THE RESPIRATORY INFLAMMATORY RESPONSE OF OCCUPANTS IN A WATER-DAMAGED OFFICE BUILDING

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"When I was that dizzy from the heat of the cooking that if I didn't take a breath of fresh air I'd faint, I'd stick my head out of the kitchen window, and close my eyes... everything clean and quiet, no dust, no dirt, breezes blowing the breath of flowers…" The Night-Born by Jack London

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OBJECTIVE

•We investigated building-related respiratory health in employees of a large office building in the northeastern United States. Workers reported respiratory problems that they perceived to be building-related. Approximately 1,300 people work in the building. The facility is a 20-floor building with parking garages on the bottom four floors and a lobby/cafeteria/mezzanine area on the 5th floor. A history of water damage exists, particularly on the upper floors of the building.

•We hypothesized that airways inflammation may be related to building-related symptoms and exposures. To test those hypotheses, we investigated airways inflammation using non-invasive exhaled breath condensate (EBC) nitrite, interleukin-8 (IL-8), and exhaled nitric oxide (ENO). We tested the association of these outcomes with exposures or symptoms in workers at the office building.

METHODS

•**The Study Population**

In September 2001, we conducted a site visit and administered a short health questionnaire. Based on this questionnaire, we invited 202 symptomatic and 154 asymptomatic employees to participate in medical testing. During the site visit, an additional 15 employees asked to take part in the survey. The analysis for the present work is restricted to current non-smoking participants who completed either EBC or ENO testing.

•**Definitions**

Any lower respiratory symptom: Cough, wheezing, shortness of breath, or chest tightness in the last four weeks.

Any nasal symptom: Itchy nose, blockage of the nose, sneezing, or runny nose in the last four weeks.

Any sinus symptom: Headache, pain in face, blowing out thick mucus, or postnasal drip in back of throat in the last four weeks.

Work-related symptom: Symptom improves when employee is away from work.

•**Spirometry**

Trained technicians followed ATS recommendations for spirometry. Airways obstruction was defined as both FEV1 and FEV1/FVC% below the LLN from the NHANES III reference values. In subjects with baseline FEV1 less than 70% of the predicted value, a bronchodilator was offered to detect any reversible bronchoconstriction.

•**Methacholine Challenge Test (MCT)**

MCT was performed using standardized techniques with five different doses (0.125, 0.5, 2.0, 8.0, and 32.0 milligrams per milliliter (mg/mL)) of methacholine. We reported methacholine dose as PC20.

•**Exhaled Breath Condensate (EBC)**

EBC was collected over a 15-minute period from subjects using previously published techniques. Subjects were asked to perform normal tidal breathing into a disposable cold trap-collection device consisting of a coil of corrugated respiratory tubing (Corr-A-Flex II, Hudson Respiratory Care, Inc., Temecula, CA) submerged into a -15°C bath of 50% ethylene glycol. We measured interleukin-8 (IL-8) and nitrite in the exhaled breath.

•**Exhaled Nitric Oxide (ENO)**

ENO was measured off-line using standardized techniques with a rapid-response chemiluminescence analyzer (Sievers Instruments model 280; Boulder, CO) by using 10-liter Mylar® gas-collection balloons.

•**Skin Prick Testing**

Skin prick allergy testing was done with commercially available extracts of seven common indoor and outdoor allergens: dust mite mix, German cockroach, cat hair, grass mix, ragweed mix, common weed mix, and Eastern tree mix. An average diameter at least 3mm larger than the negative control and greater than 25% of the average wheal diameter of the positive control from any antigen was considered as atopy positive.

•**Environmental sampling**

Floor and chair dust were collected from each participant's work environment into polyethylene filter socks (Midwest Filtration Company, Fairfield, OH) with a crevice tool and a L'il Hummer™ backpack vacuum (100 CFM, 1.5 HP). The dust samples were sent to a commercial laboratory for culturable fungi, endotoxin, cat allergen, and dust mite (*Dermatophagoides farinae* and *pteronyssinus*) analayses.

RESULTS

•ENO or EBC were completed by 239 participants. Since smoking is highly related to measurements we used in this study, we included only the 207 (86.6%) current non-smokers in the analyses (Table 1).

•In age-, gender-, and atopy-adjusted general linear model analysis, EBC IL-8 levels were significantly higher among those with symptoms (Table 2).

•ENO level was significantly lower in those participants with physician-diagnosed chronic bronchitis. EBC IL-8 was higher among workers with physician-diagnosed asthma (Table 3). ENO was higher in those with self-reported hay fever ($p=0.019$) (data not shown).

•ENO was significantly associated with cat allergen and total yeast. EBC IL-8 level was significantly related to *Penicillium*, *Aspergillus*, and *Eurotium spp*. combination in floor dust (Table 4).

Table 1. Characteristics of participant office workers	
Workers	239
Age (year, mean ± SD)	47.4±8.3
Female %	59.9
Never smoker %	62.0
Former smoker %	24.0
Current smoker %	14.0
Airways obstruction %	10.7
Atopy %	57.7
Positive methacholine or bronchodilator response %	17.4

Table 2. Age-, gender-, and atopy-adjusted estimated mean ENO, nitrite, and IL-8 levels by selected symptoms among non-smoking employees.						
	ENO		Nitrite		IL-8	
	Estimated mean (95%CI)	p	Estimated mean (95%CI)	p	Estimated mean (95%CI)	p
Cough						
Yes	6.4 (5.8-7.0)	0.739	0.6 (0.5-0.8)	0.077	3.3 (3.0-3.7)	**0.007**
No	6.5 (6.0-7.1)		0.5 (0.4-0.6)		2.8 (2.6-3.0)	
Shortness of breath						
Yes	6.6 (5.8-7.4)	0.774	0.7 (0.5-0.9)	**0.046**	3.0 (2.7-3.5)	0.889
No	6.4 (6.0-6.9)		0.5 (0.4-0.6)		3.0 (2.8-3.2)	
Sneezing						
Yes	6.4 (5.9-7.0)	0.808	0.5 (0.4-0.6)	0.943	3.3 (3.0-3.6)	**0.003**
No	6.5 (5.9-7.1)		0.5 (0.4-0.6)		2.7 (2.5-3.0)	
Runny nose						
Yes	6.6 (6.1-7.2)	0.480	0.5 (0.4-0.7)	0.860	3.3 (3.0-3.6)	**0.004**
No	6.3 (5.8-6.9)		0.5 (0.4-0.7)		2.7 (2.5-3.0)	
Any lower airways symptoms						
Yes	6.5 (5.9-7.0)	0.970	0.6 (0.5-0.7)	**0.046**	3.3 (3.0-3.6)	**0.007**
No	6.5 (5.9-7.1)		0.5 (0.4-0.6)		2.8 (2.5-3.0)	
Work-related lower airways symptoms						
Yes	6.3 (5.6-6.9)	0.418	0.6 (0.5-0.8)	0.116	3.3 (3.0-3.7)	**0.026**
No	6.6 (6.1-7.1)		0.5 (0.4-0.6)		2.9 (2.6-3.1)	
Any nasal symptoms						
Yes	6.6 (6.1-7.1)	0.311	0.6 (0.5-0.7)	0.102	3.1 (2.9-3.4)	**0.030**
No	6.1 (5.4-6.9)		0.4 (0.3-0.6)		2.6 (2.3-3.0)	
Work-related nasal symptoms						
Yes	6.4 (5.9-7.1)	0.921	0.6 (0.5-0.7)	0.221	3.2 (2.9-3.6)	0.099
No	6.5 (5.9-7.0)		0.5 (0.4-0.6)		2.9 (2.7-3.1)	
Any sinus symptoms						
Yes	6.5 (6.1-7.1)	0.603	0.5 (0.4-0.6)	0.621	3.2 (2.9-3.4)	**0.039**
No	6.3 (5.7-7.0)		0.6 (0.4-0.7)		2.7 (2.4-3.1)	
Work-related sinus symptoms						
Yes	6.3 (5.7-7.0)	0.494	0.6 (0.5-0.7)	0.496	3.3 (2.9-3.7)	0.054
No	6.6 (6.1-7.1)		0.5 (0.4-0.6)		2.9 (2.7-3.1)	

Table 3. Age-, gender-, and atopy- adjusted estimated mean ENO, nitrite, and IL-8 levels by physician-diagnosed diseases, and pulmonary function tests among non-smoking employees.

	ENO		Nitrite		IL-8	
	Estimated mean (95%CI)	p	Estimated mean (95%CI)	p	Estimated mean (95%CI)	p
Physician-diagnosed asthma						
Yes	7.0 (6.2-7.9)	0.108	0.6 (0.5-0.8)	0.240	3.4 (3.0-3.8)	**0.040**
No	6.2 (5.8-6.7)		0.5 (0.4-0.6)		2.9 (2.7-3.1)	
Physician-diagnosed chronic bronchitis						
Yes	5.2 (4.3-6.3)	**0.008**	0.6 (0.5-0.9)	0.647	3.4 (2.8-4.1)	0.162
No	6.6 (6.2-7.0)		0.5 (0.4-0.6)		3.0 (2.8-3.2)	
Obstructive spirometry						
Yes	6.2 (5.2-7.4)	0.678	0.5 (0.3-0.7)	0.581	2.8 (2.3-3.4)	0.397
No	6.5 (6.0-6.9)		0.5 (0.4-0.6)		3.0 (2.8-3.3)	
Positive methacholine or bronchodilator response						
Yes	7.0 (6.0-8.2)	0.155	0.5 (0.3-0.7)	0.724	3.0 (2.6-3.4)	0.685
No	6.2 (5.8-6.7)		0.5 (0.4-0.6)		2.9 (2.7-3.1)	

Table 4. Age-, gender-, and atopy-adjusted analyses of ENO, nitrite, and IL-8 levels by individual chair/floor dust measurements among non-smoking employees

		ENO		Nitrite		IL-8	
		t value	p	t value	p	t value	p
Total mite	chair (µg/ch)	-0.04	0.971	0.74	0.458	1.54	0.125
	floor (µg/m^2)	0.20	0.844	-0.24	0.809	0.68	0.498
Total fungi	chair (cfu/ch)	1.25	0.213	1.67	0.097	0.59	0.556
	floor (cfu/m^2)	0.22	0.826	1.56	0.120	0.05	0.960
Total yeast	chair (cfu/ch)	2.24	**0.026**	1.11	0.267	0.31	0.757
	floor (cfu/m^2)	-0.18	0.861	0.60	0.552	-0.50	0.616
Pen., Asp., Eur. spp	chair (cfu/ch)	0.98	0.327	1.85	0.067	0.09	0.928
	floor (cfu/m^2)	0.71	0.481	1.80	0.074	2.41	**0.017**
Endotoxin	chair (EU/ch)	0.70	0.483	1.18	0.240	0.91	0.365
	floor (EU/m^2)	0.43	0.671	0.30	0.767	-0.44	0.659
Cat	chair (µg/ch)	2.10	**0.037**	1.94	0.054	0.24	0.809
	floor (µg/m^2)	0.71	0.478	0.51	0.609	0.98	0.328

CONCLUSIONS

- Of the three potential markers of inflammation evaluated, EBC IL-8 showed the most significant relationship with a number of symptoms and physician-diagnosed asthma cases.
- IL-8 level was also associated with the level of Penicillium, Aspergillus, and Eurotium spp. combination in floor dust, which are commonly found in damp indoor environments.

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