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Bluyssen, P.M.; Zhang, D.; Ortiz, Marco A.

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Self-reported rhinitis and headaches of students from universities in Taiwan, Chile, Suriname, China and the Netherlands, and its association with their home environment

Philomena M. Bluyssen ⬤, Dadi Zhang ⬤ and Marco Ortiz ⬤

Chair Indoor Environment, Faculty of Architecture and the Built Environment, Delft University of Technology, Delft, Netherlands

ABSTRACT

Next to personal, psychosocial and physiological aspects, environmental aspects of homes may affect the health and comfort of their occupants. This study aimed to investigate the multifactorial character of both rhinitis and headaches among five groups of students from universities in five different cities: Taichung (Taiwan), Concepcion (Chile), Paramaribo (Suriname), Beijing (China) and Delft (The Netherlands). Among the students studied, 18% declared having suffered from rhinitis in the last 12 months, and 30% from headaches in the last 3 months. Self-reported characteristics of 682 students and their homes were linked to self-reported rhinitis and headaches. Logistic regression modelling was applied to explore relations between building-related factors and rhinitis, and between building-related factors and headaches. After full adjustment, the regression model for both rhinitis and headaches confirmed their multifactorial character. While personal-related factors family rhinitis and age were associated with rhinitis, negative events and PANAS negative were with headaches. Biological pollutants (caused by pets) were associated both with rhinitis and headaches; chemical pollutants, caused by open bookshelves and lack of sweeping floors, were associated with rhinitis. The study concludes that the identified risk factors seemed independent of season or climate region.

1. Introduction

There is an increasing concern about the quality of the indoor environment in homes and the rising prevalence of diseases and disorders (Ortiz, Itard, and Bluyssen 2020). Health and comfort of occupants are affected by 'bad' indoor environmental quality (IEQ) (including indoor air, thermal, acoustical and lighting quality). IEQ is determined by the outdoor environment (such as location, soil and traffic), the occupants and their activities (cleaning, cooking, showering, etc.), other non-human occupants (pets, pests), and the dwelling and its systems (construction and furnishing materials, lighting, ventilation, heating systems, furniture, etc.) (Bluyssen 2015; Bluyssen 2019). The quality of the indoor environment can lead to complaints about mould growth and respiratory problems, thermal comfort stress (people feel too cold, too warm) and noise annoyance, and other health problems as a consequence of repeated comfort stress (Bluyssen 2020). Mental health effects (Houtman et al. 2008), cardiovascular diseases (Lewtas 2007), a variety of asthma-related health outcomes (Fisk, Lei-Gomez, and Mendell 2007), and obesity (Bonnefoy et al. 2004) have been associated with exposure indoors. It is known that these effects can be influenced by factors and stressors other than the environmental parameters used in

guidelines, whether of psychological, physiological, personal, social or environmental nature (Bluyssen 2020). Most IEQ studies in homes mainly involve children (e.g. Bornehag et al. 2005; Tham et al. 2007; Sun and Sundell 2013; Takaoka, Suzuki, and Nörback 2014; Choi et al. 2014), few on (young) adults or students (e.g. Zhang et al. 2019; Mendell and Heath 2005; Sun et al. 2013; Bluyssen, Ortiz, and Roda 2016). Additionally, very few studies have simultaneously investigated the impact of environmental and individual factors on health (Bluyssen 2020). The assessment procedures applied in those studies (on schools and children (Bluyssen et al. 2018), office buildings and office workers (Roda et al. 2015; Bluyssen, Ortiz, and Roda 2016; de Kluizenaar et al. 2020) and homes and (young) adults (Bluyssen, Ortiz, and Roda 2016)), using checklists and questionnaires, made it possible to identify other factors and stressors than the environmental parameters used in guidelines. Then, with the use of multivariate analysis, it was possible to determine patterns of factors that are associated with certain health effects. For example for the study with 396 Dutch students with the 'Home' questionnaire, both personal and environmental factors were linked to rhinitis in young adults, confirming that rhinitis is a multifactorial disease (Bluyssen, Ortiz, and Roda 2016). Besides genetics, rhinitis was associated with the presence of pets, the presence of MDF from less than one-year-old furniture, opening windows in the bedroom more than once a week, and working out.

To study health and comfort of students in other countries, the previously developed 'Home' questionnaire (Bluyssen, Ortiz, and Roda 2016) was distributed among five groups of students from five universities in five cities: Taichung (Taiwan), Concepcion (Chile), Paramaribo (Suriname), Beijing (China) and Delft (the Netherlands). The outcome showed that rhinitis was the most reported disease (18%), while the most reported symptoms were headaches (30%).

Based on the large database from the survey conducted on students and their homes from the universities in five cities of different countries, this study explored the associations between the indoor environment of the students' homes, the students personal and psychosocial aspects, and both rhinitis and headaches, aimed at identifying building-related factors that are associated with health effects (rhinitis and headaches), independently of the climate and season.

2. Methods

2.1. Study design

Students from universities in different cities were asked to complete a digital questionnaire on their health and comfort in relation to their homes, at least three weeks before the outcome was presented at their university on the following dates and places:

- School of architecture, Feng Chia University in Taichung, Taiwan, 12 December 2018.
- Faculty of Architecture and the Built Environment, Delft University of Technology (TUD), Delft, The Netherlands, 10 April 2019.
- Departamento Diseño y Teoría de la Arquitectura, Universidad del Bio-Bio Concepción, Concepcion, Chile, 29 July 2019.
- Faculteit Technologische Wetenschappen, Studierichting Infrastructuur, Anton de Kom Universiteit van Suriname, Paramaribo, Suriname, 22 October 2019.
- School of Architecture of Tsinghua University, Beijing, China, 10 December 2019.

The students received an invitation by e-mail with a link to the digital questionnaire on the website of the TU Delft. In the e-mail, the purpose and the procedure of the survey were explained and the deadline for completing the questionnaire was given. In principle, all students who were registered/invited for the lecture received an invitation. It was estimated that the questionnaire would take 30 min to complete. A participant could save the survey at any time and resume it later.

2.2. Questionnaire

The electronic-based questionnaire was voluntary, anonymous and available in English, Chinese, Spanish and Dutch. It was based on the OFFICAIR questionnaire (Bluyssen et al. 2015), including the International Positive and Negative Affect Schedule Short Form, I-PANAS-SF (Thompson 2007) and Emocard to assess the self-reported emotional status at the moment of filling in the questionnaire (Desmet,

Overbeeke, and Tax 2001), the dwelling questionnaire (Dassonville et al. 2009) and the HOPE checklist for homes (Roulet et al. 2006). It included questions about personal data, health and physical effects, some psychological characteristics, events, home environment, occupants, materials and procedures such as cleaning. The questionnaire included 125 questions at maximum (without skip logic questions) and one optional question about respondents' interest in the questionnaire and ease to fill in.

2.3. Ethical aspects

The students were asked to give informed consent to start the survey. Participants were able to skip any question they would not feel comfortable with. To decrease involuntary missing answers, an automatic check of completeness was performed, and missing answers were signalled to the participant at the end of each page of the questionnaire.

2.4. Data management and analysis

All data were digitally completed and imported from the Qualtrics XM platform to IBM SPSS statistics 25 (SPSS Inc., Chicago, IL, USA) for analysis of the data. First, the data for the respondents whose progress was less than 50% were filtered out. Then, the participants that didn't answer all the questions about diseases and symptoms, were deleted as well. Descriptive statistics such as percentages, range (minimum– maximum), arithmetic mean with standard deviation (SD) were used to summarize students' and home characteristics. The differences between the different student groups were analysed with ANOVA test (for the variables at the interval level, such as age) and Chi-squared test (for the variables at nominal level, such as gender).

To examine the relations between rhinitis (the most reported disease) and building characteristics, and headaches (the most reported and most statistically different (between countries) building-related symptom) and building-related aspects, multiple linear regressions were fitted. For rhinitis potential personal factors were: gender, age, family history of rhinitis, smoking status (yes vs. no), and psychological aspects (negative events). For headaches potential personal factors were: gender and age.

Concerning the building-related aspects: building type ('detached' versus 'not detached', as a measure for density of buildings), construction date ('before 1945' versus 'after 1945'; and 'before 1981' versus 'after 1981'), building location ('urban' – combining mixed area, city centre, town, versus 'rural area' – combining suburban, village or rural area) and outdoor pollution sources were analysed. Heating and cooking amenities ('gas' versus 'no gas'), type of wall/floor coverings, furniture, presence of plants, cleaning activities ('at least once a week' versus 'less than once a week'), use of consumer products ('at least once a week' versus 'less than once a week'), ventilation systems, humidity signs and opening of windows ('more than once a week' versus 'once per week or less'), were taken into account.

Variables associated with a P-value of less than 0.20 in the bivariate analyses and personal risk factors were included in the multivariate analysis. The final model was obtained by eliminating variables associated with a P-value greater than 0.05. Collinearity among variables in the model was measured by the variance inflation factor (VIF). No multicollinearity was detected (VIF<4). Results are expressed as adjusted odds ratios (OR) with their confidence intervals at 95% (95% CIs).

3. Results

3.1. Participation rate and characteristics of the study respondents

In Table 1, the total number of student questionnaires, the response rates, the climate characteristics and the mean outdoor air temperature and relative humidity during the study period of the five cities are presented. For all cities, it was the heating season, except for Paramaribo, which does not have a heating season. A total of 682 questionnaires were submitted. The response rate was 75% (ranging from 35% to 94%). According to the Köppen–Geiger climate classification system (Geiger, 1954), the five investigated cities belong to five different climate zones (see Table 1).

Table 2 shows some of the characteristics of the respondents. The mean age of the students that participated differed significantly between the cities ($p < 0.001$). In Concepcion, the mean age of the students (mean 30 years) was approximately 10 years higher than the mean ages of the participating students in the other cities. The chi-square test results indicated that gender ($p = 0.06$) and marital status ($p < 0.001$)

Table 1. Number of investigated students and response rate, the climate characteristics and the mean outdoor air temperature and relative humidity of the five cities (Geiger, 1954; Timeanddate, 2020).

City	Taichung 2018	Delft 2019	Concepcion 2019	Paramaribo 2019	Beijing 2019
Type of students	Bachelors	Bachelors	Masters/PhDs	Bachelors	Bachelors
Students on list	71	396	57	58	100
Completed questionnaires[a]	67	354	31	27	35
Response rate (%)	94	89	54	47	35
Climate classification	Cwa (temperate, dry winter, hot summer)	Cfb (temperate, no dry season, warm summer)	Csb (temperate, dry summer, warm summer)	Af (tropical, rainforest)	Dwa (Cold, dry winter, hot summer)
General climate characteristics	mild, generally warm and temperate; the summers have much more rainfall than the winters	warm and temperate; significant rainfall throughout the year	mild, generally warm and temperate; winters have much more rainfall than the summers	tropical climate; significant rainfall throughout the year	cold and temperate; the summers have much more rainfall than the winters
Study season	Winter	Spring	Winter	Autumn	Winter
Time of year	November	March	July	October	November
Mean outdoor temperature °C	22	8	6	27	10
Mean RH %	85	82	51	79	86

[a]Questionnaires that were used for analysis were based on completion for more than 50%.

also differed significantly among different cities. For example, most of the students from Beijing were male (71%), while most of the participants from Paramaribo were female (67%). All the students from Beijing were single, while most (58%) students from Concepcion were married.

In terms of their lifestyle, a lot of significant differences were found among the students from the different cities. For time spent at home (during weekdays: $p < 0.001$; during weekends: $p < 0.001$), students from Taichung spend the least time at home, during weekdays as well as during weekends. For physical activity ($p < 0.001$), students from Beijing spend more hours physically active than the others. From the Chi-squared tests, it can be seen that the percentage of students who performed physical activities ($p < 0.001$), who smoke ($p < 0.001$), and who drank alcohol also differed a lot among these cities ($p < 0.001$). Almost all (97%) students from Beijing exercised and never smoked, while in Paramaribo and Delft respectively 44% and 58% exercised. In Beijing, 66% did not drink alcohol, while in Delft this was only 10%.

Also, concerning the psychophysical aspects, the experiences of the students differed significantly between cities (positive event: $p = 0.003$; negative event: $p = 0.009$). In Paramaribo, 56% recently experienced positive events, while in Beijing this was only 23%. The percentage of students who experienced negative events was also the lowest in Beijing (6%), while in Concepcion this was the highest (39%).

In Concepcion, the highest incidence of rhinitis (45%) was reported, while in Delft it was the lowest (14%). Headaches had the highest self-report rates in Delft (33%) and the least among students in Beijing (17%). Both were found statistically significantly different between the students from the different cities ($p < 0.001$).

Students emotional state at the time of filling in the questionnaire is presented in Figure 1. 24%, 27%, 26%, 26% and 41% felt tense, irritated, sad or bored in respectively Delft, Taichung, Beijing, Concepcion and Paramaribo. For almost all emotions, there was no statistically significant difference between the students from the different cities, except for 'neutral' ($p = 0.020$).

3.2. Building-related aspects of the student homes

In the questionnaire, several characteristics of the homes of the respondents were inquired about (see Appendix A). Again, several statistically relevant differences can be seen between the means of reported characteristics for the five cities. For example, the majority of students in Taichung, Beijing and Concepcion live in apartment and gallery complexes, while in Paramaribo the majority lives in detached houses. Most of the houses the Delft students live in are from before 1981, while the houses of the students from the other cities mostly date from after 2000. Delft had the lowest number of students living in houses that are located

Table 2. Some characteristics of the students studied.

Characteristics	Taichung n* (%)	Delft n* (%)	Concepcion n* (%)	Paramaribo n* (%)	Beijing n* (%)	Total n* (%)	Compare p-value
Personal							
Gender							**0.006** [c]
Female	32 (48)	197 (56)	12 (39)	18 (67)	10 (29)	269 (52)	
Male	35 (52)	157 (44)	19 (61)	9 (33)	25 (71)	245 (48)	
Age							**<0.001** [a]
Min-max	19–38	17–35	24–39	17–28	18–21	17–39	
Mean (SD)	20 (4)	19 (2)	30 (7)	21 (3)	19 (1)	20 (4)	
Marital status							**<0.001** [c]
Single	65 (97)	345 (97)	13 (42)	25 (93)	35 (100)	483 (94)	
Married/living together	2 (3)	9 (3)	18 (58)	2 (7)	0 (0)	31 (6)	
Lifestyle							
Time spend at home – in hours							
Weekday: mean (SD)	11 (5)	14 (3)	14 (3)	14 (3)	13 (3)	13 (3)	**<0.001** [a]
Weekend: mean (SD)	13 (6)	15 (6)	18 (4)	19 (3)	18 (4)	15 (6)	**<0.001** [a]
Workout							
Yes	47 (70)	337 (95)	28 (90)	12 (44)	34 (97)	458 (89)	**<0.001**
Days/week: mean (sd)	4 (2)	5 (2)	4 (2)	4 (2)	6 (1)	5 (2)	**<0.001** [a]
Smoking status							**<0.001** [c]
Current	6 (9)	136 (39)	6 (19)	6 (23)	0 (0)	154 (30)	
Former	7 (10)	12 (3)	4 (13)	3 (12)	1 (3)	27 (5)	
Never	54 (81)	205 (58)	21 (68)	17 (65)	34 (97)	331 (65)	
Alcohol consumption: yes	33 (49)	319 (90)	24 (77)	19 (70)	12 (34)	407 (79)	**<0.001** [c]
Psychophysical aspects							
Positive Events (yes)	35 (52)	120 (34)	13 (42)	15 (56)	8 (23)	191 (37)	**0.004** [c]
Negative events (yes)	22 (33)	127 (36)	12 (39)	9 (33)	2 (6)	172 (34)	**0.009** [c]
Family medical history							
Family rhinitis	15 (23)	78 (22)	8 (26)	10 (37)	9 (27)	120 (23)	0.244 [c]
Health in the last 12 months							
Rhinitis	18 (27)	49 (14)	14 (45)	5 (19)	6 (17)	92 (18)	**<0.001**
Building-related symptoms in last 3 months							
Headaches	14 (21)	117 (33)	10 (32)	8 (31)	6 (17)	155 (30)	**<0.001**

Notes: *number of students may vary because of missing information; Min-max = minimum and maximum; SD = standard deviation; [a]means ANOVA test; [c]means Chi-squared test. p-values in bold mean statistically significant at the 5% level.

in a suburban area with large gardens (6%), while Paramaribo had the largest number of students (52%) living in such houses.

With regards to other occupants in the house, in Concepcion and Paramaribo more than 50% of the students had a pet, mostly a dog and/or a cat. Pests were reported most in Paramaribo (e.g. cockroaches (74%), ants (67%), mice (59%) and rats (26%)) and the least in Taichung. While silverfishes were the biggest problem in Delft (39%), moths were the biggest problem in Beijing (46%), ants in Concepcion (29%) and cockroaches in Taichung (28%).

In both Taichung and Beijing, only one person painted or refurbished their living quarters, while in the other cities more students did this (ranging from 38 to 50% of the students reported to have done this). With regard to cleaning, Concepcion students dusted surfaces the most (90%), in Paramaribo the least (44%), while vacuum cleaning or sweeping floors was performed the least in Taichung (75%).

In Delft, Concepcion and Paramaribo, the polluting consumer products used most often were spray deodorants, air fresheners and disinfectants. In Taichung and Beijing, very few polluting consumer products were used, while in Paramaribo they used the most. In Concepcion, the highest percentage of students reported having furniture made out of MDF less than one-year-old in their bedroom (25%), while in Delft they had the most natural plants in their homes (85%).

While in Concepcion, electrical heating or other systems are used for heating, in Delft and Beijing radiators seem to be most common, and in Taichung and Paramaribo air heating or other systems. Air conditioning is used by most students in Taichung, Beijing and Paramaribo (resp. 88%, 88% and 67%), while in Concepcion only one student pointed out to have it.

Operable windows were reported the most in Beijing (97%) and the least in Taichung (45%), while in Delft the highest percentage of mechanical ventilation was reported (21%) and the lowest in Beijing
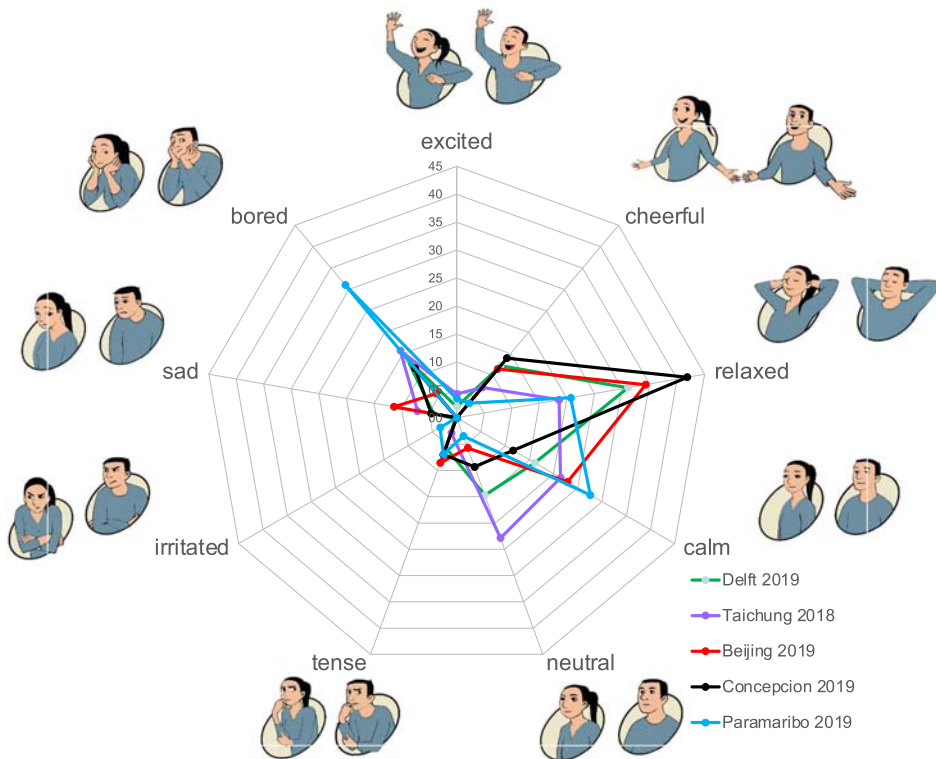
Figure 1. Students emotional state according to the mood scale of Desmet et al. for each of the student group investigated, expressed in percentage of respondents per mood state.

(3%). Condensation on the inside of windows and visible growth of moulds indoors was reported the most in Concepcion (resp. 65% and 36%).

3.3. Building-related aspects versus rhinitis and headaches

In Appendix B, the results from the univariate analyses are presented. Tables 3 and 4 show the multivariate logistic regression models for respectively rhinitis and headaches.

Table B1 shows the associations of personal and building-related aspects with suffering from rhinitis from the univariate analysis, before and after adjustment for gender, age, smoking status, family

Table 3. Multivariate logistic regression model of the relations between rhinitis and building-related factors.

Variable	Adjusted OR (95% CI)	p-value	VIF
Gender* female vs. male	0.89 (0.48–1.63)	0.696	1.083
Age* 17–25 vs 26–39	3.69 (1.44–9.42)	**0.006**	1.133
Smoker* no vs. yes	0.83 (0.44–1.57)	0.570	1.069
Family rhinitis no vs. yes*	0.24 (0.13–0.44)	**0.000**	1.021
Negative events* yes, recently vs none	0.66 (0.35–1.24)	0.193	1.079
Location urban vs. rural	0.39 (0.18–0.84)	**0.016**	1.235
Pets no vs. yes	0.28 (0.13–0.60)	**0.001**	1.214
Sweeping less than 1/week vs. at least 1/week	1.99 (1.05–3.77)	**0.035**	1.056
Dryer vented out vs. not out	0.45 (0.17–1.20)	0.110	1.092
Landfill source no vs. yes	0.29 (0.05–1.60)	0.154	1.030
Open fireplace vs. no fireplace	2.12 (0.79–5.65)	0.135	1.185
Exposed bookshelves vs. no bookshelves	2.43 (1.30–4.53)	**0.005**	1.067
Washer location other places (cellar, kitchen, bathroom, laundry room) vs. in living space	0.48 (0.21–1.09)	0.078	1.052

Notes: *adjusted variables; OR = Odds Ratio; CI = Confidence interval; VIF = variance inflation factor; P-values below 0.05 are in bold.

Table 4. Multivariate logistic regression model of the relations between headaches and building-related factors.

Variable	Adjusted OR (95% CI)	p-value	VIF
Gender* female vs male	1.10 (0.694–1.731)	0.693	1.076
Age* 17–25 vs. 26–39	0.58 (0.262–1.283)	0.179	1.134
Negative event yes vs. no	1.60 (1.003–2.546)	**0.049**	1.042
Building type attached vs. detached	1.45 (0.849–2.462)	0.175	1.269
Building year before 45 vs. after 45	1.59 (0.932–2.694)	0.089	1.080
Location urban vs. rural	0.58 (0.343–0.963)	**0.035**	1.329
PANAS negative low vs. high	0.40 (0.206–0.773)	**0.006**	1.045
Spray deodorant at least once a week vs. less	1.60 (0.929–2.763)	0.090	1.092
Pets yes vs. no	1.92 (1.141–3.227)	**0.014**	1.169
Condensation outside windows yes vs. no	0.68 (0.422–1.081)	0.102	1.046
Open fireplace no vs. yes	0.54 (0.281–1.042)	0.066	1.193

*adjusted variables; OR = Odds Ratio; CI = Confidence interval; VIF = variance inflation factor; *P*-values below 0.05 are in bold.

rhinitis, and negative events. After adjustment rhinitis was associated ($p < 0.05$) positively with marital status (single versus married), open bookshelves (yes versus no) and bubbles or yellow discoloration of the floor (yes versus no); negatively with building location (urban vs rural) and presence of pests (no versus yes). A tendency was observed with a nearby construction site (yes versus no), the presence of other pets than dogs, cats, rodents or birds, and washer location (living space versus others).

Table 3 shows the results of the multivariate logistic regression model for rhinitis. Location (urban versus rural) (adjusted OR: 0.39, CI: 0.18–0.84) and having no pets (adjusted OR: 0.28, CI: 0.13–0.60) were negatively related to rhinitis. Sweeping the floor (less than 1/week versus at least 1/week) (adjusted OR: 1.99, CI: 1.05–3.77) and exposed bookshelves (adjusted OR: 2.43, CI: 1.30–4.53) were positively related to rhinitis. Rhinitis was also related to personal factors age (17–25 versus 26–39 years) (adjusted OR: 3.69, CI:1.44–9.42) and family rhinitis (adjusted OR: 0.24, CI: 0.13–0.44).

Table B2 shows the associations of personal and building-related aspects with suffering from headaches from the univariate analysis, before and after adjustment for gender and age. After adjustment headaches were associated ($p < 0.05$) positively with alcohol use (yes versus no), negative events (yes versus no), presence of noise pollution source: water bodies (yes versus no), use of air freshener (at least once a week versus less), use of incense (at least once a week versus less), presence of pets (yes versus no) and presence of mice (yes versus no). A tendency was observed with the use of disinfectant (at least once a week versus less), and condensation outside windows (yes versus no).

Table 4 shows the results from the multivariate logistic regression model for headaches. Negative event (adjusted OR: 1.60, CI: 1.00–2.55) and having pets (adjusted OR: 1.92, CI: 1.14–3.23) were positively related to having headaches. Location (urban versus rural) (adjusted OR: 0.57, CI: 0.34–0.96) and PANAS negative (low versus high) (adjusted OR: 10.40, CI: 0.21–0.77) were negatively related to headaches. The presence of an open fireplace showed a tendency for a relation with headaches.

4. Discussion

4.1. Strengths and limitations

This study was based on a survey among students from universities in different cities (mean age 20 years), from different climate regions, in the heating season (except for Paramaribo, which does not have a heating season) that collected data on a broad range of relevant stressors, including personal factors, other factors of influence, and events. The response rate of 75% was high, although differences occurred between countries (35–94%). This could be related to the fact that the survey was connected to an (invited) lecture at which the outcome of the survey was presented.

The study sample was not representative of students attending universities in the different countries. All students had an architecture and/or building engineering background, which can introduce a potential bias to the results. Therefore, the results cannot be generalized to the entire student population.

Also, because of the cross-sectional nature of the study, no causal pathway could be established. The study comprised of self-reported data only, no monitoring or inspection of the homes of the students was performed.

4.2. Building-related factors and rhinitis

On average 18% of the students (with a range of 14–45% for the different universities) reported having suffered from rhinitis in the last 12 months, which confirms previous studies (Dykewicz and Hamilos 2010; Bousquet et al. 2008; Wheatley and Togias 2015; Mösges et al. 2016). Dykewicz and Hamilos (2010) estimated that 10–25% of the population in Western societies has rhinitis. Bousquet et al. (2008) indicated a range of 17–28.5% in Europe, Wheatley and Togias (2015) a range of 15–30% for the USA, and Mösges et al. (2016) reported in Asia a from 10% (in Korea) to 50% (in Vietnam and Thailand).

Multivariate analysis in this study confirmed an association with both allergic and non-allergic conditions: biological allergens from the presence of pets and chemical pollutants from exposed bookshelves and sweeping the floor less than once per week. The strongest association was found for students that have relatives who suffer from rhinitis ($p < 0.001$), confirming an earlier study with students in the Netherlands (Bluyssen, Ortiz, and Roda 2016). Besides a family connection (genes from parents), age was also found to be associated with rhinitis: students under the age of 25 had a higher risk for having rhinitis.

Animal dander and secretions (allergic pollutants) (e.g. cats, dogs, rodents and others) have been associated with rhinitis (Wang et al. 2015). The presence of pets can cause allergic responses in both children and adults (Wang et al. 2015). In this study 'not having pets' resulted in a decreased risk for rhinitis, similar to the decreased risk found in an earlier study with students in the Netherlands (Bluyssen, Ortiz, and Roda 2016).

A decreased risk of rhinitis was found for living in an urban area (versus living in a rural area). A significant difference in having pets between living in an urban area and living in a rural area ($p < 0.001$), indicates that this decreased risk is related to having pets.

An increased risk of rhinitis was found for the presence of exposed bookshelves and for sweeping the floor less than once a week, indicating the presence of chemical pollutants and/or dust in the indoor environment (Bluyssen 2015).

Although in the univariate analysis, bubbles or yellow discolouration of the floor (yes vs no) showed an increased risk for rhinitis and a possible relation with humidity problems, in the final model this risk was no longer present.

4.3. Building-related factors and headaches

On average 30% of the students (ranging between 17% and 33% for the different universities) reported having experienced headaches in the last 3 months, related to staying in their home. Headaches, specifically tension-type headache, is a highly prevalent condition that has been found to occur over a wide range from 1.3% to 65% in men and 2.7% to 86% in women (Swartz et al. 2020). Headaches were among the most reported building-related symptoms in two studies in the Netherlands (Kim and Bluyssen 2020; Eijkelenboom, Kim, and Bluyssen 2020). According to Wang (2003), the percentage of people suffering from headaches was 15.6% to 25.7% in the Asia area.

Headaches have a multifactorial character and can be affected by personal, psychosocial and environmental aspects (Schwartz et al. 1998). Few studies have looked into the relationship between headaches and IEQ. Some studies found that the air temperature and relative humidity had a significant effect (e.g. Norbäck and Nordström 2008); light and lighting were common triggers of migraine and headache (e.g. Shepherd 2010); others have observed relations with particulate exposure (e.g. Dales, Cakmak, and Vidal 2009) and/or other air pollutants (e.g. Fisk et al. 1993).

In the home questionnaire, we did ask for satisfaction with glare, artificial lighting, and natural lighting, and the descriptive analysis showed that only the students in Paramaribo had problems with glare (44%). Dissatisfaction with natural lighting varied from 5.6% in Paramaribo to 24.2% in Beijing, and with artificial lighting from 2.9% in Concepcion to 22.2 in Taichung and Paramaribo. However, no relation was found between problems with glare (a possible risk factor for headaches) and the reporting of headaches.

Multivariate analysis in this study showed an association with psychosocial factors (negative events and PANAS negative) as well as biological air pollutants through the presence of pets. Living in an urban area again showed a decreased risk of having headaches, most likely related to the association with having no pets

(similar to what is seen with rhinitis). The presence of air pollutants (e.g. fine particles) through the open fireplaces showed a tendency for an increased risk of headaches.

While in the univariate analysis use of alcohol, presence of water bodies (noise source), use of air freshener (at least once a week), use of incense (at least once a week), and presence of mice, showed an increased risk for headaches, in the final model these risks were no longer present.

5. Conclusion

A questionnaire was distributed among five groups of students from universities in five different cities. The questionnaire resulted in a database of information on the health and comfort of the students and the characteristics of their homes all over the world.

Multivariate analysis confirmed for both rhinitis and headaches their multifactorial character with building-related risk factors and several personal-related risk factors: biological pollutants (caused by pets) were associated both with rhinitis and headaches in students from different countries. Chemical pollutants, caused by open bookshelves and lack of sweeping floors, were associated with rhinitis; while the presence of air pollutants (e.g. fine particles) through the open fireplaces showed a tendency for an increased risk of headaches. Personal-related factors family rhinitis and age were associated with rhinitis, and negative events and PANAS negative with headaches.

The risk factors identified for having rhinitis and/or headaches, seemed to be independent from the season or climate region.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Notes on contributors

Prof. dr. Philomena M. Bluyssen, initiator and creator of the SenseLab, was appointed full Professor Indoor Environment in 2012 at the Faculty of Architecture and the Built Environment, after working for more than 21 years for TNO, a research institute in the Netherlands. She holds a master degree (building engineer) from the Technical University of Eindhoven (1987) and a PhD from the Technical University of Denmark (1990). She has written more than 260 publications in (inter)national journals and conference proceedings. For the Indoor Environment Handbook: How to make buildings healthy and comfortable, she was awarded the *Choice Outstanding Academic Titles of 2010 Award*. Her book titled 'The Healthy Indoor Environment – How to assess occupants' wellbeing in buildings', published by Taylor & Francis in 2014, was awarded the *Interior Design Educators Council 2016 book award*.

Dr. Dadi Zhang is a postdoctoral researcher in the Chair of Indoor Environment at the Faculty of Architecture and the Built Environment, of the Delft University of Technology. She holds a master degree (heating, gas supply, ventilating, and air conditioning engineering) from the University of Science and Technology Beijing (2016), and a PhD from the Delft University of Technology (2020). Her research interests include indoor environmental quality, ventilation strategy, and noise control.

Dr. Marco Ortiz is a postdoctoral researcher in the Chair of Indoor Environment at the Faculty of Architecture and the Built Environment, of the Delft University of Technology. His main research focus is on the comfort behaviours of occupants and their effects on energy consumption. He earned his PhD at the Faculty of Architecture and the Built Environment (2019) and holds an MSc in Industrial Design Engineering (2014) both from the TU Delft.

ORCID

Philomena M. Bluyssen http://orcid.org/0000-0002-5732-5362
Dadi Zhang http://orcid.org/0000-0002-1293-0542
Marco Ortiz http://orcid.org/0000-0002-9087-9666

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