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Health Assessment and Indoor Environmental Quality in Multiple Romanian Rural Schools

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Abstract. The current study was realized in three schools located in regional Romania. The results of this article draw upon the diversity of school’s typologies analyzed: new, existing refurbished and old. The analysis was carried using answers given by 138 children to a survey that covered questions related to their learning environment and health problems. Children were asked to rank the perceived quality of several indoor environment parameters (IAQ, outdoor air quality, illumination, noise), the stressful and friendly nature of the schools, and their overall satisfaction. The survey was accompanied by experimental measurements of air temperature, humidity, noise and illuminance levels, CO2 concentration and dust particles. The most prevalent symptoms experienced at school were sneezes (34.1%), fatigue (18.9%), runny nose (14.5%), stuffed/blockeD nose (11.6%), and headache (8.7%). Out of the five main health symptoms reported at school, the majority has been recorded in the renovated school.

1. Introduction

Most people are aware that outdoor air pollution can impact their health, but indoor air pollution can also have significant and harmful effects. The U.S Environmental Protection Agency (EPA) studies of human exposure to air pollutants indicate that indoor levels may be two to five times and occasionally more than 100 times higher than outdoor levels [1]. Among the environments where children spend most of their time, schools are ranked second after their homes. It has been estimated that a typical child spends on average 4.7 hours per day in schools or recreational centers [2], exposes them to consistently higher concentrations of air pollutants than present outdoors and can lead to several health symptoms being developed. The most common symptoms experienced or reported in school buildings with IAQ problems are mucous membrane irritation and respiratory symptoms [3]. Indoor air pollutants may also irritate the skin, eyes, nose, throat and upper airways. They may also create dry mucous membranes, and abnormal taste with the prime culprits being formaldehyde and other VOCs, highly scented products, combustion derivatives (carbon monoxide and nitrogen oxide), and particulates. Pulmonary effects such as rapid breathing, exacerbation of asthma, allergies, and flu-like symptoms together with headache and dry eyes can also be included in the category of health...
symptoms caused by improper IAQ [4] and can be categorized under the label: Sick-Building Syndrome – SBS. Such symptoms may also be caused by other factors and are not necessarily attributable to poor IAQ alone. Rarely is it possible to prove that these symptoms are related to any particular indoor air pollutant alone. Other pollutants include tobacco smoke, ozone, pesticides, radon, pollen, molds and bacteria. While there is a large literature coverage on the impact of tobacco smoke on the health of the occupants, there is less consensus in the academic world concerning VOCs. There are varied sources of indoor air pollution in an educational building such as: the presence of mold, asbestos, lead, or non-low emitting paints covering the walls, the use of certain furniture materials, cleaning products or inks and chalk, or whether certain animals are kept as pets [5]. Reality shows that occupants are simultaneously exposed to a wide variety of indoor air contaminants and even low concentration levels can cause health problems if combined effects are considered. Evidently, as IAQ deteriorates and/or the duration of exposure increases, more people tend to be affected and symptoms tend to be more serious. Children, even more likely than adults, may be adversely affected by indoor air pollution. As they breathe a greater volume of air relative to their body weight this may lead to an increased burden of pollutants on their bodies. In addition, younger children cannot easily choose to attend another school and are less likely than adults to comprehend and clearly communicate their symptoms [6]. Moreover school work performed by children is almost always new to them (while adults frequently deal with routine, well-practiced tasks), warranting the need for proper IAQ conditions [7-8]. Surprisingly, even after acknowledging the adverse effects had on children, the environmental conditions in schools are often inadequate.

In the context of IAQ, relative humidity also plays an important role. According to [9] humans have difficulties perceiving changes of the (RH), due to lack of sensory receptors for humidity. The same thing does not happen for temperature since humans are equipped with specific sensors. However, it is not uncommon that people report “dry air” and this has been associated with poor IAQ or a sub-standard indoor environment since the 1980’s [10]. This perception of “dry air” was correlated to mucous membrane irritation of the eyes (e.g. dry eyes) and upper airways (sensory irritation) which is an important component included in the classic SBS in non-industrialized buildings [11-12].

The NZEB standard for schools impose very low energy required but in the same time such energy efficient schools should maintain good health and comfort for the occupants. The studied schools in this paper are not respecting the NZEB standard as these were already refurbished during the last decade. At national level, there are only few NZEB schools and most of the Romanian schools are either renovated in a classic manner (e.g. thermal insulation of walls 5 cm, double glazed windos and in some cases LED lighting). The comfort levels in rural schools, as the one presented in the paper, are acceptable according to the pupils responses despite the large variation of temperature (19°C in the morning to 23°C at the end of classes).

2. Survey study

A survey study was carried out in three rural schools, further called old, new and renovated, and the only educational establishments present in the commune of Mateesti situated in the north-western part of Valcea County at approximately 250km from the Romanian capital, Bucharest.
Figure 1. a. Old School b. New School c. Renovated school (Ghita and Catalina, 2015)

The old school is facing as main orientation NORT, while both new school and renovate school are facing mainly EAST.

A standardized questionnaire was based on the validated format used in the SINPHONIE European Project (Sinphonie 2014). The English version was translated in the local language, and a back-to-back translation has been performed to ensure that the information contained was not altered. The questionnaire was then distributed among the three different schools (old, new, and renovated) with the help of the teachers at the start of class hours during three different days of the same week (02/06/2014 – 08/06/2014). To eliminate all ambiguity, before the children received the questionnaires the teachers were briefed on the meaning of the questions being asked. The questions referred to socio-demographic data (age, gender, grade), lifestyle (exposure to environmental tobacco smoke), occurrence of health problems (e.g. asthma attacks, wheezing, eczema, dry throat, dry eyes, headache) within the past 7 days. Children were also asked to rank the perceived quality of several indoor environment parameters (IAQ, outdoor air quality, illumination, noise), the stressful and friendly nature of the schools, and their overall satisfaction.

The new and renovated schools had a centralized heating system using hot water radiators located below the windows without a set point or deadband temperature control. The old school used closed fireplaces to heat the classrooms. Domestic hot water was not produced for any of the schools investigated. The energy used for heating was solid fuel, either in the form of wood or coal. Referring to the issue of natural ventilation, all schools used operable windows that can be opened or closed by the occupants. Usually these were opened during breaks or teaching hours or after the school schedule had ended. During the heating season, usually one window was open (aprox. 1.2 sqm free apertura area), especially during the breaks and at the end of the classes. The average duration for natural ventilation for the 6 hours classes was arround 50 minutes. During the classes all the doors of the classroom were closed but of cours for the old school multiple cracks in the door were observed. For the cooling season, in general there were two windows per classroom open, during the breaks, teaching hours and after classes. Passive ventilation grids were present in the window frames of the new and renovated school buildings allowing constant intake of outside air. No air transfer openings between rooms were present. Moreover, all classrooms followed the same cleaning procedure and the same substances were used. Windows were opened during this interval. Among all children invited in 10 of the 23 classrooms covered by the checklist investigation, 7 children did not fill out the questionnaire administered, resulting in a study population of 138 children.
3. Survey results

The participation rate was 95%. Among all children invited in 10 of the 23 classrooms covered by the checklist investigation, 7 children did not fill out the questionnaire administered, resulting in a study population of 138 children. The mean (sd) age of all respondents was 12.4 (1.3) years (age range of 10 – 15 years). The old school was frequented by the older children, 13.4 (1.2) years old while the children from the other two schools are on average close to 12 years old. The student population covered is between the 4th and 8th grade. Children in the new school are in the 5th (N02), 6th (N04) or 7th (N05) grade. Those from the old school are either in the 6th (O01) or 8th (O02) grade. Finally the children in the renovated school are studying in the 4th (R14N), 5th (R08N), 6th (R10N), 7th (R11N) or 8th (R07N) grade. The metabolic rate of the pupils corresponds to light office work (around 1 met), the clothing factor varied from 0.8 clo to 1.2 clo (the survey also gathered information on the clothing degree) and the general health off all respondents was very good during the time of survey. The indoor temperatures during the time of the survey varied from 19 °C in the morning to 22 °C at the end of classes. An wood boiler system for the school heating was turned on at 6:00 am (2 hours before the arrival of the childre) and turned off at 10:00 am. The humidity values were also measured and varied from 45% (morning) to 55% (end of classes). With regards to exposure to environmental tobacco smoke, as expected the exposure took place mostly at home (61.2% of all responses) followed by ‘in other places’ (56.8%), and at school (6.0%). More than 80% of exposed respondents declared to have been in contact with tobacco smoke less than an hour, judging the exposure to be light (70.1%) or moderate at most (16.4%). Three children declared to have suffered asthma attacks while at school. About 86% of the children had experienced in the past week at least one of the symptoms listed. The prevalence of health complaints at home, at school, and in other places was 82.3%, 80.4%, and 60.0%, respectively. The most prevalent symptoms experienced at school were sneezes (34.1%), fatigue (18.9%), runny nose (14.5%), stuffy/block nose (11.6%), and headache (8.7%). Out of the five main health symptoms reported at school, the majority has been recorded in the renovated school. Thus, from the category of children that had a runny nose, were fatigued or experienced a headache during the last 7 day interval, more than 80% came from the renovated school, while sneezes and stuffy or blocked nose occurred for 70% and 50% of the time spent inside this school. Most of the prevalent health symptoms reported at school (runny nose, sneezes, stuffy or blocked nose, fatigue, and headache) started in the classroom (see Table 1). This table presents the prevalence in overall and per school, and there is no relation between the occurrence of these symptoms inside the classroom and the school investigated.

Figure 2. Distribution by school of the most prevalent symptoms experienced by the school children (during the time spent in the educational establishment)

Note: Values expressed in percentages [%]
Table 1. Prevalence of the most frequent health symptoms noted at school and which started in the classroom, in overall and per school investigated.

| SYMPTOMS          | All schools | OLD (O) school | NEW (N) school | RENOVATED (R) school | p    |
|-------------------|-------------|----------------|----------------|----------------------|------|
| Runny nose        | 15 (75.0)   | 1 (6.7)        | 2 (13.3)       | 12 (80.0)            | 1.0  |
| Sneezes           | 29 (61.7)   | 5 (17.2)       | 5 (17.2)       | 19 (65.5)            | 0.245|
| Stuffy or blocked nose | 13 (81.3) | 4 (30.8)       | 2 (15.4)       | 7 (53.9)             | 0.271|
| Fatigue           | 21 (80.8)   | 2 (9.5)        | 1 (4.8)        | 18 (85.7)            | 0.236|
| Headache          | 6 (50.0)    | 1 (16.7)       | 0              | 5 (83.3)             | 1.0  |

*Values are numbers (percentages): n(%)  
* p: p-value of Fisher’s exact test

The data is segmented by class type in Figure 3 where the health symptoms are expressed as percentages out of the total number of individual complaints recorded throughout the 3 schools. In the renovated school, the most common symptom indicated by children is having a runny nose, followed by fatigue, headache, and the occurrence of a stuffy or blocked nose. Classroom O01 had an almost even split between sneezes and a runny nose as the main symptoms, while classroom O02 saw a stuffy or blocked nose as being the main health complaint (over 50%). From the new school, in classroom N02 approximately 30% of the children complained about a runny nose, another 30% about sneezes while 20% indicated a stuffy or blocked nose; only 10% reported fatigue as the main problem.

Figure 3. Frequency of the most prevalent health issues segmented by classroom

*R07-R14N are classrooms from the renovated school; O02 is from the old school and N02 is from the new school

The Figure 4 presents how children were satisfied with their school while also covering how stressful and friendly was their school. Concerning overall school satisfaction, children from the new building were significantly more content with their surroundings, mean (sd)=8.4 (1.6) and mode=10. Close second was the renovated building, mean (sd)=8.4 (2.3) and mode=9, while the old school comes last, mean (sd)= 7.3 (2.0) and mode=7. The reasons for dissatisfaction as noted by the children from the
various schools are as follows: Children from the old building complained about dust present, fumes coming from the fireplace and cold air draft during winter. Those from the new building referred to unpleasant body odors and dust present as well as the lack of enough fresh air. In terms of school stressful the school work is, there was no difference between schools with minor differences. It is interesting to mention that the pupils from the old non-renovated school are nevertheless less stressed probably due to their low expectations of the school environment or teaching activities.

Figure 4. Distribution of children’s satisfaction and how they perceived school friendliness and school related stress

Table: Distribution of children’s satisfaction and how they perceived school friendliness and school related stress

| Perception (0=totally dissatisfied; 10=totally satisfied) | All schools N=138 | Old school N=20 | New school N=24 | Renovated school N=44 | P  |
|------------------------------------------------------------|-------------------|----------------|-----------------|----------------------|----|
| Min – Max                                                  | 0-10              | 2-10           | 2-10            | 0-10                 | 0.009 |
| M (sd)                                                     | 8.2 (2.1)         | 7.3 (2.0)      | 8.4 (1.6)       | 8.4 (2.3)            |     |
| Median                                                     | 9                 | 7              | 9               | 9                    |     |
| Mode                                                       | 10                | 1              | 9               | 10                   |     |

| Perception (0=not at all stressful; 10=extremely stressful) | All schools N=138 | Old school N=20 | New school N=24 | Renovated school N=44 | P  |
|---------------------------------------------------------------|-------------------|----------------|-----------------|----------------------|----|
| Min – Max                                                    | 0-10              | 3-10           | 0-10            | 0-10                 | 0.009 |
| M (sd)                                                       | 3.9 (3.0)         | 3.1 (2.0)      | 4.3 (3.9)       | 4.0 (3.7)            |     |
| Median                                                       | 3                 | 2              | 3.5             | 3                    |     |
| Mode                                                         | 2                 | 3.5            | 0.8             | 0.7                  |     |

4. Conclusions

The survey study is based on the responses of 138 children from three different country-side schools situated in the same vicinity. These schools were different in terms of age, heating system used or degree of renovation which allowed for comparisons to be made and interesting results to be recorded. In aggregate about half of the schoolchildren were boys (sex boy/girl ratio: 1:09), the children from all three schools being thus close to evenly spread between genders. The mean (sd) age of all respondents was 12.4 (1.3) years (age range of 10 – 15 years). The most prevalent symptoms experienced at school were sneezes (34.1%), fatigue (18.9%), runny nose (14.5%), stuffed/blocke
d nose (11.6%), and headache (8.7%). The lack of a humidification system was among the problems that were encountered during the campaign. Several times the occupants complained about eyes and throat irritations despite the relative humidity recordings that measured values between 45% to 55%. Finally, the complaints from the renovated building revolved around body odors, dust and detergent smell present as well as not having enough ventilation during classes. In terms of overall school satisfaction, children from the new building were significantly more content with their surroundings, close second was the renovated building, while the old school comes last. The purpose of the study was to find by an extensive survey on 138 children there perception on the school environment and eventually different health issues that could be related to the school environment. As expected the old rural school was classified as the „worst learning,” environment due to multiple issues (non-uniform heating, low temperatures in the winter mornings, low natural lighting) while the other schools (new and renovated) ensured a more uniform temperature during winter season and better daylight factors.
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