JOURNAL OF SCHOOL HEALTH

American School Health Association
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RESEARCH ARTICLE

Association Between Markers of Classroom Environmental Conditions and Teachers' Respiratory Health

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ABSTRACT

BACKGROUND: Studies have assessed health in schoolchildren. Less is known about the environmental and occupational health of teachers.

METHODS: A cross-sectional survey of teachers was conducted in 24 randomly selected public elementary schools. Questionnaire included sociodemographic information, healthcare, school conditions, and health outcomes. Chi-square and logistic regression were used to analyze bivariate relationships. Multivariable logistic regression model was created for each health outcome, adjusted for sex and smoking to calculate estimates of association (OR) for variables that were significant in bivariate analysis.

RESULTS: Response rate was 71.2 % (N = 797). Classroom conditions significantly associated with respiratory symptoms included having no windows or windows that do not open were associated with asthma or colds (OR 2.0); carpeting was associated with having asthma, itchy eyes, and eye irritation (OR 1.9); mold or water damage was associated with respiratory infections, eye irritation (OR 2.1), nasal congestion (OR 2.4), and sore throat (OR 2.7); visible dust was associated with frequent colds (OR 2.2), nasal congestion (OR 1.7), and sore throat (1.9).

CONCLUSIONS: Asthma, respiratory infections, colds, eye irritation, nasal congestion, and sore throat were associated with the classroom environment. Results indicate that the school environment could affect teachers' respiratory health. Further assessments are necessary to establish causation.

Keywords: teacher health; school environment; asthma; environmental health; occupational health; indoor air quality; respiratory symptoms.

Citation: Claudio L, Rivera GA, Ramirez OF. Association between markers of classroom environmental conditions and teachers' respiratory health. J Sch Health. 2016; 86: 444-451.

Received on February 24, 2014
Accepted on January 14, 2016

The impact of the school environment on children's health has been previously investigated.[1-4] However, less attention has been paid to the effect that the school environment may have on teachers.[5,6] This could be partially due to the lack of information on the condition of school environments nationwide. In the United States, the last comprehensive survey of the condition of schools facilities was conducted in 1995, with a smaller survey of a representative sample of schools conducted in 1999. At that time, the average school building in the United States was 40 years old, and approximately 28% of elementary schools reported that the heating/ventilation/air conditioning was less than adequate.[7] In schools in which more than 70% of the students were eligible for free or reduced-price lunch, the average age of the school building was 44 years and 35% reported less than adequate heating/ventilation/air conditioning systems.[7] These data suggest that lower-income communities often have older school buildings with poorer indoor envi-

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This study was conducted in close collaboration with Dr. Chris Proctor, Director of the Safety and Health Department for the United Federation of Teachers. We extend our thanks to the dedicated teachers and school principals who participated in this study.

ronments. Since the 1970s, chronic illness has been associated with buildings and building construction materials.[8] Many studies have shown an association between the indoor environment and workers' health and work performance.[6,9-11]

There are several factors specific to the school environment that could affect teachers' health. Indoor air quality in schools differs from other buildings because school occupancy is generally denser than in homes or office buildings, with the typical school averaging 4 times as many occupants per square foot as the typical office building.[12] In many public schools, heating, ventilation, and air conditioning systems often malfunction, are outdated, or are nonexistent.[7,13] Higher occupancy densities combined with lower ventilation rates may lead to an increased incidence of infectious diseases as well as odor and comfort complaints.[11] Indoor pollutants may exacerbate diseases such as asthma and allergies that produce symptoms or absenteeism that impair learning and performance.[9,14]

One of the important sources of concern is some of the materials used in schools. For example, carpets can be a source of chemical emissions and can also act as a "sink" for chemical and biological pollutants including pesticides, dust mites, and molds.[15,16] The presence of water-damaged materials and high humidity is also linked to the presence of biocontaminants, especially mold.[9] Humidity in buildings is considered to be a possible trigger of asthma, allergic symptoms, such as irritation of the eyes, and of the upper airways.[17,18] Dust may also contribute to symptoms due to allergens and airborne materials such as dust mites, cat dander, cockroach antigens, and mold.[14]

It has been documented that occupational respiratory disease can be more highly prevalent in certain workplaces like the ones specifically related to manufacturing, transport, equipment operators, agriculture, and fishing.[19,20] However, little is known about the exposures and health outcomes in teachers. Previous work has shown that teachers are more likely to suffer from head and chest colds, particularly during the school year, than the general population.[5] According to reports from the United Federation of Teachers (UFT), the most frequent complaint of teachers is poor indoor air quality in the schools where they work.[21] This is important, especially at a time when school teachers' performance is increasingly under scrutiny. For instance, studies have documented that improvement in the quality of indoor air can have a significant and positive influence on the productivity of office workers,[14,15,22] and one study has shown that measures of school environment are associated with short-term sick leave among teachers.[6] The purpose of this study is to assess the health conditions prevalent in teachers and whether these might be related to factors associated with the school environment.

Table 1. **Sociodemographic Characteristics of the Sample**

	N	%
Sex		
Female	711	89.2
Age (years)		
		42.5 ± 12.1
20-30	146	18.3
31-40	207	26.0
41-50	165	20.7
51-60	166	20.8
≥61	55	6.9
Household income		
$25,000-$49,999	94	11.8
$50,000-$74,999	216	27.1
$75,000-$100,000	240	30.1
More than $100,000	231	29.0
Educational attainment		
Bachelor	85	10.7
Master	628	78.8
PhD	9	1.1
Other	68	8.5
Race/ethnicity		
White	509	63.9
Black	112	14.1
Latino	110	13.8
Multiracial	39	4.9
Asian	18	2.3
Marital status		
Married/lifetime partnership	457	57.3
Single	225	28.2
Divorced/separated/widowed	113	14.2
Born in the United States		
Yes	644	80.8
No	150	18.8
Years in the United States (mean ± SD)	26.8 ± 11.6	

METHODS

Participants

A cross-sectional study was conducted in randomly selected elementary public schools during the 2010-2011 and 2011-2012 school years. Schools were selected based a multistage stratified random sampling, as previously described.[23] This sampling method was used to obtain a study population of teachers working in neighborhoods of diverse race/ethnicity (black, white, and Latino) and socioeconomic levels from the 5 boroughs of New York City. In brief, Census 2010 data were used to identify zip codes with demographic data of greater than 50% black, white, or Hispanic populations in the 5-14 years age range. These zip codes were then stratified into high (>$50,000), median ($35,000-$50,000), and low (< $35,000) annual household income groups (Table 1). Three zip codes in each stratum were randomly selected for inclusion in the study, except for Hispanic zip codes for which none could be classified as high income.

In second stage sampling, enrollment and demographic population data from the school year were obtained from the New York City Department of

Education. Three public elementary schools (K-5) with greater than 40% black/white/Hispanic population, respectively, were randomly selected in each zip code. In total, 24 schools were selected for participation. One school refused participation, at which point another school was randomly selected from the remaining eligible schools within the zip code.

Data Collection

After scheduling with each school principal, an informational letter about the study was distributed to the teachers 3-5 days before the school visit. All classroom teachers in the school were eligible for the study.

During school visits, teachers were contacted either at their classrooms, during staff meetings, or during a lunch period to invite them to participate. To maintain confidentiality of the teachers' responses, the completed questionnaires were deposited by the teachers in sealed envelopes into a locked box located at the main office. To encourage participation, the school principal and all teachers who returned completed questionnaires were given nominal incentives consisting of $25 gift certificates to be redeemed for school supplies. During the data collection phase of the study, the UFT sent out a letter of support to the chapter leaders of each selected school to inform the teachers about the study.

Questionnaire Content

The questionnaire contained items on sociodemographic information, employment information, healthcare access and utilization, school conditions, and general and psychological health. The questionnaire was pilot-tested and revised after receiving input on the content, clarity, and length from the UFT and from teachers not participating in the study.

Occupational factors addressed included self-reported work environment conditions, such as the presence of dust, pests (cockroaches, mice, and rats), carpet (wall to wall carpet, area rug), and windows (no windows or windows that does not open). Some answers were pooled for analytical purposes (no window and windows that do not open) because they were considered in terms of deficiency of indoor air circulation. Similarly, the presence of mice and rats was pooled in variable called "rodents." The variable "carpet" was defined as the presence of wall to wall carpet or the presence of area rug. For the variable "dust," a positive answer was considered as presence of visible dust or enough to write in it.

The method used to construct the variable definition associated with the health conditions was defined using the following question: "Have you been told by a doctor that you have any of the following conditions?" Recall time asked was 12 months. Symptoms like itchy eyes, sore throat, and nasal congestion were asked for recall in the previous 2 weeks and were defined by the question: "In the past 2 weeks, have you had episodes of the following?" Variables that were not dichotomous were changed to this form for analysis purposes.

Data Analysis

Response rates were adjusted using the estimated average teacher absenteeism rate. Survey procedures in SAS 9.1.3 (SAS Institute, Cary, NC) were used to account for the sampling design for stratification by income and race/ethnic distribution and for clustering by school. Chi-square analysis was used to assess the relationship between indoor work environment responses and symptoms and diseases, followed by logistic regression to confirm the association. An a priori probability value of $p < .05$ was considered as statistically significant. Subsequently, a multivariate logistic regression model was created, adjusting for sex, race/ethnicity, and smoking status as selected cofounders to calculate estimates of association (OR) for variables that were significant in the bivariate analysis. Demographic information about our sample was compared with data from the National Center for Education Statistics for New York teachers.

RESULTS

Sociodemographic Characteristics

A total of 797 teachers completed the questionnaire, which represents a response rate of 71.2%, after adjusting for teacher absenteeism rates. The sample consisted of 28.7% general education teachers, 15.1% worked in more than one position, 14.4% were special education teachers. The remaining 41.8% were classroom and cluster teachers. Substitute teachers were not included because they generally did not work in the same school for extended periods of time. The mean number of years working in the New York City Board of Education was 12.1 ± 8.0 (compared to a city mean of 12 years). Teachers spent a mean of 36.2 ± 12.8 hours weekly in the school. The average classroom size was 22.5 ± 7.0 students, close to 23.5 students per class being the average for New York City.

Most of the responders were women (Table 1) with a mean age of 42.5 ± 12.1 years (40 years is the mean citywide). The household income categories follow an almost homogenous distribution from $50,000 to more than $100,000 (Table 1). Household income increased with teacher years of experience. Most of the teachers had a master's degree and most were born in the United States (Table 1). Healthcare utilization patters are shown in Table 2.

The majority of the teachers identified themselves as white (67.9%). There was some degree of concordance

Table 2. **Healthcare Utilization**

	N	%
Type of insurance		
NYC health plan/UFT Welfare Fund	727	91.2*
My spouse/partner's plan	44	5.5*
Private plan	15	1.9*
Other	6	0.8*
Usual source of healthcare		
Private doctor's office	690	86.6
Community clinic/health center	57	7.2
Emergency Department	9	1.1
No usual source	16	2
Other	20	2.5
Visited the emergency department in past 12 months		
Yes	145	18.2
No	645	80.9
Overnight hospital patient		
Yes	69	8.7
No	718	90.1
Preventive health-related test		
Blood pressure checked	643	80.7
Annual physical exam	571	71.6
Cholesterol checked	480	60.2
Colonoscopy	123	55.7†
Mammogram	359	50.5‡
Prostate exam	26	32.1§

UFT, United Federation of Teachers.
*Variables are based on the first choice of answer, because many checked several answers (ie NYC health plan and spouse's plan).
†221 respondents, 50 years and older.
‡771 women in total.
§81 men in total.

Table 3. **Building Conditions**

	N	%
Accumulated dust		
Visible dust, not enough to write in it	428	53.7
At least enough to write in	247	31.0
No visible dust	112	14.1
Observed in the building or in the school grounds		
Cockroaches	214	26.9
Mold/water-damaged materials	130	16.3
Mice	122	15.3
Rats	8	1.0
Present or in use in the classroom		
Windows that open	652	81.8
Area rug	425	53.3
Windows that do not open	107	13.4
Carpet (wall-to-wall)	20	2.5
No windows/no natural light	14	1.8

Table 4. **Self-Reported Disease Frequencies**

	N	%
Diseases		
Allergies	797	30.4
Asthma	797	6.1
Infections		
Flu	530	25.1
Cold	764	80.4
Respiratory infections	797	1.3
Symptoms		
Itchy eyes	797	33.5
Nasal congestion	797	53.1
Sore throat	797	47.7

between the race/ethnicity of the teachers and that of the student population in the schools where they worked. For instance, 86.0% of teachers were white in schools with a majority white student population. Although black teachers constituted only 11.2% of the sample, they comprised 28.5% of teachers who worked in schools where most of the students were black. The same tendency was observed for Latino teachers, where they were 13.6% of the total sample, but they constituted 28.4% of the teachers who worked in primarily Latino schools. As shown in Table 1, the sample compares well with the racial/ethnic composition of New York City teachers. According to data from the National Center of Education Statistics data for 2011-2012, 60% of New York teachers were white, 14.8% were black, 16.7% were Hispanic, 6.9% were Asian, and 1.2% identified themselves as multiracial.

School Building Conditions

More than half of all the teachers reported the presence of visible dust in the workplace. Pests such as cockroaches, mice, and rats were reported to be highly prevalent (Table 3). More than half of the teachers reported the existence of carpets in the classrooms, 53.3% reported the presence of area rugs, and 2.5% reported wall-to-wall carpets. Most of the teachers reported having functioning windows (81.8%). Mold and water damage were reported by 16.3% of the teachers.

Health Conditions

Table 4 shows the frequency of respiratory health conditions. Over 30% of the teachers reported having allergies and 6.1% of the teachers reported having been diagnosed with asthma. The timing of this diagnosis is not known. In this study, 83.9% and 31.7 of the teachers reported having cold and flu in the past 12 months, respectively. Also 1.3% of the teachers reported having a respiratory infection during the past 12 months. For symptoms that could be related to indoor environment, such as itchy or irritated eyes, runny nose or nasal congestion, and sore throat, the prevalence was 33.5%, 53.1%, and 47.7%, respectively.

Teachers reported a low prevalence of current cigarette smoking (9.4%), but 24.0% said they were former smokers. In this study, 41.7% reported being in very good health, and 34.5% reported having good health. Most of the participants (91.2%) use the New

Table 5. **Self-Reported Health Conditions and Occupational Factors Associated With School Environment***

	OR	Confidence Interval
Asthma		
Lack of windows that open	2.0	(1.1-3.8)
Presence of carpets	1.9	(1.1-3.4)
Cold		
Lack of windows that open	2.4	(1.1-5.2)
Presence of dust	2.2	(1.3-3.6)
Respiratory infections		
Presence of mold or water damage materials	2.0	(1.2-3.4)
Itchy eyes		
Presence of mold or water damage materials	2.1	(1.4-3.1)
Presence of carpets	1.4	(1.1-2.2)
Nasal congestion		
Presence of mold or water damage materials	2.4	(1.6-3.7)
Presence of dust	1.7	(1.1-2.7)
Sore throat		
Presence of mold or water damage materials	2.7	(1.7-4.1)
Presence of dust	1.9	(1.2-3.0)

*Models adjusted for sex and self-reported smoking status.

York City health insurance plan (Table 2). A private physician's office was the most common source of healthcare (86.6%).

Work Environment Characteristics

Chi-square and linear regression analyzes were performed to determine the association between self-reported work environment characteristics, health symptoms, and diagnoses of respiratory disease. Subsequently, a multivariable model was constructed adjusting for sex, race/ethnicity, and smoking status as potential confounders (Table 5).

Differences between women and men were significant only in reporting having sore throat; women were twice more likely to report having it (OR 2.0) than men. Some significant differences were found among smokers, former smokers, and nonsmokers. Teachers who reported being current smokers were found to be more likely to report having itchy eyes, cold, and flu than nonsmokers. Also smokers were found to be twice as likely to report having itchy eyes than were former smokers.

After adjusting for sex, race/ethnicity, and smoking, teachers who reported the absence of windows or windows that do not open in the workplace were more likely to report having asthma or cold (OR 2.0) than teachers who had windows that opened.

An association was found between having carpets and having asthma as well as having itchy eyes or eye irritation. Teachers who reported the presence of carpets in the workplace were almost twice more likely to report having asthma (OR 1.9) as compared with teachers who reported not having carpets. The presence of mold or water damage was significantly associated with respiratory infections, eye irritation, nasal congestion, and sore throat. Teachers who reported the presence of mold or water damage were twice as likely to report having these symptoms than teachers who did no report having them in their classrooms. An association was found between the presence of visible dust and having cold, nasal congestion, and sore throat (OR = 2.2) compared to the ones who did not report having it.

DISCUSSION

There are several occupations that have historically been considered at high risk of exposure for work related respiratory diseases such as manufacturing, mechanics, agriculture, among others.[19,20] Not much has been written about teachers' risks in their work environment. The purpose of this study was to survey the self-reported conditions prevalent in teachers and whether these might be related to occupational factors associated with the school environment.

We found that the perception of their general health for teachers who participated in the study is similar to the general population. Data from the 2011 National Health Interview Survey (NHIS) reported that 61% of the participants aged 18 years and over described their health as excellent or very good, compared to our study population where 58.8% reported their health as excellent or very good.[24] This indicates that teachers do not differ significantly in their perception of their health than the general population.

The frequency of self-reported smoking in teachers was lower than that of the general population. In NHIS, 19% of the respondents were current smokers as compared with 9.4% in this study.[24] Smoking has been associated with having asthma and respiratory diseases;[25] therefore, it would have been expected that the prevalence of asthma and upper respiratory tract symptoms should have been lower in teachers than that of the population in general. In spite of their low smoking rate, the prevalence of asthma among teachers (6.1%) was comparable to that of the general population. According to the NHIS, 8.2% of the adult population in the United States reported having asthma.[24] We adjusted our multivariable model by smoking status and still observed associations between having asthma and factors associated with the school environment. Similar to others, we found that teachers may be at higher risk of having colds and influenza, which could be due to continuous contact with children and the high occupant density in their workplace.[5]

Study participants reported a higher frequency of nasal congestion, itchy or irritated eyes, and sore throat than reported in the general population. In the NHIS, Occupational Health Supplement the prevalence of nasal congestion, itchy or irritated eyes, and sore throat was lower compared to the teachers in the

present study.[26] This may be indicative of indoor air quality issues that may be more prevalent in the school environment.[21]

Some previous studies have found differences between men and women reporting symptoms related to occupational factors.[11,17,19,27] Women were more likely to report having sore throat than were men. This is consistent with the notion that women tend to have more voice and throat problems than men because of sex-related differences of the larynx.[27] Ebbehøj et al[17] found a difference between female and male teachers regarding reports of eye and nasal irritation. Probably, due to the continued use of the vocal instrument, teachers are generally more at risk for throat problems.[27] In a previous research assessing the prevalence of respiratory symptoms among female flight attendants and teachers, both were significantly more likely to report throat symptoms than working women in other occupations.[13] However, we adjusted our models for sex and the elevated odds of sore throat when a teacher reported exposure to dust or mold and water-damaged materials remained.

Not having windows or having windows that do not open may cause poor indoor ventilation that may increase use of air conditioning and heating systems. Occupants in air conditioned buildings suffer more respiratory-related symptoms than ones in naturally or mechanically ventilated buildings.[22] Decreased ventilation rates can cause low indoor air quality with accumulations of mold, allergens, and moisture. According to Kinshella et al[12] improving the ventilation rate by a factor of 4 decreases the risk of allergic symptoms by a factor of 2. The relationship between lack of windows to having asthma and cold can indicate the presence of allergens, dampness, or that the air exchange between outside and inside was not enough to dilute contaminants within the building.[15]

The presence of carpets was found to be associated with an increased risk of having asthma and itchy eyes. Building materials including carpets are considered an important cause of poor indoor air quality.[20,28] Wargocki et al[16] conducted an experiment simulating 2 normal offices, 1 low level pollution and 1 free of pollution. In the uncarpeted office, participants were more satisfied about indoor air quality and complained less about symptoms related to indoor air. Carpets accumulate moisture and create a favorable climate for mold to grow, which can serve as asthma exacerbating factors. Mold can also grow on wood, paper, carpet, foods, and insulation. Because its growth requires both dampness and oxygen, controlling moisture is essential.[29]

Water damage or mold was significantly associated with self-reported respiratory infections, eye irritation, nasal congestion, and sore throat. In a study conducted in Sweden about moisture in buildings and health effects, researchers found a strong and consistent association between indoor moisture-related problems and symptoms among children and their parents.[30]

Indoor dust can contain chemically and biologically active elements, such as microbes, endotoxins, allergens, and irritants.[31] The presence of visible dust was associated with having cold, nasal congestion, and sore throat. These results are similar to previous studies. For instance, Chao et al found that upper respiratory symptoms were significantly correlated with total airborne fungal concentrations and total fungal concentrations. The authors also found that the amount of dust on floors was a significant predictor of eye irritation.[28]

Limitations

The symptom, disease, and work environment characteristics analyzed were all self-reported. We did not take any direct environmental samples to confirm the presence of any disease-related contaminants in the workplace. Recall bias could have influenced the results because it is possible that teachers who believe that they have been affected by the school environment may report higher prevalence of symptoms. To address this, we limited the recall question to the previous 12 months for diagnosed conditions and to the previous 2 weeks for symptoms. One should note that only respiratory outcomes and not other ailments were found to be significant, which provides confidence in our results.

Another limitation is that, although the model controls for sex, race, and smoking as confounding variables, it cannot be said with certainty that the symptoms or diseases are due only to exposure at work as there may be unmeasured variables contributing to residual confounding. Nevertheless, given the lack of information about the health of teachers and the current interest in their work performance, this study provides some basic information about their health status and working conditions.

Conclusions

The following conclusions can be made from our study:

1. The study population consisted of 797 teachers. The sample showed no significant differences in educational level, income level, and racial/ethnic composition, or mean age as compared to the general population of teachers.
2. Self-reported asthma, colds, respiratory infections, eye irritation, nasal congestion, and sore throat correlated with factors in the school environment such as dampness, pests, dust, and poor indoor-outdoor air exchange as measured by self-reported surrogate variables.

3. Although teachers reported low smoking rates, their asthma rates were comparable to that of the general population.
4. This is one of few studies that have aimed to assess teachers' health as it may relate to the occupational setting of the school environment. Collaboration with the UFT, school administration and the Department of Education were essential for the conduct of this study. Moving forward, research on cost-effective interventions to improve the school environment may benefit students and teachers.

IMPLICATIONS FOR SCHOOL HEALTH

Schoolchildren have been recognized to be particularly vulnerable to environmental exposures. For that reason, much attention has been paid to the role that the school environment may play on children's health as they spend a significant amount of time in school buildings. Several of our studies have shown high rates of asthma in New York City children.[32,33,34]

Much less attention has been paid to whether the school environment may also affect teachers' health. This article is one of a few that investigates whether markers of school environmental conditions may affect teachers' health.[35] We found that respiratory symptoms were evident in this population, especially in those reporting that they work in school buildings showing signs of high humidity, pests, dust, and low air exchange. Recommendations that may help reduce potentially detrimental conditions in schools may include:

1. Improving air circulation in classrooms
2. Implement low-cost integrated pest management techniques to reduce the presence of pests
3. Improve dust control in the classrooms
4. Work with teachers' organizations to implement occupational health surveillance

Working with school officials may help improve these conditions for teachers.

Human Subjects Approval Statement

The project was reviewed and approved by human subjects review boards at 3 institutions: (1) the Mount Sinai Institutional Review Board, the Mount Sinai Health Insurance Portability, and Accountability Act (HIPAA) Privacy Office; (2) the Proposal Review Committee of the New York City Department of Education Division of Assessment and Accountability; and (3) the UFT.

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