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Influence of gender of classroom occupants on indoor air quality

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Abstract: *Teachers and students spend a lot of time in the classrooms. It is therefore important to have a good indoor air quality.A cross sectional survey was conducted to characterize the indoor air quality (IAQ) in schools and its relationship with gender of the occupantsas well as its influence on the development of symptoms of allergic conjunctivitis on the teachers who attended these classrooms. Concentrations of total volatile organic compounds (TVOCs), carbon dioxide and temperature were assessed in four girls' and three boys' secondary schools in Nakuru, Kenya. The results indicate that the concentrations of carbon dioxide($p=0.043$) and TVOCs ($p=0.048$) were significantly higher in girls' classrooms than in the boys' classrooms.There was an association between the gender of classroom occupants and development of symptoms of allergic conjunctivitis among the teachers who taught in those classrooms ($\chi^2=5.145$; $p=0.023$).This study concludes that the gender of the classroom occupants influences the indoor air quality of the classroom. It recommends that teachers and students should be trained on the importance of opening windows*

Keywords: *Allergic Conjunctivitis, Carbon dioxide, indoor air quality, Teachers,Temperature, Volatile Organic Compounds*

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I. Introduction

Teachers and students spend a lot of time in the classrooms (Rosbach et al., 2013). It is therefore important to have a good indoor air quality. Indoor air quality is extremely variable and depends on ventilation. Ventilation allows for dilution of the pollutants as well as allows them to be pushed out and cleared out of the room (Seppänen and Kurnitski, 2009). In a poorly ventilated room, the vapours of the VOCs can tend to accumulate to unacceptable levels (Dodson *et al*., 2008; Wyon and Wargocki, 2008; Matysik*et al*., 2010; McIntosh, 2011; Willem, 2013; Noguchi *et al*., 2016). The effectiveness of the ventilations can be determined by studying the concentration of the carbon dioxide in the classroom (Godwin and Batterman, 2007; Lu*et al*., 2015). Humans produce and exhale carbon dioxide (CO_2) making concentrations of CO_2 in occupied indoor spaces to be higher than concentrations outdoors (Lazović*et al*., 2015; Chiu *et al*., 2015). As the ventilation rate decreases, the magnitude of the indoor–outdoor difference in CO_2 concentration increases.

The indoor classroom temperature is a combination of radiations received through the roof and walls of the building (Ponni and Baskar, 2015). It is influenced by the external temperatures which depend on the number of buildings, the type of manmade materials in the surrounding and presence or absence of vegetation in the surrounding (Kleerekoper*et al*., 2012; Scott *et al*., 2017). It is also as a result of heat generated by the classroom occupants through physiological body activities (Cowan *et al*., 2010). The indoor temperatures are usually regulated by the classroom occupants by managing the operable ventilations based on their comfort (Lazović*et al*., 2015). Low temperature makes the room occupants to close the operable ventilation resulting in indoor accumulation of the VOCs. It also reduces photochemical reaction rates of the VOCs and in the process increase their atmospheric lifetime (Hellen*et al*., 2012; Hinks*et al*., 2016).

Allergic conjunctivitis is an inflammation of the conjunctiva as a result of a reaction of the body's immune system to an allergen (Bielory and Friedlaender, 2008). The symptoms of allergic conjunctivitis include itching, irritation or hurting, stinging or burning sensation, watery eyes, discomfort, swelling of the eyelids, red eyes and a feeling of presence of foreign particles in the eyes or 'fullness' in the eye. Itching is the hallmark of allergic conjunctivitis and without it a person may not be suffering from allergic conjunctivitis even if all the other symptoms are present. Itching may be mild or severe (Ono and Abelson, 2005; Leonardi, 2013; Miraldi and Kaufman, 2014).

II. Materials And Methods

The design was cross sectional design. Three boys' and four girls' secondary schools which used whiteboards in their classrooms werepurposefully selected in Nakuru County, Kenya. The teachers from these schools were selected randomly constituting a sample size of 129 teachers. Questionnaires were used to collect information on self-reported symptoms of allergic conjunctivitis. Two classrooms from each school were selected randomly for air sampling. Air samples were collected from each of the sampled classrooms using a transparent polythene bag which was actively flapped to allow the air into the bag. The air samples were collected at 1.5m height above the floor which is the breathing level (Olumayede and Okuo, 2013), and also at 0.5m. These samples were collected at a distance of 30cm from the centre of the whiteboard where the teacher is likely to spend most of his/her time during the lesson. More air samples were also collected at 8m towards the back of the classroom because this is the average length of a Kenyan classroom (GOK, 2006). Sampling was done at the same heights of 1.5m and 0.5m above the floor.

Air was sampled in the morning before the lessons started, at 12.40pm before the students broke for lunch and at 2.00pm just before the afternoon lessons started. The air samples were analyzed using the gas chromatography. During the air sampling, the concentration of carbon dioxide and the classroom temperatures were measured using the electronic carbon dioxide sensor, AZ-0004. The concentration of the VOCs in the air samples from the classrooms was determined by use of gas chromatography using a Varian 3400CX gas chromatograph with non-polar column. Thiscolumn was a chiral fused silica with a length of 25m, an internal diameter of 0.25mm and a film thickness of 0.12 µm. A flame ionization detector (FID) was used because it is very stable and it detects a very large number of VOCs (Sannik, 2013). The gas in the oven was hydrogen gas while the carrier gas was nitrogen gas. The samples were injected into the injector manually using1 µl syringes. The conditions of the gas chromatograph were such that the inlet temperature was 150 °C while the column temperature program started at 50.0 °C for 1.00 minute and was then ramped at 14.0 °C per minute until 120 °C was obtained. The column was kept at a constant flow of 1.6 ml/min and the detector temperature was set at 180 °C. The flow rate for hydrogen was 30.0 ml/min, for air was 400.0 ml/min, and the makeup flow of nitrogen was 25.0 ml/min.

III. Findings And Discussion

3.1 Carbon dioxide

The results showed that the overall carbon dioxide concentrations ranged from 335ppm to 2207ppm with an average of 621.39ppm. The median was 533 ppm with 37% of the classrooms having more than 600ppm while 74.1% of the classrooms had 100ppm and above being the difference between the indoor and outdoor concentration of carbon dioxide (dCO_2). The ventilations were effective when open allowing the classroom air dilution to a concentration of 335ppm which is close to that of the outdoor air (306ppm). The standard deviation was very high (339.173) indicating lack of consistency in the concentration of carbon dioxide in the classrooms at the different times of sampling.

The results from this study show that the concentration of the carbon dioxide kept changing in the course of the day. The mean concentration of carbon dioxide was found to be 949.73ppm at 8.00am during morning prep, 639.24ppm at 12.40pm just before lunch break and 319.00ppm at 2.00pm just before the afternoon lessons started. The concentration of carbon dioxide at the different times of the day was found to be significantly different (p=0.042) when tested using one way ANOVA (Table 1).

Table 1: Comparison of concentration of CO_2 at different times of the day

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1357841.107	2	678920.554	3.358	.042
Within Groups	10512875.802	52	202170.688		
Total	11870716.909	54			

The concentration of carbon dioxide was higher during the morning prep than during the afternoon (12.40pm) lesson because it was colder in the morning (20.6 ^{o}C) than in the afternoon (26.7^{o}C). Most of the classroom operable windows (3/4 and above) were therefore closed in all the classrooms during the prep time at the times of visit. This agrees with the findings of Lazović*et al*. (2015) who found that thermal comfort influences the management of operable ventilations. Closing the windows limits ventilation and abated ventilation increase the concentration of carbon dioxide in a classroom (Lu*et al*., 2015). In this study, temperature was found to be negatively correlated with the concentration of carbon dioxide (r=-0.113) (Table 2). Decrease in temperature therefore resulted in increase in the concentration of carbon dioxide.

Table 2: Relationship between CO_2 and temperature

		Temperature
CO_2	Pearson Correlation	-.113
	Sig. (2-tailed)	.368
	N	65

The concentration of carbon dioxide was lowest during the lunch break (2.00pm) because the classrooms were empty or had the least occupancy. The students had moved out of the room to take their lunch. Statistical test showed that the concentration of carbon dioxide was significantly correlated with the number of students in the classroom (r=+0.333; p=0.007) (Table 3). Lu *et al*. (2015) also found an increase in the concentration of CO_2 with increase in the number of workers in a building located in Taipei City.

Table 3: Relationship between concentration of CO_2 and number of students

		Number of students per classroom
CO_2	Pearson Correlation	.333
	Sig. (2-tailed)	.007
	N	65

There was a significant difference in the concentration of carbon dioxide between the girls' and boys'classrooms (t=2.152; p=0.043) indicating poor ventilation in girls' classrooms (Table 4).

Table 4: CO_2 concentrations in girls' and boys' classrooms

Classroom	Mean of CO_2 concentration (ppm)	Statistics		
		t value	df	P value (2-tailed)
Girls' classroom	670.30	2.152	22	0.043
Boys' classroom	503.36			

It was observed that all the girls' classrooms had ¾ or more of the windows closed during the times of visit. This could be attributed to the fact that girls tend to feel colder than the boys (Cheung, 2015). This is due to the fact that they have a thicker and a more evenly distributed layer of fat just below the skin surface compared to the males (Westerbacka, 2004; Tarulli*et al*., 2007; Olesen, 2015). When they get cold, they constrict their blood vessels to the skin faster than the males reducing the flow of blood to the skin significantly (Kaciuba-Uscilko and Grucza, 2001; Olesen, 2015). The layer of fat under the skin act as an effective insulator preventing the heat from the body to reach the skin making the skin of the females to feel colder than that of the males. They also have lower heat generation to heat loss surface area ratio (Kaciuba-Uscilko and Grucza, 2001) making the heat loss more effective than its generation.

When the relationship between carbon dioxide and total volatile organic compounds was tested, the results showed a positive correlation (r =+0.525; p=0.003) (Table 5).

Table 5: Relationship between CO_2 and TVOCs concentration

		concentration in ppm
CO_2	Pearson Correlation	.525
	Sig. (2-tailed)	.003
	N	29

High concentration of carbon dioxide is an indication of poor ventilation (Godwin and Batterman, 2007; Lu*et al*., 2015) allowing the TVOCs to accumulate in the classroom. Increase in concentration of TVOCs with reduced ventilation agrees with the findings of several studies. Lu *et al*. (2015) in his study on SBS among the workers in a building in Taipei City found that the TVOCs compounds increased in a room with reduced ventilation. Du *et al*. (2015) studied the effects of air exchange rates on the migration of VOCs from the basement in Detroit residences and found that good ventilation which results in high air exchange rates diluted the indoor VOCs and resulted in a reduced VOCs concentration.

3.2 Temperature

Temperatures also fluctuated during the different times of the day. It was hottest in the afternoon (26.7 ^{o}C) and coldest in the mornings (20.6^{o}C). The statistical test (one way ANOVA) showed that the temperatures at the three times of the day were significantly different (p=0.000) (Table 6). In his book on atmosphere-ocean interface, Considine and Considine (2013) says that the temperature tend to reach its maximum about 2-3 hours after a local noon and its minimum at sunrise.

Table 6: Comparison of temperature at different times of the day

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	409.453	2	204.727	29.675	.000
Within Groups	365.641	53	6.899		
Total	775.094	55			

The results show that the indoor concentration of TVOCs increase as the temperature reduces (r=-0.038). This agrees with Pegas et al. (2011) who observed that higher indoor TVOC concentrations occurred more often in the colder months. Low temperature influences the behavior of the room occupants (Lazović et al., 2015) resulting in indoor accumulation of the TVOCs. It also reduces photochemical reaction rates of the VOCs and in the process increase their atmospheric lifetime (Hinks et al., 2016; Hellen et al., 2012). However increase in temperature did not decrease the concentration of the TVOCs vapours significantly (P= 0.841) because the temperature variation was small (Standard deviation =3.6847).

Although the mean temperature of the girls classrooms was slightly lower than that of the boys classrooms (23.582^{o}C and 25.836 ^{o}C), the difference was not significant (Table 7). This agrees with Olesen (2015) who claims that the core body temperature of the two sexes is not significantly different. The room temperature is influenced by the heat produced by the occupants of a classroom as well as the environment.

Table 7: Indoor temperature in girls' and boys' classrooms

Classroom	Mean temperature(^{o}C)	Statistics		
		t value	df	P value (2-tailed)
Girls' classroom	23.582	1.671	23	0.108
Boys' classroom	25.836			

When the concentration of ink VOCs in the two categories of classrooms was compared, the girls' classrooms (202ppm) were found to have higher concentration than the boys' classrooms (199ppm). When the mean concentration of the TVOCs in the two categories of classrooms was statistically compared using one way ANOVA, the results indicated that the difference was significant (p=0.048) (Table 8).

Table 8: One way ANOVA for concentration of TVOCs between girls' and boys' classrooms

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1077395994.747	1	1077395994.747	4.114	.048
Within Groups	12047008338.511	46	261891485.620		
Total	13124404333.258	47			

This study found that many of the windows (3/4) in the girls' classrooms were closed at the time of visit. This abates ventilation in the classrooms allowing accumulation of the TVOCs in the classroom. This agrees with Du *et al*. (2015) and Jin *et al*. (2014) who associate abated ventilation with increased concentration of VOCs. Du *et al*. (2015) found that low air exchange rates in residences in Detroit resulted in high concentration of VOCs while Jin *et al*. (2014) found that good ventilation reduced the air pollutants responsible for development of lung cancer among the Chinese population. In the current study, the classrooms of the boys had ¾ or more of their windows open at the time of visit resulting in good air exchange rate.

3.3 Incidences of symptoms of allergic conjunctivitis among the teachers

The teachers from girls' schools had higher incidences of symptoms (21.7%) of allergic conjunctivitis than those from the boys' schools (8.2%). When Chi-Square of independence was carried out, the results showed that there was a significant association between symptoms of allergic conjunctivitis and the type of students in the classroom (χ^2= 5.145; P=0.023) (Table 9).

Table 9: Influence of the type of students on the development of symptoms of allergicconjunctivitis

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	5.145	1	.023		
Continuity Correction	4.128	1	.042		
Likelihood Ratio	5.272	1	.022		
Fisher's Exact Test				.032	.020
Linear-by-Linear Association	5.109	1	.024		
N of Valid Cases	142				

Poor ventilation in the girls' classrooms made the VOCs to accumulate in the classrooms. The VOCs from the beauty products used by the girls may also have interacted with the whiteboard marker ink VOCs resulting in a more potent mixture than that found in the boys' classrooms. Mixtures are more likely to have a health effect on a person than individual VOC components (Nielsen *et al*., 2007).

The incidences of symptoms of allergic conjunctivitis increased with increase in concentration of VOCs in the classrooms (Figure 1). This was established by taking the mean concentration of the VOCs in the air samples collected in each of the six schools. Regression was used to assess the relationship between the concentration and the percentage incidence of the symptoms of allergic conjunctivitis among the teachers in those schools during that time of observation (Figure 4.21).

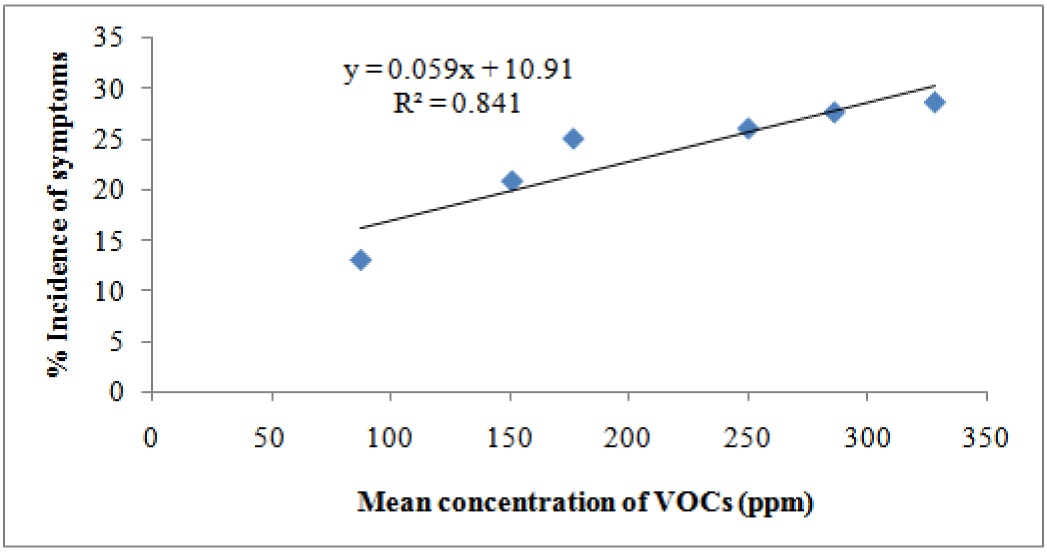

Figure 1: Relationship between incidences of symptoms of allergic conjunctivitis and concentration of VOCs

When the relationship between the concentration of the VOCs and the symptoms of allergic conjunctivitis was statistically tested, the results showed that the relationship was significant (F=21.163; p=.010) (Table 10)

Table 10: Relationship between incidences of symptoms of allergic conjunctivitis andconcentration of VOCs

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	142.017	1	142.017	21.163	.010
	Residual	26.843	4	6.711		
	Total	168.860	5			

Increase of symptoms with increase in the concentration of VOCs agrees with Madureira*et al*., (2009) who found a significant correlation between the levels of TVOCs and the development of upper mucosal irritation among the Portuguese teachers. Increase in incidences of the symptoms with increased exposure (biological gradient) is an indication of a causal-effect-relationship between the VOCs and the symptoms of allergic conjunctivitis. This is according to Hills criteria as reported by several authors (Rothman and Greenland, 2005; Swaen and van Amelsvcort, 2009; Fedak*et al*., 2015).

IV. Conclusion

Gender of the classroom occupants influences the indoor air quality with the girls' classrooms having a poorer air quality than that found in boys' classrooms. Poor air quality in turn influences the development of symptoms of allergic conjunctivitis among the teachers who teach in those classrooms.

V. Recommendations

This study recommends that the teachers and students in classrooms occupied by girls should be made aware of the importance of opening the windows so that the ventilation is effective to prevent the accumulation of VOCs in theclassroom. The researcher also recommends that a study be carried out to establish the identity of the VOC compounds found in the girl' and boys' classrooms in order to isolate the potent mixture of compounds.

References

[1]. Bielory, L. and Friedlaender, M. H. (2008). Allergic Conjunctivitis. *Immunology and Allergy Clinics of North America, 28(1*), 43-58.

[2]. Cheung, S. S. (2015). Responses of the hands and feet to cold exposure. *Temperature, 2*(1): 105-120

[3]. Chiu, C.-F. Chen, M.-H. and Chang, F.-H. (2015). Carbon Dioxide Concentrations and Temperatures within Tour Buses under Real-Time Traffic Conditions. *PLoS one,10(14): e125117*

[4]. Considine, D.M. and Considine, G. D. (2013). *Van nostrand's scientific encyclopedia* (8th edition). New York. Springer.

[5]. Cowan, J. M., Burris, J. M., Hughes, J. R. and Cunningham, M. P. (2010).The relationship of normal body temperature, end-expired breath temperature, and BAC/BrAC ratio in 98 physically fit human test subjects. *Journal of Analytical Toxicology, 34*(5): 238-242

[6]. Dodson, R.E., Levy, J.I., Spengler, J. D., Shine, J.P. and Bennett, D.H. (2008). Influence of basements, garages, and common hallways on indoor residential volatile organic compound concentrations.*Atmospheric Environment, 42*: 1569-1581

[7]. Du, L., Batterman, S., Godwin, C., Rowe, Z. and Chin, J. Y. (2015). Air exchange rates and migration of VOCs in basements and residences. *Indoor air, 25*(6): 598-609.

[8]. Fedak, K. M., Capshaw, Z. A. and Gross, S. (2015). Applying the Bradford Hill criteria in the 21st Century: how data integration has changed causal inference in molecular epidemiology. *Emerging themes in epidemiology, 12*:14

[9]. Godwin, C. and Batterman, S. (2007). Indoor air quality in Michigan schools. *Indoor Air, 17*(2): 109-121.

[10]. Government of Kenya (2006). *Early childhood development service standard guidelines for Kenya*. Nairobi. Government printers.

[11]. Hellen, H., Tykka, T. and Hakola, H. (2012). Importance of monoterpenes and isoprene in urban air in northern Europe. *Atmospheric Environment, 59*:59–66.

[12]. Hinks, M. L., Brady, M.V., Lignell, H., Song, M., Grayson, J.W., Bertram, A. K., Lin, P., Laskin, A., Laskin, J., Nizkorodov, S. A. (2016). Effect of viscosity on photodegradation rates in complex secondary organic aerosol materials. *Physical Chemistry Chemical Physics, 18*: 8785–8793.

[13]. Kaciuba-Uscilko, H. and Grucza, R. (2001). Gender differences in thermoregulation. *Current opinion in clinical nutrition and metabolic* care, *4*: 533-536.

[14]. Jin, Z. Y., Wu, M., Han, R. Q., Zhang, X. F., Wang, X. S., Liu, A. M., Zhou, J. Y., Lu, Q. Y., Kim, C. H., Mu, L., Zhang, Z. F. and Zhao, J. K. (2014). Household ventilation may reduce effects of indoor air pollutants for prevention of lung cancer: A case-control study in a Chinese population. *PLoS one, 9*(7): e102685

[15]. Kleerekoper, L., van Esch, M. and Salcedo, T. B. (2012). How to make a city climate-proof, addressing the urban heat island effect. *Resources, conservation and recycling, 64*: 30-38

[16]. Lazović, I., Jovašević-Stojanović, M., Živković, M., Tasić, V. and Stevanović, Ž. (2015) PMand CO2 variability and relationship in different school environments. *Chemical Industry and Chemical Engineering Quarterly, 21* (1): 179−187.

[17]. Leonardi, E., Bogacka, J. L., Fauquert, M. L., Kowalski, A., Groblewska, M. and Jedrzejczak, C. (2012). Ocular allergy: Recognizing and diagnosing hypersensitivity disorders of the ocular surface. *Allergy, 67*: 1327-1337

[18]. Lu, C., Lin, J., Chen, Y. and Chen, Y. (2015). Building-related symptoms among office employees associated with indoor carbon dioxide and total volatile organic compounds. *International Journal of Environmental Research and Public Health, 12*(6): 5833–5845.

[19]. Madureira, J., Alvim-Ferraz, M. M., Rodrigues,S.Gonçalves, C.,Azevedo, M. C.,Pinto, E. and Mayan, O. (2009). Indoor air quality in schools and health symptoms among Portuguese teachers. *Human and Ecological Risk Assessment: An International Journal, 15*(1): 159-169

[20]. Matysik, S., Ramadan, A. B. and Schlink, U. (2010). Spatial and temporal variation of outdoor and indoor exposure of volatile organic compounds in Greater Cairo. *Atmospheric Pollution Research, 1*: 94-101.

[21]. McIntosh, J. (2011). *The indoor air quality in 35 Wellington primary schools.* Masters thesis. Victoria University of Wellington, Wellington, New Zealand.

[22]. Miraldi, U. V. and Kaufman, A. (2014). Allergic eye disease. *Pediatric clinics of North America, 61*: 607-620

[23]. Nielsen, G. D., Wolkoff, P. and Alarie, Y. (2007). Sensory irritation: Risk assessment approaches. *Regulatory toxicology and pharmacology, 48*: 6-18

[24]. Noguchi, M., Mizukoshi, A., Yanagisawa, Y. and Yamasaki, A. (2016). Measurements of volatile organic compounds in a newly built daycare Center. *International Journal of Environmental Research and Public Health, 13*(7): 736.

[25]. Olesen, B.W. (2015). Are women feeling colder than men in air-conditioning buildings? *REHVA Journal, 5*:12-13

[26]. Olumayede, E. G. and Okuo, J. M. (2013). Ambient air pollution and assessment of ozone creation potential for reactive volatile organic compounds in urban atmosphere of southwestern, Nigeria. *African Journal of Environmental Science and Technology, 7*(8): 815-823

[27]. Ono, S. J. and Abelson, M. B. (2005). Allergic conjunctivitis update on pathophysiology and prospects for future treatment. *Allergy in clinical immunology, 115*(1), 118-122.

[28]. Pegas, P. N., Alves, C. A., Evtyugina, M. G., Nunes, T., Cerqueira, M., Franchi.,M., Pio, C. A., Almeida, S. M., Verde, S. C. and Freitas, M.C. (2011). Seasonal evaluation of outdoor/ indoor air quality in primary schools in Lisbon. *Journal of environmental monitoring, 13*(3): 657-667

[29]. Ponni, M. and Baskar, R. (2015). A study on indoor temperature and comfort temperature. *International Journal of Engineering Science Invention, 4*(3): 7-14.

[30]. Rosbach, J. T., Vonk, M., Duijm,F., Ginkel, J. T.,Gehring, U. and Brunekreef B. (2013). A ventilation intervention study in classrooms to improve indoor air quality: the FRESH study. *Environmental Health, 12*: 110-120

[31]. Rothman, K. J. and Greenland, S. (2005). Causation and causal inference in epidemiology. *American Journal of Public Health, 9*(1): S144-S150

[32]. Sannik, S. (2013). *Validation of the gas chromatographic method for determination of volatile organic compounds (VOCs) in industrial workplace air*. Unpublished masters thesis at University of Tartu. Estonia.

[33]. Seppänen, O. and Kurnitski, J. (2009). Moisture control and ventilation. In*: WHO Guidelines for Indoor Air Quality: Dampness and Mould.* Geneva: World Health Organization.

[34]. Swaen, G. and Van Amelsvcort, L. A. (2009). Weight of evidence approach to causal inference. *Journal of clinical epidemiology 62*(3): 270-277

[35]. Tarulli, A.W. Chin, A. B. Lee, K. S. and Rutkov, S. B (2007). Impact of Skin-Subcutaneous Fat Layer Thickness on Electrical Impedance Myography Measurements: An Initial Assessment. *Clinical Neurophysiology, 118*(11): 2393–2397.

[36]. Westerbacka, J. Cornér, A., Tiikkainen, M., Tamminen, M., Vehkavaara, S., Häkkinen, A. M., Fredriksson, J. andYki-Järvinen, H. (2004). Women and men have similar amounts of liver and intra-abdominal fat, despite more subcutaneous fat in women: implications for sex differences in markers of cardiovascular risk. *Diabetologia. 47*(8):1360-1369.

[37]. Willem, H., Hult, E. L., Hotchi, T., Russell, M. L., Maddalena, R. L. and Singer, B. C. (2013). *Ventilation Control of Volatile Organic Compounds in New U.S. Homes: Results of a Controlled Field Study in Nine Residential Units*. Berkeley. LBNL

[38]. Wyon, D. P. and Wargocki, P. (2008). Window opening behavior when classroom temperature and air quality are maintained experimentally. *Indoor air,119* (17-22): 1-6

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