The Spectrum of Building-Related Airway Disorders*

Difficulty in Retrospectively Diagnosing Building-Related Asthma

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Introduction: **The specific causes and mechanism(s) for asthma occurring among occupants of nonresidential buildings with poor indoor air quality are not known, but allergic and nonallergic processes are possible explanations**
Methods: **Repeated indoor air quality measurements were made while employees were working in a building where cigarette smoking was allowed. Seven of 19 employees who sought medical care from their private physicians because of respiratory complaints received a diagnosis of asthma. Subsequently, 19 symptomatic employees were examined at the University of South Florida (USF) 2 ± 0.8 months (mean ± SD) after removal from the building.**
Results: **The first floor of the building, where employee complaints were prevalent, was characterized by markedly reduced outdoor fresh air supply, diminished air circulation to the occupant spaces, and elevated airborne concentrations of formaldehyde. Nineteen workers examined at the USF 2 ± 0.8 months after leaving the building reported ear, nose, and throat irritation and asthma-like symptoms while working in the building. There was resolution of symptoms in most of the seven employees (37%) with asthma previously diagnosed by their private physician. In fact, 16 of 19 subjects (84%) reported resolution or significant improvement of symptoms. Among 11 persons with symptoms suggesting asthma while working in the building, 4 persons (21%) showed a negative provocative concentration of methacholine producing a 20% fall in FEV_1, including two subjects with doctor-diagnosed asthma.**
Conclusions: **Confirmation of building-related asthma is influenced by time factors and the clinical criteria used for diagnosis. A nonallergic mechanism seems operative in our cases. While considered an example of occupational asthma, building-related asthma is a challenge for the practicing physician to confirm retrospectively.** ***(CHEST 2005; 128:1720–1727)***

Key words: building-related asthma; environmental tobacco smoke; formaldehyde; indoor air quality; irritant-induced asthma

Abbreviations: CFM = cubic feet per minute; HVAC = heating, ventilation, and air-conditioning; PC_{20} = provocative concentration of methacholine producing a 20% fall in FEV_1; USF = University of South Florida

The specific cause and mechanism responsible for asthma occurring among occupants of nonresidential buildings with poor indoor air quality are not known, but allergic and nonallergic processes are possible explanations.[1–3] Dust mite, pet, and cockroach allergens are usually associated with the home environment.[3] Mold has the potential for producing allergic responses at nonresidential sites.[4] Volatile organic compounds, formaldehyde, and reactive

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chemicals are potential causative agents for a nonallergic, nonresidential etiology.[4,5]

This report describes employees working on the first floor of a nonresidential building with adverse indoor air quality typified by reduced delivery of fresh air from the outdoors and elevated levels of formaldehyde and possibly other irritant vapors. Many of the individuals became ill, and some sought medical care because of new-onset asthma. Subsequently, these employees were evaluated approximately 2 months after their exposure in the building was terminated. The results of the investigation suggest that a clinical designation of building-related asthma requires caution and underscores the difficulty a practicing physician may have in retrospectively reaching such as diagnosis.

Methods and Materials

Details of the Building

The first floor of a two-story building serviced customers who entered and exited the building on a continuous basis, while the second floor was used as office space, a conference room, and a break room. Cigarette smoking was permitted on both floors without restriction. The health complaints started shortly after a contractor completed repairs on a first-floor heating, ventilation, and air-conditioning (HVAC) unit; there were separate HVAC systems for each floor. Over the next few months, employees on the first floor reported respiratory and mucosal irritation-type symptoms and noted an odor, most often described as a "dead fish smell." Some symptomatic workers consulted their private physician, and some received a diagnosis of "asthma." Within 2 years of occupancy, all employees were removed from the facility to another location as result of health concerns and employee dissatisfaction with these spaces. Symptomatic employees were subsequently evaluated at the University of South Florida (USF) within 1 to 4 months after vacating the building

Indoor Air Quality Measurements

Repeated environmental measurements were completed on both floors over a several-month period while employees were still working in the building; concurrent outdoor measurements were also completed. Ventilation measurements utilized standardized methods to determine ventilation rates for each floor in cubic feet per minute (CFM).[6] The percentage of outdoor air that was added to the indoor ventilation was calculated from corrected airflow measurements from an (Alnor flow head products; Shoreview, MN) , rotating vane anemometer and a heated element anemometer.[7] Air sampling for formaldehyde, conducted over a 6- to 8-h sampling period, used a portable sampling pump calibrated to 1 L/min and a pair of in-line midget impingers containing a sodium bisulfate media. Samples were analyzed by spectrophotometry using an analytical method with a detection limit of approximately 0.001 ppm for an 8-h sample. Airborne bioaerosols were sampled using the Anderson N6 method with malt extract in agar.[6]

Examination at the USF

The USF evaluations took place 2 ± 0.8 months (mean ± SD; range, 1 to 4 months) after subjects were removed from the building and had no further building-related exposures. The USF examinations included completion of a questionnaire, directed medical and allergic history, physical examination, allergy skin-prick tests, spirometry, and methacholine challenge. Subjects were asked whether they sought medical care and received a doctor's diagnosis and/or treatment of asthma during the time they were working in the building. Questioning also addressed "bronchial irritability" to a variety of exposures such as cigarette smoke, aerosol sprays, strong odors, and other nonspecific triggers.[8] USF testing adhered to accepted guidelines for spirometry and methacholine challenge testing.[9–11] For the latter, increasing concentrations of methacholine from 0.03 to 32 mg/mL were aerosolized using a Wright nebulizer (S&M Instruments; Doylestown, PA) that was driven by compressed air. A positive response was determined by extrapolation of the doses to where there was a $\geq$ 20% fall in FEV_1 (provocative concentration of methacholine causing a 20% fall in FEV_1 [PC_{20}]). Allergy skin-prick testing was performed and interpreted in a standard way to 55 different allergens including 17 types of mold allergens. A positive skin-prick test result required erythema $>$ 21 mm in diameter and a wheal $\geq$ 3 mm (*eg*, 2 + skin test). If skin-prick test results were negative or equivocal, intradermal testing was used at a concentration of 1:500.

Clinical designations were based on the symptoms subjects reported having during the time they were working. A designation of *upper airway irritation* required reporting two or more eye, nose, and/or throat symptoms considered indicative of irritation (eyes: eyes itching, tearing, burning, eyelid swelling, light sensitivity or eye pain; nose: nasal burning or repeated sneezing, runny, or stuffy nose; throat: sore throat). Employees considered to have a*sthma symptoms complex* claimed a "yes" response to three or more typical asthma symptoms during their employment in the building.[12] The typical asthma symptoms were as follows: (1) episodic cough with or without sputum production, (2) self-evident wheezing, (3) exertional and/or episodic shortness of breath, and (4) chest tightness associated with breathlessness.[12] A *doctor's diagnosis of asthma* implied a diagnosis of asthma made by a private physician during employment in the building and before the USF evaluation; this fact was documented by both subject statement and review of the medical records. The doctor's treatment for asthma was also documented by both subject statement and review of the medical records.

Results

Environmental Data

Table 1 reports the first and second floors and outdoor environmental measurements while subjects were still working. A decreased delivery of fresh air from the outdoors to the first floor was significantly reduced to 3.6% (approximately 0.012 L/s/feet^2). The value of 6.7 CFM of total outdoor fresh airflow rate per individual was approximately one third of the recommended value and based on occupancy of 21 employees.[13] This reduced value is considered an overestimation since the first floor constantly serviced customers, and typically $>$ 21 people were present indoors. Additionally, carbon dioxide concentrations on the first floor, an indirect measurement of the adequacy of fresh outdoor airflow, were significantly elevated. Table 1 also provides an estimated level of comfort.[14] Delivery of air to the