants' health [19,22,23].

The main causes of IAQ problems in school environments are inadequate ventilation and biological and chemical indoor contaminants [3,24]. A recent study in Finland [25] demonstrated that according to the measurements and ventilation problems reported by principals, 58% and 38% of schools have insufficient ventilation, respectively.

Owing to inadequate ventilation, indoor pollutant levels can increase, and pollutants can accumulate to levels that can cause health and comfort problems [26,27]. Inadequate ventilation may increase, e.g., carbon dioxide (CO_2) concentrations in schools to levels that do not meet building standards [1,20,28]. In classrooms, which typically have a large number of occupants at the same time, suitable ventilation is required in order to maintain low levels of CO_2 [29]. High CO_2 levels can affect school attendance [30,31], reduce student concentration [2], and cause respiratory problems [32,33]. Levels of ventilation rates may also strongly affect pupils' welfare, since better ventilation rates improve academic achievement [10,34,35] and decrease absence due to illness [21]. Good ventilation systems not only distribute adequate amounts of air to occupants and remove pollutants, they also control temperature and humidity to provide thermal comfort [36]. Indoor air that is too cold or too warm has been shown to increase symptom perceptions [37]. In Finland, indoor temperatures are often too high during the heating season—that is, winter time—particularly in buildings with mechanical ventilation, which desiccates the indoor air. There is evidence that very high room temperature (T) is associated with decreased academic achievement [10] and may increase the risk of flu-like symptoms [38]. Stuffiness has been reported as one of the factors that most frequently causes inconvenience in Finnish schools [11]. Furthermore, a correlation between increased classroom temperature and perceptions of poor IAQ was found [11]. A high relative humidity (RH) may be associated with airway infections [39].

Moisture damage in building materials enables the growth of microorganisms, and may cause higher exposure to spores, spore fragments, secondary metabolites, and cellular components of microbes [40,41]. The prevalence of moisture damage is estimated to be at least 25% in Finnish school buildings [4,25]. Although it is well known that indoor dampness and mold are strongly linked with an increased risk of respiratory symptoms, such as asthma development, the aggravation of asthma symptoms, dyspnea, wheeze, and cough [13,42–48], few studies have focused on mold and moisture problems in school buildings, as compared to home environments [49,50]. Moisture damage at schools may adversely impact pupils' [9,49–52] as well as teachers' respiratory health [15].

To investigate IAQ, in the 1990s in Örebro (at the Department of Occupational and Environmental Medicine in Örebro, Sweden), Kjell Andersson developed a standardized indoor air questionnaire (MM-40) for occupants at workplaces and schools [53]. The aim was to create a short and simple questionnaire with reliable, valid, and clear questions. In addition, questionnaires for pupils of secondary schools (MM-60) and for parents of primary school children (MM-80) were developed. In Finland, the Finnish Institute of Occupational Health (FIOH) created an Indoor Air Questionnaire based on MM-40 [54]. At the same time as when the MM questionnaire was presented in Finland, the so-called Tuohilampi questionnaire was developed for epidemiological studies [55]. Recently, some new questionnaires of perceived IAQ and symptoms have been developed for school environments [56].

However, currently used questionnaires are mainly used in workplaces to assess the associations between the indoor environment and the health of workers [54,57]. A commonly used method to explore perceived symptoms and IAQ with questionnaires is to inquire the prevalence of the symptoms during the last 12 or/and three months, or sometime during the last few weeks. Some studies have employed symptom diaries to investigate more accurately the differences in the symptoms and illnesses between days, normally over a span of a few weeks [58,59]. However, these are usually used to assess the agreement of a self-completed diary to monitor respiratory symptoms or assess a parent-completed retrospective questionnaire. Despite the constraints on and limitations of this study, the questionnaires

are suitable tools for investigating indoor air problems [54,55,57]. Previous research has shown that the results of subjective questionnaires correlate well with clinical and other health outcomes [60].

There is a need to develop an easy and quick online questionnaire to obtain real-time reports about the perceived IAQ and occupants' symptoms, and link this information to the measured IAQ. In the present study, we aimed to (1) develop and test a new online questionnaire in a real school environment, (2) assess the usefulness and practicality of such an approach, (3) assess the differences between the measurement data (CO_2, T, and RH) and the reported IAQ complaints and symptoms among pupils.

2. Experiments

This study is part of *Indoor Air Police project* (funded by Business Finland, grant number 4098/31/2015); detailed information of the project can be found in previously published papers [61,62]. In this study, we developed a short and relatively simple online questionnaire that could be used to report real-time indoor environment conditions, such as the perceived IAQ in a designated classroom during a specific hour. Based on this specific information, potential IAQ problems could be located, and the correlation between occurring discomfort and time and/or place could be determined precisely. In systematic usage, this questionnaire could provide information quickly to the building owner and expedite possible required actions. Questions and options were selected based on previous questionnaires on IAQ and symptoms, e.g., Örebro MM-60 and MM-80 [53]. The questionnaire was administered at schools during the field measurements, to both teachers and pupils separately. The questionnaire included sections on respiratory and other symptoms and perceived IAQ, and those were asked every time. The answering options for those were "no", "little" and "a lot of". The selection of options "little" and "a lot of" were categorized as "yes". In addition, the question about "do the symptoms decrease when you are not at school" was asked every time. Questions on age, gender, perceived health, allergic diseases, respiratory illnesses during the last two weeks, pets, moisture damage at home, size of the family, type of accommodation, and smoking were asked only the first time. The questionnaires for teachers and pupils were not very different, except that the questions on time spent during schooldays in their own classroom were only asked to the teachers. The perceived health was assessed through the question "How is your health condition at this moment", and the answering options were "excellent", "good", "rather good", "rather bad", and "bad". Filling the questionnaire took a few minutes. The questionnaire is available in the supplementary material (Supplement S1).

The teachers and pupils received a link to the questionnaires via email or through the official school communication network program called "Wilma", in order to test the suitability of the implementation. Participants were required to fill the form after every lesson in the studied classroom over a two-week period using smartphones or computers. In case of technical problems, the schools were also provided with paper versions of the questionnaires. All of the parents were informed of the study, and they had the choice to disallow their child's participation in the study. Participation was voluntary, and participants were able to discontinue at any time.

Such an approach gave us several alternatives to explore the relationship between the measured and perceived IAQ. The retrospective time of our questionnaires was one hour, the fieldwork duration was two weeks (from Monday to Friday), and the same occupants provided several answers, depending on how many lessons they had in the study classrooms. Thus, we were able to get several answers from the same pupils and teachers from different locations at different times. We were thus able to assess the differences between location, perceived IAQ factors, and possible symptoms. We could also observe in parallel measurement and perceived data on an hourly basis, which enabled the very accurate inspection of potential deviations.

Seasonal factors can affect occupants' perceptions [63]. In this study, the questionnaires were conducted between October 2016 and March 2017, which is during the cold winter season. Therefore, seasonal variations between schools are minor, and the outdoor conditions can be considered comparable in each questionnaire.

The fieldwork was conducted in six secondary schools with (four schools) and without (two schools) reported IAQ problems between October 2016 and March 2017. The schools were located in the metropolitan area of Helsinki in southern Finland. Therefore, the schools were located in an urban area. However, they were not located in the city center, near crowded streets, or close to heavy traffic. All of the schools had mechanical supply and extract ventilation systems. The pupils were in the fifth to ninth grades (age range, approximately 11 to 15 years) and primarily in the seventh to ninth grades. From each school, we assessed six classrooms, so altogether, 36 classrooms were investigated in the study. The principals of the selected schools and the main indoor air worker specialists of the city were asked to select the classrooms so that they represented the IAQ situation of the each school as accurately as possible. Selection criteria was as follows: normal classroom (no extra emissions such as chemistry classroom), teaching hours as much as possible and preferably only classrooms with seventh to ninth-grade pupils. In addition, the principals named one classroom that had the worst conditions or had the most indoor air problems. Information about the school buildings is presented in Table 1.

Table 1. Information about the studied school buildings.

Number	City	Year of Construction	Year of Renovation
School 1 *	Vantaa	1980, extension 2013–2014	—
School 2	Vantaa	2006	—
School 3	Vantaa	2006	—
School 4 *	Helsinki	1955	2010–2012 (also repaired for low energy use)
School 5	Vantaa	1968, extension 2002	2003–2005
School 6	Helsinki	2009	—

* reference schools.

CO_2, T, and RH measurements were conducted in every one of the 36 classrooms during the two-weeks fieldwork period using Rotronic CL 11 devices. The device performed measurements every 10 min for the entire two weeks, and the device was placed on the teachers' table in the front of the classroom. The accuracy of the Rotronic CL 11 devices for each parameter is as follows: T $\pm$ 0.3 °C, RH $\pm$ 3% (10% … 95%), and CO_2 $\pm$ 30 ppm, +5% of reading. In one school, two classrooms faced technical problems, wherein the measurement was performed only for one day in one classroom and three days in the other classroom. All of the measurements were performed for the same time using the questionnaire. For the analysis, we classified the results according the Finnish Classification of Indoor Environment and Material Emission [64], which is a national classification in Finland to estimate IAQ. Classification is based on three classes: S1 (best possible), S2 (good IAQ), and S3 (minimum requirements of Finnish regulations). The threshold values of the Finnish Classification of Indoor Environment and Material Emission are presented in Table 2.

Table 2. The objective values of CO_2, temperature, and relative humidity of indoor air in Finland according the Finnish Classification of Indoor Environment and Material Emission.

	Unit	S1	S2	S3
CO_2	ppm	<350 + outdoor count	<550 + outdoor count	<800 + outdoor count
Room tempetarture *				
minimum values	°C	20.5–22.5	20.5–23	20
maximum values	°C	22–25	21–26	27
Relative humidity **	%	not notified	not notified	not notified
Stability of the conditions	%	90	90	—

* operative, the values depend on the outdoor temperature; ** former 25–45% in S1: used in our classification in Tables 4–9.

In addition, in the most problematic classrooms (based on the most frequently reported IAQ problems), several other IAQ measurements (humidity, temperature, carbon dioxide, TVOC, ozone, arsine, ammonia, hydrogen sulfide, formaldehyde, particulate matter, dustiness, noise, and lightness) were carried out. The results of these will be published in a separate paper (manuscript under preparation).

For the analyses, we used cross-tabulations, Pearson χ^2-test, and Fisher's exact test. Analyses were performed by using the procedure in SPSS-25.0 for Windows (SPSS, Inc., Chicago, IL, USA).

3. Results

3.1. Basic Information

From all six studied schools, 105 teachers and 1268 pupils answered the questionnaire. We received 719 answers from the teachers and 6322 answers from the pupils over two weeks. Pupils' answers from schools varied between 235 and 1478 and between 49 and 213 for teachers. We noticed that pupils under 12 years old had difficulties in filling out the online questionnaire within a few minutes. The most common problem among both teachers and pupils was that internet connections were unstable, and we therefore also received filled-out paper questionnaires (20%). Some pupils' answers were inappropriate, and were removed from the final data (less than 5% of the total).

Of the total, 24.8% of the teachers and 50.5% of the pupils were men. The teachers' and the pupils' median ages were 42 years and 14 years, respectively. The most common allergic disease was allergic rhinitis, and the most common respiratory illnesses during the two weeks prior were flu for both teachers and pupils. Among the teachers and pupils, 26.7% and 51.2% had pets, respectively. Among the teachers and pupils, 61.9% and 76.8% respectively reported that their perceived health is good or excellent. The proportion of the responses received and the background information are presented in Table 3.

Table 3. Proportion of the responses received from all of the schools, and the background information of the teachers and pupils.

	Teachers	**Pupils**
Total answers	**n = 719**	**n = 6322**
	n (%)	**n (%)**
Schoools with IAQ-problems	537 (74.7)	4732 (74.8)
Reference schools *	182 (25.3)	1590 (25.2)
School 1 *	49 (6.8)	335 (5.3)
School 2	164 (22.8)	1969 (31.1)
School 3	213 (29.7)	1050 (16.6)
School 4 *	133 (18.5)	1255 (19.9)
School 5	111 (15.4)	1478 (23.4)
School 6	49 (6.8)	235 (3.7)
Firts answers	**n = 105**	**n = 1268**
	n (%)	**n (%)**
Gender; men	26 (24.8)	640 (50.5)
Age; median (min-max)	42 (23–64)	14 (917)
Allergic diseases	48 (45.7)	295 (23.3)
Asthma	8 (7.6)	89 (7.0)
Hay fever/Allergic rhinitis	35 (33.3)	193 (15.2)
Atopic eczema	14 (13.3)	42 (3.3)
Allergic ophthalmia	2 (1.9)	24 (1.9)
Respiratory illnessess	44 (41.9)	602 (47.4)
Flu/common cold	40 (38.1)	564 (44.4)
Tonsillistis	1 (1.0)	16 (1.3)
Otitis	5 (4.8)	17 (1.3)

Table 3. *Cont.*

	Teachers	Pupils
Sinusitis	9 (8.6)	23 (1.8)
Bronchitis	5 (4.8)	10 (0.8)
Pneumonia	2 (1.9)	11 (0.9)
Perceived health		
Good/excellent	65 (61.9)	974 (76.8)
Pets	28 (26.7)	649 (51.2)
Dog/dogs	18 (17.1)	415 (32.7)
Cat/cats	9 (8.6)	186 (14.7)
Other	6 (5.7)	138 (10.9)
Current smoking	4 (3.8)	21 (1.7)

Associations among allergic diseases, respiratory illnesses, and perceived health in the schools with indoor air quality (IAQ) problems and reference schools demonstrated that teachers reported more allergic disease in schools with IAQ problems than in the reference schools, and the difference between atopy were significant (p-value 0.010). However, respiratory illnesses were more common in the reference schools. In addition, the perceived health was better among teachers in the reference schools. Among the pupils, those differences were more obvious, and pupils of schools with IAQ problems reported more allergic diseases, respiratory illnesses, and worse perceived health. Differences were significant among asthma (p-value 0.030), respiratory illnesses during the last two weeks and flu (p-value <0.001), and perceived health (p-value 0.03). The results are presented in Supplement Table S1.

3.2. Symptoms and Perceived IAQ between Reference and IAQ Problem Schools

Teachers reported poorer IAQ and different symptoms during the last hour than pupils. In addition, occupants of schools with IAQ problems reported poorer IAQ and more symptoms. Differences were significant among teachers with both poor IAQ and symptoms during the last hour, and among pupils with symptoms during the last hour (p-values < 0.001). Both teachers and pupils mostly reported dry air and stuffy air, and teachers also reported dustiness and pupils reported cold air. Among the teachers, differences in the poor IAQ factors were more obvious than in the pupils, and dry air, very cold air, draftiness, stuffy air, and dustiness were significantly elevated among teachers in schools with IAQ problems. However, very warm air was significantly elevated in reference schools among both pupils and teachers. Most of the symptoms during the last hour were significantly elevated in schools with IAQ problems among both teachers and pupils. Most reported symptoms were sore throat, hoarseness, headache, eye symptoms, and stuffiness. Pupils reported also tiredness. Pupils reported more commonly that symptoms decrease when not at school, as compared to teachers; however, there were no significant differences between IAQ problems and reference schools. These results are presented in Supplement Table S2.

3.3. Symptoms and Perceived IAQ between Six Study Schools

The results between the six schools indicate that two schools (schools 5 and 6) in particular had IAQ problems unlike the other schools, when observing different IAQ factors among teachers. Furthermore, teachers from the school with IAQ problems (school 2) reported very different symptoms during the last hour (Supplement Table S3). The same trend was seen among pupils but not so clearly; however, all of the differences were significant (Supplement Table S4). In schools with a high prevalence of IAQ factors and symptoms (school 6), atopy among teachers and allergic eye inflammation among pupils were significantly elevated. In addition, in another school (school 5 and school 3 (results not shown)) with a high prevalence of IAQ factors, flu was significantly reported among pupils.

3.4. Measurement Data

The measurement data CO_2, T, and RH were counted from school days and classified according the Finnish Classification of Indoor Environment and Material Emission S1, S2, and S3. In IAQ problem schools, the maximum measurement value of CO_2 was 1164 ppm, while in reference schools, it was 1623 ppm. In both IAQ problem and reference schools, approximately half of the classrooms were in classification S3 when observing CO_2 measurements. In addition, 41.7% of the reference school's classroom exhibited worse than S3 classification values. In IAQ problem schools, the second largest group was the S2 classification (37.5%).

In IAQ problem schools, the maximum temperature was 29.9 °C, and in reference schools, the maximum temperature was 26.2 °C, yet the averages were higher in the reference schools. In reference schools, 58% of the classrooms were in classification S3 or >S3, while in the IAQ problem school, the S1 classification was the largest (45.8%). The RH measurements indicated that indoor air is very dry, and the results were similar in both IAQ problem and reference schools.

3.5. Symptoms and Perceived IAQ between Classrooms in Each Study Schools

The results of the questionnaire demonstrated that there were many significant differences between the classrooms in both IAQ problem and reference schools. Humidity, very cold air, and stuffy air were most commonly reported significant issues between classrooms. However, the results between measurements and reported data were not entirely consistent. In four schools, the maximum CO_2 levels were observed in the same classroom, where the prevalence of stuffy air was high. Regarding the temperature, the measurement data agreed with the questionnaire data, but not so obviously. Inconsistencies were also observed in many cases. In addition, when the range between the maximum and minimum values of the temperature was high, the prevalence of draught was also higher in a few schools. There was no consistency between the RH measurements and questionnaire data with respect to dry or humid air.

The most commonly significant differences between classrooms among symptoms were dry/sore throat, tiredness, headache, and skin symptoms. The symptom prevalence was quite distinct between the different classrooms, since only in one IAQ problem school, almost all of the symptoms clearly increased in one classroom (school 5). Overall, there was no obvious similarity between the elevated reported IAQ quality factors and elevated reported symptoms in the classroom. Only in school 6 did the results demonstrate that both symptoms and IAQ factors were elevated in one classroom. More obvious was that IAQ factors were clustered in one or two classrooms, but the symptoms were steadily distributed, except for school 5, in which almost all of the symptoms were elevated in one classroom. The more obvious result was that the same classrooms that reported reduced IAQ factors also reported reduced symptoms. These results are presented in Tables 4–9.

Table 4. Differences between the classrooms in the IAQ problems and symptoms during the last hour among pupils, and the results of CO_2, temperature, and relative humidity measurements in school 1.

	Classroom 1–6						
	1	**2**	**3**	**4**	**5**	**6**	***p*-Value**
School 1 (Reference)	**n = 28**	**n = 34**	**n = 16**	**n = 89**	—	—	
IAQ-problems during last 1 h, %	10 (35.7)	9 (26.5)	**7 (43.8)**	28 (31.5)	—	—	*0.645*
Dryness of the air	**7 (25.0)**	2 (5.9)	**4 (25.0)**	10 (11.2)	—	—	*0.070*
Humidity of the air	2 (7.1)	1 (2.9)	**4 (25.0)**	5 (5.6)	—	—	***0.050***
Too cold	8 (28.6)	3 (8.8)	**6 (37.5)**	16 (18.0)	—	—	*0.063*
Too warm	4 (14.3)	2 (5.9)	**4 (25.0)**	10 (11.2)	—	—	*0.256*
Draughtiness	**3 (10.7)**	2 (5.9)	1 (6.3)	4 (4.5)	—	—	*0.589*
Stuffy air	**7 (25.0)**	3 (8.8)	0 (0.0)	14 (15.7)	—	—	*0.101*
Too dusty/Too dirty	**7 (25.0)**	1 (2.9)	2 (12.5)	12 (13.5)	—	—	*0.070*
Odour of mold	**3 (10.7)**	0 (0.0)	1 (6.3)	3 (3.4)	—	—	*0.122*
Fragnance/perfume	**3 (10.7)**	1 (2.9)	0 (0.0)	3 (3.4)	—	—	*0.312*
Two weeks measurements *							
CO2: Average (min-max)	628 (414–1323)	660 (404–1360)	484 (358–854)	666 (370–1411)	560 (423–967)	571 (349–1143)	
IAQ-classification ^	>S3	>S3	S2	>S3	S3	S3	
Temperature: Average (min-max)	21.5 (18.7–23.2)	22.2 (17.8–25.5)	21.8 (20.3–23.3)	21.1 (16.1–23.1)	23.3 (22.4–24.7)	23.0 (21.7–24.3)	
IAQ-classification ^^	S1	S3	S1	S1	>S3	S3	
Humidity: Average (min-max)	28.3 (16.0–56.7)	27.0 (13.9–49.2)	25.2 (14.3–44.9)	29.1 (15.9–52.9)	24.3 (13.4–43.4)	23.8 (13.2–40.5)	
IAQ-classification ^^^	S1	S1	S1	S1	below	below	
Symptoms during last 1 h, %	7 (25.0)	5 (14.7)	**6 (37.5)**	25 (28.1)	—	—	*0.310*
Stuffy nose/cold	6 (21.4)	4 (11.8)	**4 (25.0)**	10 (11.2)	—	—	*0.299*
Dry/sore throat	**3 (10.7)**	3 (8.8)	0 (0.0)	9 (10.1)	—	—	*0.697*
Phlegm	2 (7.1)	**3 (8.8)**	0 (0.0)	4 (4.5)	—	—	*0.635*
Dry cough	2 (7.1)	**3 (8.8)**	1 (6.3)	6 (6.7)	—	—	*0.964*
Hoarseness	**3 (10.7)**	3 (8.8)	0 (0.0)	4 (4.5)	—	—	*0.400*
Shortness of breath	0 (0.0)	2 (5.9)	0 (0.0)	3 (3.4)	—	—	*0.745*
Weezing cough	0 (0.0)	2 (5.9)	0 (0.0)	3 (3.4)	—	—	*0.745*
Eye symptoms	**4 (14.3)**	2 (5.9)	0 (0.0)	5 (5.6)	—	—	*0.361*
Tiredness	5 (17.9)	3 (8.8)	**3 (18.8)**	16 (18.0)	—	—	*0.626*
Pain in joints	0 (0.0)	2 (5.9)	**1 (6.3)**	4 (4.5)	—	—	*0.576*
Muscle pain	2 (7.1)	**3 (8.8)**	0 (0.0)	3 (3.4)	—	—	*0.452*
Headache	**5 (17.9)**	4 (11.8)	1 (6.3)	7 (7.9)	—	—	*0.450*
Skin symptoms (itch/erythema)	0 (0.0)	**1 (2.9)**	0 (0.0)	1 (1.1)	—	—	*0.717*
Concetration difficulties	1 (3.6)	**3 (8.8)**	1 (6.3)	2 (2.2)	—	—	*0.275*

* School days during 8–16 o'clock; Highest prevalences are bolded; *p*-values < 0.05 are bolded; ^ The maximum values for CO_2 are: 700 ppm S1, 900 ppm S2, 1200 ppm S3; ^^ In winter. 21–22 °C S1, 20–22 °C S2, 20–23 °C S3; ^^^ 25–45% in winter S1, S2 and S3 not notified.

Table 5. Differences between the classrooms in the IAQ problems and symptoms during the last hour among pupils, and the results of CO_2, temperature, and relative humidity measurements in school 2.

	Classroom 1–6						
	1	**2**	**3**	**4**	**5**	**6**	***p-Value***
School 2	**n = 244**	**n = 382**	**n = 382**	**n = 235**	**n = 334**	**n = 368**	
IAQ-problems during last 1 h, %	76 (35.2)	**178 (50.3)**	109 (28.5)	84 (38.5)	111 (34.3)	160 (43.5)	***<0.001***
Dryness of the air	35 (16.2)	82 (23.2)	71 (18.6)	54 (24.8)	66 (20.4)	**112 (30.4)**	***<0.001***
Humidity of the air	12 (5.6)	6 (1.7)	15 (3.9)	11 (5.0)	11 (3.4)	**23 (6.3)**	***0.045***
Too cold	43 (19.9)	**116 (32.8)**	63 (16.5)	40 (18.3)	53 (16.4)	62 (16.8)	***<0.001***
Too warm	10 (4.6)	11 (3.1)	16 (4.2)	10 (4.6)	18 (5.6)	**40 (10.9)**	***<0.001***
Draughtiness	16 (7.4)	**45 (12.7)**	31 (8.1)	24 (11.0)	19 (5.9)	33 (9.0)	***0.036***
Stuffy air	39 (18.1)	85 (24.0)	72 (18.8)	51 (23.4)	65 (20.1)	**106 (28.8)**	***0.009***
Too dusty/Too dirty	32 (14.8)	49 (13.8)	53 (13.9)	**34 (15.6)**	38 (11.7)	51 (13.9)	*0.856*
Odour of mold	11 (5.1)	14 (4.0)	19 (5.0)	13 (6.0)	19 (5.9)	**28 (7.6)**	*0.402*
Fragnance/perfume	5 (2.3)	7 (2.0)	12 (3.1)	**12 (5.5)**	13 (4.0)	14 (3.8)	*0.256*
Two weeks measurements *							
CO2: Average (min-max)	513 (416–817)	551 (404–1025)	595 (396–969)	567 (410–1095)	580 (426–889)	540 (392–1095)	
IAQ-classification ^	S2	S3	S3	S3	S2	S3	
Temperature: Average (min-max)	20.0 (19.2–21.4)	19.3 (16.6–21.7)	19.9 (18.8–21.4)	20.5 (19.2–22.2)	20.6 (18.3–22.2)	21.7 (19.9–23.3)	
IAQ-classification ^^	S2	<S2	<S2	S2	S2	S1	
Humidity: Average (min-max)	22.2 (10.0–37.0)	24.2 (9.4–43.0)	24.1 (9.9–42.6)	23.4 (8.5–43.8)	21.9 (8.0–41.8)	20.4 (7.9–37.8)	
IAQ-classification ^^^	below	below	below	below	below	below	
Symptoms during last 1 h, %	77 (31.6)	**154 (40.3)**	102 (26.7)	93 (39.6)	121 (36.2)	**148 (40.2)**	***<0.001***
Stuffy nose/cold	35 (14.3)	72 (18.8)	53 (13.9)	**49 (20.9)**	66 (19.8)	73 (19.8)	*0.085*
Dry/sore throat	20 (8.2)	59 (15.4)	42 (11.0)	**45 (19.1)**	45 (13.5)	60 (16.3)	***0.004***
Phlegm	17 (7.0)	20 (5.2)	19 (5.0)	**26 (11.1)**	20 (6.0)	31 (8.4)	***0.034***
Dry cough	19 (7.8)	39 (10.2)	20 (5.2)	19 (8.1)	29 (8.7)	**38 (10.3)**	*0.130*
Hoarseness	17 (7.0)	47 (12.3)	19 (5.0)	24 (10.2)	30 (9.0)	**49 (13.3)**	***0.001***
Shortness of breath	7 (2.9)	32 (8.4)	17 (4.5)	**23 (9.8)**	19 (5.7)	26 (7.1)	***0.010***
Weezing cough	7 (2.9)	12 (3.1)	5 (1.3)	**11 (4.7)**	8 (2.4)	9 (2.4)	*0.228*
Eye symptoms	17 (7.0)	49 (12.8)	38 (9.9)	28 (11.9)	41 (12.3)	**49 (13.3)**	*0.159*
Tiredness	40 (16.4)	**81 (21.2)**	49 (12.8)	38 (16.2)	64 (19.2)	64 (17.4)	*0.060*
Pain in joints	7 (2.9)	12 (3.1)	8 (2.1)	**13 (5.5)**	8 (2.4)	9 (2.4)	*0.204*
Muscle pain	5 (2.0)	12 (3.1)	11 (2.9)	4 (1.7)	8 (2.4)	**12 (3.3)**	*0.822*
Headache	40 (16.4)	**80 (20.9)**	50 (13.1)	46 (19.6)	63 (18.9)	67 (18.2)	*0.090*
Skin symptoms (itch/erythema)	11 (4.5)	16 (4.2)	19 (5.0)	**21 (8.9)**	21 (6.3)	25 (6.8)	*0.153*
Concetration difficulties	15 (6.1)	46 (12.0)	22 (5.8)	**37 (15.7)**	34 (10.2)	33 (9.0)	***<0.001***

* School days during 8–16 o'clock; Highest prevalences are bolded; *p*-values < 0.05 are bolded; ^The maximum values for CO_2 are: 700 ppm S1, 900 ppm S2, 1200 ppm S3; ^^ In winter: 21–22 °C S1, 20–22 °C S2, 20–23 °C S3; ^^^ 25–45% in winter S1, S2 and S3 not notified.

Table 6. Differences between the classrooms in the IAQ problems, and symptoms during the last hour among pupils and results of CO_2, temperature, and relative humidity measurements in school 3.

	Classroom 1–6						
	1	**2**	**3**	**4~**	**5**	**6 ///**	***p*-Value**
School 3	**n = 247**	**n = 128**	**n = 184**	**n = 114**	**n = 128**	**n = 246**	
IAQ-problems during last 1 h, %	93 (37.7)	52 (40.6)	58 (31.5)	51 (44.7)	49 (38.3)	**116 (47.2)**	***0.028***
Dryness of the air	48 (19.4)	30 (23.4)	34 (18.5)	24 (21.1)	33 (25.8)	**71 (28.9)**	*0.090*
Humidity of the air	21 (8.5)	**16 (12.5)**	13 (7.1)	9 (7.9)	**16 (12.5)**	21 (8.5)	*0.433*
Too cold	64 (25.9)	27 (21.1)	29 (15.8)	30 (26.3)	32 (25.0)	**67 (27.2)**	*0.082*
Too warm	21 (8.5)	**16 (12.5)**	17 (9.2)	9 (7.9)	**16 (12.5)**	22 (8.9)	*0.648*
Draughtiness	24 (9.7)	14 (10.9)	11 (6.0)	13 (11.4)	**18 (14.1)**	23 (9.3)	*0.285*
Stuffy air	61 (24.7)	34 (26.6)	31 (16.8)	29 (25.4)	**38 (29.7)**	**73 (29.7)**	*0.054*
Too dusty/Too dirty	42 (17.0)	24 (18.8)	18 (9.8)	16 (14.0)	**25 (19.5)**	44 (17.9)	*0.141*
Odour of mold	24 (9.7)	14 (10.9)	13 (7.1)	7 (6.1)	**15 (11.7)**	24 (9.8)	*0.570*
Fragnance/perfume	23 (9.3)	**17 (13.3)**	13 (7.1)	9 (7.9)	15 (11.7)	18 (7.3)	*0.320*
Two weeks measurements *							
CO2: Average (min-max)	531 (394–887)	525 (411–792)	568 (406–919)	633 (438–902)	511 (399–798)	534 (394–1012)	
IAQ-classification ^	S2	S2	S3	S3	S2	S3	
Temperature: Average (min-max)	19.3 (17.7–21.6)	21.2 (19.7–22.9)	21.1 (19.9–22.2)	21.5 (20.1–22.4)	21.8 (19.8–23.1)	20.7 (13.8– 22.8)	
IAQ-classification ^^	<S2	S1	S1	S1	S1	S2	
Humidity: Average (min-max)	25.6 (13.0–39.3)	23.6 (12.4–36.8)	24.8 (11.8–39.9)	32.1 (29.5–36.5)	22.0 (10.5–34.7)	33.0 (25.1–49.5)	
IAQ-classification ^^^	S1	below	below	S1	below	S1	
Symptoms during last 1 h, %	72 (29.1)	39 (30.5)	41 (22.3)	**40 (35.1)**	31 (24.2)	81 (32.9)	*0.091*
Stuffy nose/cold	**46 (18.6)**	20 (15.6)	20 (10.9)	20 (17.5)	14 (10.9)	42 (17.1)	*0.172*
Dry/sore throat	21 (8.5)	15 (11.7)	13 (7.1)	16 (14.0)	8 (6.3)	**37 (15.0)**	***0.024***
Phlegm	10 (4.0)	**7 (5.5)**	5 (2.7)	5 (4.4)	4 (3.1)	12 (4.9)	*0.819*
Dry cough	**17 (6.9)**	4 (3.1)	3 (1.6)	6 (5.3)	6 (4.7)	5 (2.0)	***0.040***
Hoarseness	8 (3.2)	9 (7.0)	6 (3.3)	6 (5.3)	7 (5.5)	**20 (8.1)**	*0.144*
Shortness of breath	10 (4.0)	4 (3.1)	3 (1.6)	3 (2.6)	**12 (9.4)**	6 (2.4)	***0.008***
Weezing cough	4 (1.6)	2 (1.6)	0 (0.0)	2 (1.8)	3 (2.3)	9 (3.7)	*0.160*
Eye symptoms	12 (4.9)	**8 (6.3)**	8 (4.3)	2 (1.8)	5 (3.9)	11 (4.5)	*0.678*
Tiredness	32 (13.0)	12 (9.4)	11 (6.0)	15 (13.2)	13 (10.2)	**40 (16.3)**	***0.031***
Pain in joints	**3 (1.2)**	1 (0.8)	0 (0.0)	1 (0.9)	1 (0.8)	0 (0.0)	*0.461*
Muscle pain	**6 (2.4)**	1 (0.8)	3 (1.6)	2 (1.8)	3 (2.3)	4 (1.6)	*0.904*
Headache	36 (14.6)	11 (8.6)	17 (9.2)	**20 (17.5)**	13 (10.2)	41 (16.7)	*0.055*
Skin symptoms (itch/erythema)	4 (1.6)	1 (0.8)	1 (0.5)	**6 (5.3)**	3 (2.3)	3 (1.2)	***0.045***
Concetration difficulties	14 (5.7)	6 (4.7)	4 (2.2)	6 (5.3)	**9 (7.0)**	11 (4.5)	*0.452*

* School days during 8–16 o'clock; Highest prevalences are bolded; *p*-values < 0.05 are bolded; ^ The maximum values for CO2 are: 700 ppm S1, 900 ppm S2, 1200 ppm S3; ^^ In winter: 21–22 °C S1, 20–22 °C S2, 20–23 °C S3; ^^^ 25–45% in winter S1, S2 and S3 not notified; ~only one day measuremnts; /// only three days measurements.

Table 7. Differences between the classrooms in the IAQ problems and symptoms during the last hour among pupils and results of CO_2, temperature, and relative humidity measurements in school 4.

	Classroom 1–6						
	1	**2**	**3**	**4**	**5**	**6**	***p-Value***
School 4 (Reference)	**n = 227**	**n = 247**	**n = 61**	**n = 113**	**n = 252**	**n = 287**	
IAQ-problems during last 1 h, %	115 (50.7)	69 (27.9)	20 (32.8)	29 (25.7)	109 (43.3)	**171 (59.6)**	***<0.001***
Dryness of the air	59 (26.0)	46 (18.6)	11 (18.0)	12 (10.6)	39 (15.5)	**110 (38.3)**	***<0.001***
Humidity of the air	20 (8.8)	19 (7.7)	8 (13.1)	9 (8.0)	7 (2.8)	**53 (18.5)**	***<0.001***
Too cold	22 (9.7)	23 (9.3)	8 (13.1)	20 (17.7)	9 (3.6)	**56 (19.5)**	***<0.001***
Too warm	38 (16.7)	30 (12.1)	12 (19.7)	14 (12.4)	58 (23.0)	**105 (36.6)**	***<0.001***
Draughtiness	18 (7.9)	13 (5.3)	8 (13.1)	5 (4.4)	5 (2.0)	**46 (16.0)**	***<0.001***
Stuffy air	73 (32.3)	45 (18.2)	16 (26.2)	13 (11.5)	55 (21.8)	**125 (43.9)**	***<0.001***
Too dusty/Too dirty	29 (12.8)	21 (8.5)	10 (16.4)	12 (10.6)	20 (7.9)	**67 (23.3)**	***<0.001***
Odour of mold	17 (7.5)	13 (5.3)	8 (13.1)	15 (13.3)	4 (1.6)	**49 (17.1)**	***<0.001***
Fragnance/perfume	16 (7.0)	16 (6.5)	10 (16.4)	10 (8.8)	5 (2.0)	**58 (20.2)**	***<0.001***
Two weeks measurements *							
CO2: Average (min-max)	567 (403–1286)	604 (409–969)	547 (412–1017)	592 (406–962)	595 (409–1063)	726 (419–1623)	
IAQ-classification ^	>S3	S3	S3	S3	S3	>S3	
Temperature: Average (min-max)	23.0 (21.9–24.2)	22.8 (21.7–24.2)	22.5 (19.8–24.3)	21.8 (20.6–24.0)	21.9 (20.6–23.4)	24.5 (23.1–26.2)	
IAQ-classification ^^	>S3	S3	S3	S2	S2	>S3	
Humidity: Average (min-max)	20.3 (12.3–29.2)	21.2 (13.4–28.7)	19.8 (12.4–30.4)	21.8 (13.1–30.9)	21.9 (14.1–32.7)	20.7 (12.5–28.2)	
IAQ-classification ^^^	below	below	below	below	below	below	
Symptoms during last 1 h, %	86 (37.9)	50 (20.2)	13 (21.3)	16 (14.2)	76 (30.2)	**88 (30.7)**	***<0.001***
Stuffy nose/cold	22 (9.7)	28 (11.3)	4 (6.6)	4 (3.5)	31 (12.3)	**37 (12.9)**	*0.085*
Dry/sore throat	23 (10.1)	15 (6.1)	4 (6.6)	2 (1.8)	12 (4.8)	**32 (11.1)**	***0.005***
Phlegm	9 (4.0)	5 (2.0)	**5 (8.2)**	0 (0,0)	3 (1.2)	12 (4.2)	***0.008***
Dry cough	6 (2.6)	10 (4.0)	3 (4.9)	**6 (5.3)**	11 (4.4)	9 (3.1)	*0.798*
Hoarseness	11 (4.8)	9 (3.6)	2 (3.3)	0 (0.0)	7 (2.8)	**16 (5.6)**	*0.135*
Shortness of breath	10 (4.4)	3 (1.2)	2 (3.3)	0 (0.0)	**16 (6.3)**	8 (2.8)	***0.008***
Weezing cough	3 (1.3)	4 (1.6)	**2 (3.3)**	0 (0.0)	1 (0.4)	3 (1.0)	*0.325*
Eye symptoms	11 (4.8)	5 (2.0)	3 (4.9)	0 (0.0)	**17 (6.7)**	14 (4.9)	***0.028***
Tiredness	**46 (20.3)**	22 (8.9)	9 (14.8)	6 (5.3)	31 (12.3)	46 (16.0)	***0.001***
Pain in joints	2 (0.9)	2 (0.8)	**1 (1.6)**	0 (0.0)	1 (0.4)	1 (0.3)	*0.668*
Muscle pain	3 (1.3)	4 (1.6)	0 (0.0)	2 (1.8)	**10 (4.0)**	7 (2.4)	*0.378*
Headache	**28 (12.3)**	12 (4.9)	2 (3.3)	3 (2.7)	22 (8.7)	31 (10.8)	***0.003***
Skin symptoms (itch/erythema)	**5 (2.2)**	3 (1.2)	0 (0.0)	0 (0.0)	5 (2.0)	6 (2.1)	*0.611*
Concetration difficulties	**16 (7.0)**	9 (3.6)	1 (1.6)	1 (0.9)	11 (4.4)	11 (3.8)	*0.105*

* School days during 8–16 o'clock; Highest prevalences are bolded; *p*-values < 0.05 are bolded; ^ The maximum values for CO_2 are: 700 ppm S1, 900 ppm S2, 1200 ppm S3; ^^ In winter: 21–22 °C S1, 20–22 °C S2, 20–23 °C S3; ^^^ 25–45% in winter S1, S2 and S3 not notified.

Table 8. Differences between the classrooms in the IAQ problems and symptoms during last hour among pupils and results of CO_2, temperature, and relative humidity measurements in school 5.

	Classroom 1–6						
	1	**2**	**3**	**4**	**5**	**6**	***p-Value***
School 5	**n = 194**	**n = 74**	**n = 437**	**n = 282**	**n = 195**	**n = 285**	
IAQ-problems during last 1 h, %	111 (57.2)	**49 (66.2)**	153 (35.0)	152 (53.9)	101 (51.8)	167 (58.6)	***<0.001***
Dryness of the air	65 (33.5)	27 (36.5)	84 (19.2)	104 (36.9)	71 (36.4)	**108 (37.9)**	***<0.001***
Humidity of the air	**39 (20.1)**	2 (2.7)	38 (8.7)	46 (16.3)	23 (11.8)	44 (15.4)	***<0.001***
Too cold	46 (23.7)	**23 (31.1)**	80 (18.3)	80 (28.4)	44 (22.6)	79 (27.7)	***0.010***
Too warm	**43 (22.2)**	2 (2.7)	36 (8.2)	56 (19.9)	30 (15.4)	40 (14.0)	***<0.001***
Draughtiness	33 (17.0)	4 (5.4)	41 (9.4)	50 (17.7)	26 (13.3)	**53 (18.6)**	***0.001***
Stuffy air	**83 (43.0)**	22 (29.7)	88 (20.1)	93 (33.0)	71 (36.6)	119 (41.8)	***<0.001***
Too dusty/Too dirty	**56 (28.9)**	6 (8.1)	60 (13.7)	63 (22.3)	45 (23.1)	76 (26.7)	***<0.001***
Odour of mold	**42 (21.6)**	3 (4.1)	43 (9.8)	48 (17.0)	30 (15.4)	47 (16.5)	***<0.001***
Fragnance/perfume	**42 (21.6)**	4 (5.4)	42 (9.6)	44 (15.6)	26 (13.3)	40 (14.0)	***0.001***
Two weeks measurements *							
CO2: Average (min-max)	517 (388–858)	528 (392–1037)	637 (392–1306)	537 (396–956)	513 (391–963)	558 (389–920)	
IAQ-classification ^	S2	S3	>S3	S3	S3	S3	
Temperature: Average (min-max)	21.8 (19.5–24.3)	21.8 (20.3–27.9)	21.2 (19.9–22.72)	23.1 (21.4–29.9)	22.9 (19.9–26.3)	22.2 (20.5–23.8)	
IAQ-classification ^^	S1	S1	S1	>S3	S3	S3	
Humidity: Average (min-max)	15.7 (4.8–28.8)	15.9 (3.6–29.3)	17.3 (6.3–30.3)	14.3 (4.2–25.2)	13.5 (3.2–25.1)	15.2 (4.1– 28.2)	
IAQ-classification ^^^	below	below	below	below	below	below	
Symptoms during last 1 h, %	71 (36.6)	35 (47.3)	130 (29.7)	112 (39.9)	77 (39.5)	**148 (51.9)**	***<0.001***
Stuffy nose/cold	36 (18.6)	16 (21.6)	69 (15.8)	55 (19.6)	41 (21.0)	**85 (29.8)**	***0.001***
Dry/sore throat	31 (16.0)	7 (9.5)	44 (10.1)	48 (17.1)	35 (17.9)	**63 (22.1)**	***<0.001***
Phlegm	9 (4.6)	3 (4.1)	26 (5.9)	18 (6.6)	13 (6.7)	**20 (7.0)**	*0.869*
Dry cough	13 (6.7)	5 (6.8)	32 (7.3)	29 (10.3)	17 (8.7)	**41 (14.4)**	***0.021***
Hoarseness	9 (4.6)	2(2.7)	22 (5.0)	23 (8.2)	14 (7.2)	**32 (11.2)**	***0.011***
Shortness of breath	10 (5.2)	5 (6.8)	17 (3.9)	17 (6.0)	10 (5.1)	**21 (7.4)**	*0.467*
Weezing cough	3 (1.5)	1 (1.4)	7 (1.6)	3 (1.1)	3 (1.5)	**6 (2.1)**	*0.963*
Eye symptoms	24 (12.4)	4 (5.4)	27 (6.2)	31 (11.0)	22 (11.3)	**43 (15.1)**	***0.003***
Tiredness	38 (19.6)	16 (21.6)	60 (13.7)	56 (19.9)	38 (19.5)	**75 (26.3)**	***0.003***
Pain in joints	2 (1.0)	**2 (2.7)**	7 (1.6)	8 (2.8)	1 (0.5)	7 (2.5)	*0.344*
Muscle pain	**7 (3.6)**	2 (2.7)	5 (1.1)	6 (2.1)	3 (1.5)	6 (2.1)	*0.393*
Headache	36 (18.6)	**23 (31.1)**	50 (11.4)	44 (15.6)	36 (18.5)	62 (21.8)	***<0.001***
Skin symptoms (itch/erythema)	13 (6.7)	**7 (9.5)**	10 (2.3)	12 (4.3)	6 (3.1)	14 (4.9)	***0.024***
Concetration difficulties	12 (6.2)	**9 (12.2)**	27 (6.2)	22 (7.8)	18 (9.2)	23 (8.1)	*0.433*

* School days during 8–16 o'clock; Highest prevalences are bolded; *p*-values < 0.05 are bolded; ^ The maximum values for CO_2 are: 700 ppm S1, 900 ppm S2, 1200 ppm S3; ^^ In winter: 21–22 °C S1, 20–22 °C S2, 20–23 °C S3; ^^^ 25–45% in winter S1, S2 and S3 not notified.

Table 9. Differences between the classrooms in the IAQ problems and symptoms during the last hour among pupils and results of CO_2, temperature, and relative humidity measurements in school 6.

	Classroom 1–6						
	1	**2**	**3**	**4**	**5**	**6**	***p-Value***
School 6	**n = 14**	**—**	**n = 13**	**n = 101**	**n = 26**	**—**	
IAQ-problems during last 1 h, %	**14 (100.0)**	—	8 (61.5)	51 (50.5)	19 (73.1)	—	***0.002***
Dryness of the air	5 (35.7)	—	5 (38.5)	**43 (42.6)**	6 (23.1)	—	*0.338*
Humidity of the air	**5 (35.7)**	—	2 (15.4)	9 (8.9)	2 (7.7)	—	***0.037***
Too cold	**14 (100.0)**	—	6 (46.2)	38 (37.6)	16 (61.5)	—	***<0.001***
Too warm	**3 (21.4)**	—	2 (15.4)	7 (6.9)	3 (11.5)	—	*0.182*
Draughtiness	**8 (57.1)**	—	3 (23.1)	26 (25.7)	5 (19.2)	—	*0.084*
Stuffy air	**9 (69.2)**	—	4 (30.8)	21 (20.8)	8 (30.8)	—	***0.004***
Too dusty/Too dirty	**13 (92.9)**	—	3 (23.1)	22 (21.8)	3 (11.5)	—	***<0.001***
Odour of mold	**6 (42.9)**	—	2 (15.4)	8 (7.9)	3 (11.5)	—	***0.007***
Fragnance/perfume	**3 (21.4)**	—	2 (15.4)	9 (8.9)	4 (15.4)	—	*0.331*
Two weeks measurements *							
CO2: Average (min-max)	482 (409–795)	500 (395–1164)	470 (408–824)	493 (399–801)	469 (404–700)	590 (389–1052)	
IAQ-classification ^	S2	S3	S2	S2	S1	S3	
Temperature: Average (min-max)	21.1 (17.2–22.3)	21.2 (19.6–22.9)	21.3 (19.5–22.8)	20.4 (11.6–22.2)	20.5 (19.6–21.4)	18.9 (17.2–20.6)	
IAQ-classification ^^	S1	S1	S1	S2	S2	<S2	
Humidity: Average (min-max)	21.8 (11.2–28.2)	22.9 (11.0–32.5)	20.2 (9.8–28.1)	22.9 (11.0–46.0)	21.9 (10.3–29.2)	25.7 (13.9–34.3)	
IAQ-classification ^^^	below	below	below	below	below	S1	
Symptoms during last 1 h, %	**12 (85.7)**	—	3 (23.1)	49 (48.5)	9 (34.6)	—	***0.004***
Stuffy nose/cold	**7 (50.0)**	—	2 (15.4)	41 (40.6)	6 (23.1)	—	*0.095*
Dry/sore throat	**5 (35.7)**	—	3 (23.1)	24 (23.8)	1 (3.8)	—	***0.043***
Phlegm	**3 (21.4)**	—	2 (15.4)	**9 (8.9)**	1 (3.8)	—	*0.228*
Dry cough	0 (0.0)	—	0 (0.0)	**7 (6.9)**	0 (0.0)	—	*0.473*
Hoarseness	0 (0.0)	—	0 (0.0)	**9 (8.9)**	0 (0.0)	—	*0.293*
Shortness of breath	**5 (35.7)**	—	2 (15.4)	10 (9.9)	4 (15.4)	—	*0.070*
Weezing cough	0 (0.0)	—	0 (0.0)	**1 (1.0)**	0 (0.0)	—	*1.000*
Eye symptoms	0 (0.0)	—	1 (7.7)	18 (17.8)	**6 (23.1)**	—	*0.221*
Tiredness	**8 (57.1)**	—	1 (7.7)	22 (21.8)	7 (26.9)	—	***0.021***
Pain in joints	**1 (7.1)**	—	0 (0.0)	1 (1.0)	0 (0.0)	—	*0.348*
Muscle pain	0 (0.0)	—	0 (0.0)	2 (2.0)	**4 (15.4)**	—	***0.040***
Headache	**10 (71.4)**	—	2 (15.4)	17 (16.8)	7 (26.9)	—	***<0.001***
Skin symptoms (itch/erythema)	**9 (64.3)**	—	0 (0.0)	8 (7.9)	1 (3.8)	—	***<0.001***
Concetration difficulties	**6 (42.9)**	—	0 (0.0)	10 (9.9)	0 (0.0)	—	***0.001***

* School days during 8–16 o'clock; Highest prevalences are bolded; *p*-values < 0.05 are bolded; ^ The maximum values for CO2 are: 700 ppm S1, 900 ppm S2, 1200 ppm S3; ^^ In winter: 21–22 °C S1, 20–22 °C S2, 20–23 °C S3; ^^^ 25–45% in winter S1, S2 and S3 not notified.

4. Discussion

Up until the last few years, questionnaires that are used to investigate symptoms and illnesses in the school environment have usually been paper questionnaires, and more recently online questionnaire, and have been typically filled out by parents [49]. In addition, it takes approximately 15–30 min to fill out these questionnaires, and symptoms and illnesses are typically asked using a time frame from four weeks up to three or 12 months. The main difference of our online questionnaire is that it is short, and takes only a few minutes to fill out. In addition, the time period of symptoms and indoor air quality factors was only one hour. Thus, filling the questionnaire was not too burdensome, and participants were able to complete the questionnaire several times; teachers completed the questionnaire approximately seven times during the two-week period, whereas pupils completed it five times. However, the teachers' answers were usually from the same studied classroom, whereas the pupils changed their classroom during school days several times, and answered the questionnaire from different locations during the two-week periods.

One of the most significant strengths of this study was that a total of 7041 answers were obtained from 1373 occupants, so our dataset is large and enables inspection of the results from different perspectives. The same questions were asked to the same occupants several times, which is a new and different approach that provides a more detailed examination that is not possible when using the questionnaire with only one time point. In addition, the large measurement dataset along with questionnaire generates more perspectives for the analysis.

The most common problem when responding to the online questionnaire was technical problems with opening the link to the questionnaire, because of the network security system for using devices in the schools. Due to possible problems when using and filling out the online questionnaire, we also provided paper questionnaires, and the proportion of paper questionnaires varied between 5–40% of all answers. The disadvantage of the paper questionnaire was the longer response time and missing information, because in the online questionnaire, the questions could be made mandatory. Considering the analysis and final data, the most profitable solution is to make all of the questions mandatory, so there are a minimum number of possible missing cases. In such a short online questionnaire, the response time is low, and hence, the response rate is not reduced. However, despite the short questionnaire, pupils under the age of 13 had difficulties in filling out the online questionnaire within a short period of time. Recently, Lampi et al. [65] found that children between ages 9–12 could independently provide repeatable information about symptoms and IAQ. In our study, pupils that answered the online questionnaire were between 11–17 years old.

One limitation is also that the youngest pupils might not understand the questions or options correctly. In particular, "dry air" or "humid air" could be difficult to define, and they might have different perceptions, e.g., of dustiness [66]. Due to possible difficulties with understanding, the questionnaire was mainly directed to seventh to ninth-grade pupils. However, one school wanted to include a classroom with younger pupils. We also noticed that there were pupils (<3% of all) who did not take the questionnaires seriously, and we had to remove those responses from the data. However, the overall results showed that most of the pupils answered the questions correctly and reliably every time.

There is also evidence that psychosocial factors, such as school-related stress, poor teacher–student relationship, and difficulties in receiving help are associated with poor subjective IAQ [67]. In our study, such factors may have impacted the result. However, it is difficult to evaluate these impacts, because the short questionnaire did not address these questions. In addition, the awareness of the problem and the concern of their own situation or health may influence the answers and lead to bias [68]. This was possible in this study, especially because the teachers were aware of the IAQ problems in their school. In addition, the perceived health was better among teachers in the reference schools, but not significantly. This might illustrate the concern of the health or IAQ problems of the school. However, there were differences among the symptoms, not only between the problematic and reference schools, but also between the four problematic schools. Therefore, it might be relevant to assume

that the results are reliable and the teachers were able to estimate the IAQ factors and symptoms without any significant influence of awareness. Nevertheless, teachers reported both symptoms and IAQ factors more than pupils, and these results were clearly visible in every school, especially in IAQ problem schools. In addition to psychosocial factors and awareness, the ability to identify a connection between the symptoms and the building might be difficult for both teachers and pupils [56].

Furthermore, in the improvement of the questionnaire for future use, the question format should be considered carefully. In particular, the clarity of single questions is essential for underage respondents. For example, questions regarding the respondent's state of health and persistence of symptoms outside the school environment can be confusing when the questionnaire is intended for reporting current conditions several times per day. However, as shown in this study, the bias caused by sporadic misunderstandings is compensated, and the results are objective because a large number of response data were collected. However, further improvement is suggested in order to achieve the most reliable benefits from the questionnaire. We sent the online questionnaire in two ways to the occupants. One was through personal e-mail address, and other was the official school communication network program called "Wilma", where all of the teachers and pupils have personal IDs and access. The first way was quite laborious and time-consuming, since all of the e-mail addresses had to be individually sent through the platform, whereas through "Wilma", only one message was enough to reach all of the participants. However, we noticed that the personal e-mail was better considering the usability of the results, because with the e-mail address, we could assign the same ID number to the same respondent. When the questionnaire was sent through "Wilma", we could only give the study ID number if all of the names were exactly the same all of the time. Therefore, there were 769 answers from three schools, which could not identify with the study ID number. Consequently, we recommend that in the future when implementing such a study, personal e-mail addresses are a better way to send the online questionnaire.

In the Finnish winter, when the outdoor air is cold and dry, the indoor air is typically also very dry. The same trend was also revealed by our measurements. Furthermore, the mechanical ventilation system removes indoor air humidity efficiently, making extremely low relative humidity possible indoors, especially when the building is unoccupied and there is no excess moisture. The lowest measured value of relative humidity was 3.2%, and the lowest average during the two-week measurement period was 13.5%. Dry indoor air is known to cause adverse health effects [69], and it is possible also in our study that dry air partly explains the prevalence of the symptoms. Although the prevalence of dry/sore throat, dry cough, and hoarseness was quite high in schools with dryer air, there were also as high or higher prevalence of those symptoms in other schools. Based on these results and the former literature, we can assume that dry air itself does not explain the symptoms, but the interactions of different factors play an important role [70]. The important consideration is also that "dry air" or "too humid air" might be a difficult concept for younger pupils [63].

The temperature conditions are clearly different between the IAQ problem and reference schools. In reference schools, more than half of the studied classrooms had very high room temperature (S3 or >S3), while in the IAQ-problem schools, almost half of the classroom temperatures was in the S1 room temperature category. Similar differences between the room temperatures were also seen in the questionnaire data. However, even high air temperature is known to cause dissatisfaction with indoor air quality and may negatively affect health [69,71,72]; in this study, occupants from IAQ problem schools reported more too cold air and symptoms. In addition, we noticed a relationship between the measured temperature and thermal comfort, whereas the measurements of CO_2 and relative humidity illustrated more inconsistency among reported stuffy air and dry/humid air. However, classrooms with the maximum values of CO_2 appear to have a higher prevalence of reported stuffy air. In addition, other environmental factors, such as exposure to pollutants as particulate matter ($PM_{2.5}$ and PM_{10}), volatile organic compounds (VOCs) and carbon dioxide (CO_2) are related to adverse health outcomes, such as the development of respiratory symptoms [1,24,28].

The ventilation function plays a major role in a good indoor environment. In the studied schools, the ventilation systems were balanced according to the information provided by the building owner. In this study, the ventilation function was investigated based on simple measurements, which will be reported separately with the other measurements of indoor air parameters. In future studies, the comprehensive investigation of the ventilation function simultaneously with the distribution of the questionnaire will be essential.

In this study, the IAQ factors were clustered in one to two classrooms in many schools, but the symptoms were more divided between the classrooms in all of the schools. This might indicate that the impact of symptoms is more lasting, while the sensation of poor indoor air disappears after exiting the space. However, it is also possible that symptoms are more familiar as a term, and therefore more commonly reported. In addition, respiratory illnesses or allergic diseases generate different symptoms that typically continue throughout the day. Furthermore, symptoms such as headache and tiredness might be comprehensive and not necessarily linked to the IAQ of one place.

5. Conclusions

The online questionnaire developed in this study differs from commonly used questionnaires in IAQ studies. The differences with symptoms and IAQ factors between IAQ problem schools and the reference school were observed among both teachers and pupils; however, the prevalence reported by teachers was clearly higher. Our results also indicated that both measurement data and questionnaire data differed not only between schools, but also between classrooms inside the school rather widely. We can thus assume that the condition in schools and the symptom prevalence are not the same and stable between classrooms. Furthermore, occupants of the buildings are exposed to several environmental factors at the same time. Therefore, it is necessary to extend the questionnaire to all occupants of all sections in the whole building, so that a comprehensive view of all spaces is available. In addition, selected sections of interest (e.g., ventilation service area, type of flooring materials, etc.) can be investigated as individual units. The statistical and practical reliability of the results would be increased by improving the comprehensibility of the questionnaire. This type of questionnaire enables the collection of a large number of data, thus offering multiple possibilities to investigate relations between several personal, climatic, and building-related factors as well as interconnections with time and place over a specific period.

Such an approach might be a useful extra tool as a first step to try to screen and solve IAQ problems in public buildings, especially among adults; however, it requires that all occupants are involved in the study and the answering period is long enough. The information obtained from the results of the questionnaire combined with the systematic investigation of the indoor environment could be used the basis for a more detailed further investigation, as well as restorative measures.

Supplementary Materials: The following are available online at http://www.mdpi.com/s1, S1 Online questionnaire of Indoor Air Police-project, Table S1: Differences in allergic diseases, respiratory illnesses, and perceived health among teachers and pupils between IAQ-problem schools and reference schools, Table S2: Perceived IAQ and symptoms during last hour among teachers and pupils with IAQ-problems schools and reference schools, Table S3: Differences between the six study schools in the IAQ problems and symptoms during the last hour among teachers, Table S4: Differences between the six study schools in the IAQ problems and symptoms during the last hour among pupils.

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