

# National Prevalence of Asthma and Chemical Hypersensitivity: An Examination of Potential Overlap

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**Objective:** The objective of this study was to investigate the linkage between asthma and chemical hypersensitivity. **Methods:** The authors conducted a population study with a random sample of 1057 geographically weighted cases to determine the prevalence of both asthma and chemical hypersensitivity in the American population and to explore their co-occurrence. **Results:** A total of 14.1% of the respondents reported being diagnosed with asthma and 11.2% reported a hypersensitivity to chemicals. Of those with asthma, 27.2% also reported being hypersensitive to chemicals and 7.4% reported also being diagnosed with multiple chemical sensitivities (MCS). Of those diagnosed with MCS, 42% reported also being diagnosed with asthma. Additionally, 29.7% of those with asthma said air fresheners caused breathing difficulties, and 37.2% found scented products irritating. **Conclusions:** The results indicate that there is significant overlap between some forms of asthma and chemical hypersensitivity. (J Occup Environ Med. 2005;47:518-522)

Concern about the increasing occurrence of asthma in the American population has stimulated researchers to investigate its linkage with other conditions.<sup>1</sup> Recent studies have explored the possible association of certain types of asthma with chemical hypersensitivity.<sup>2</sup> These studies have suggested that chemical hypersensitivity can be a symptom of some forms of asthma.<sup>3</sup>

Acute chemical hypersensitivity is typically considered a condition distinct from asthma and is often medically diagnosed as multiple chemical sensitivities (MCS).<sup>4</sup> It can also be known as toxicant-induced loss of tolerance or environmental illness. MCS is characterized by adverse reactions to common chemical substances at levels that are normally considered tolerable. Individuals with MCS can find everyday products such as household cleaners, fresh paint, perfume, synthetic building materials, new carpets, pesticides, and other petrochemically based commodities highly irritating.<sup>5</sup> MCS is considered permanent, and the primary way that sufferers can prevent reactions is to completely avoid all offensive materials. Although the symptoms associated with asthma typically include wheezing and breathing difficulties, MCS symptoms can include these asthmatic reactions but also are characterized by dizziness, eye burning, headache, numbness, mental confusion, and edema, in addition to respiratory difficulties. MCS reactions, which can range from mild to severe,

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result from exposures to even low levels of the irritating substances.<sup>6</sup>

Research indicates that MCS exhibits a two-step process. The first step, initiation, is when the hypersensitivity first develops. Initiation can result from a single high-level exposure to a particular toxic agent, or it can emerge after chronic exposure to one or more toxic substances, even at low levels. The second step in MCS is triggering, which occurs after the original sensitization. It is characterized by adverse physical reactions that are a result of an exposure. Once the hypersensitivity has developed, symptoms can be triggered by an exposure to a wide range of offensive substances even at very low levels.

Studies that report a potential linkage between asthma and MCS suggest that co-occurrence is only present with certain types of asthma. Asthma has numerous phenotypes based on age of onset, etiology, and characteristics.<sup>7</sup> Adult-onset asthma is frequently the product of exposures to toxic materials in the workplace,<sup>8</sup> and there is also suspicion that exposures to toxins can promote some types of childhood asthma.<sup>9</sup> Adult-onset asthma has two categories: occupational asthma and work-aggravated asthma.<sup>10</sup> Occupational asthma originates from workplace exposures to toxic substances. Work-aggravated asthma is a preexisting condition that is only aggravated by irritants at work. Occupational asthma is further divided into categories based on how rapidly the condition emerges. Occupational asthma can be either "with latency" or "without latency." Occupational asthma with latency develops over time when continued exposure to a toxic substance creates allergic sensitization, whereas asthma without latency occurs immediately after a single massive toxic inhalation.<sup>11</sup> Reactive airways dysfunction syndrome (RADS), a condition identified in 1985, which can also be termed irritant-induced asthma,<sup>12</sup> is a subset of occupational asthma with-

out latency.<sup>13</sup> RADS is a persistent, airways hyperresponsiveness that occurs after a single high-level toxic exposure. RADS is considered a permanent condition,<sup>14</sup> and once sensitized, individuals with it negatively react to much lower levels of the irritating substance.

RADS sufferers frequently exhibit chemical hypersensitivity, which has led some researchers to conclude that RADS and MCS are overlapping disorders.<sup>15</sup> Apparent similarities between MCS and RADS provided the impetus for a study using animal models, which found that asthma and MCS have common etiologies and characteristics.<sup>16</sup> An additional study, which focused primarily on symptomatology, indicated that specific forms of asthma and MCS have similar dynamics, which frequently overlap.<sup>17</sup> Thus, it is becoming evident that MCS has mechanisms and etiologic commonalities with at least some types of asthma.

The increasing evidence that chemical hypersensitivity is a symptom of some categories of asthma needs to be confirmed by epidemiologic research. Currently, there are no population studies of the co-occurrence of asthma and chemical hypersensitivity or of asthma and the medical diagnosis of MCS. There have been prevalence studies, however, of chemical hypersensitivity and the medical diagnosis of MCS in the American population, and separate epidemiologic research on asthma.

### Multiple Chemical Sensitivity Prevalence

The national prevalence of chemical hypersensitivity and the medical diagnosis of MCS have not yet been definitively established. Several regional epidemiologic studies that investigated chemical hypersensitivity have also been conducted. Before these studies, the National Academy of Sciences estimated that up to 15% of the American population could experience some degree of hypersen-

sitivity to common chemicals.<sup>18</sup> The California Department of Health Services found a MCS prevalence in California of 15.9% ( $n = 4046$ ),<sup>19</sup> whereas similar studies in the Atlanta, Georgia, metropolitan area and the state of New Mexico found rates of 12.6% ( $n = 1579$ )<sup>20</sup> and 16% ( $n = 1813$ ), respectively.<sup>21</sup> These three studies used accepted epidemiologic methodology with randomly derived samples. Other published studies that attempted to determine the prevalence of chemical hypersensitivity have used anecdotal evidence, nonrandomly or self-selected subjects, or a much broader definition of hypersensitivity, producing a wide range of findings. A study that relied exclusively on conversations with medical personnel in clinical settings estimated that between 2% and 10% of the population experiences chemical hypersensitivity.<sup>22</sup> Two subsequent studies in Arizona used self-selected subjects, young adult college students, and elderly persons, and determined that approximately 15% ( $n = 809$ ) of the younger group<sup>23</sup> and more than 37% ( $n = 160$ ) of the elderly group<sup>24</sup> reported hypersensitivity to chemicals. A population survey in rural North Carolina, using a broader definition of chemical hypersensitivity that did not distinguish between an aversion to harsh chemical odors and true hyperreactiveness, found a rate of 33% ( $n = 1027$ ).<sup>25</sup>

### Asthma Prevalence

Asthma affects 5% to 10% of the world's population, and some studies estimate that up to 15% of the American population is affected.<sup>26</sup> The prevalence, morbidity, and mortality for adults increased substantially in the United States from 1980 to 1999, and the annual rates were higher for certain racial/ethnic minority groups than for Caucasians.<sup>27</sup> In 2002, an estimated 16 million American adults reported experiencing asthma. Adult asthma prevalence among racial/ethnic minority groups ranged

from 3.1% to 14.5%, with 7.6% for Caucasians.

There are numerous studies of the prevalence of children with asthma in the U.S. population, with self-reported medically diagnosed asthma for children between the ages of 6 and 14 years of age in rural Iowa, for example, being 13.4%.<sup>28</sup> Other studies, however, suggest that the prevalence for minority children may be much higher. A study of the homeless in New York found that 26.9% of the children in the survey had a prior physician diagnosis of asthma but, basing a projection on reported symptoms, speculated that a prevalence of 39.8% was more likely.<sup>29</sup>

## Materials and Methods

This study uses a national population survey to investigate the separate prevalence of asthma, chemical hypersensitivity, and also the medical diagnosis of MCS. It then explores the co-occurrence of asthma with both chemical hypersensitivity and the diagnosis of MCS. Additionally, it investigates the extent that respondents who report asthma also display the symptoms characteristic of MCS.

To assure a valid national sample, cases were obtained by using random digitally dialed phone numbers. The numbers were derived from the continental United States and regionally weighted to insure a representative national sampling. The sample was constructed to achieve a confidence level of 95% with a confidence interval of plus or minus 3%. Probability formulas indicate that a sample would need to contain 1067 cases to obtain this desired confidence level and interval.<sup>30</sup> This study used 1054 cases which created an acceptable 3.02 interval.

The questionnaire used as the research instrument initially asked respondents if they had been medically diagnosed with asthma. It also asked if they had been diagnosed with MCS. A question on MCS symptomatic characteristics, which replicated the wording used in several of the

antecedent regional population studies, was also included to facilitate validity evaluations.

Two additional questions were asked to further probe the potential linkage between asthma and MCS. MCS sufferers frequently report that commercial, home air fresheners are major irritants. Their effect on asthmatics with MCS has never been examined. A recent study found that specific types of air fresheners react with ozone in ambient indoor air to produce formaldehyde,<sup>31</sup> a known irritant both for individuals with MCS and for occupational asthma sufferers. Consequently, the entire sample was asked if air fresheners were bothersome. Positive responses were cross-tabulated with reported asthma. The first question asked if respondents felt that air fresheners caused them breathing difficulties, whereas the second question asked if the respondents found scented products on other people irritating or appealing.

To ensure reliability, the questionnaire was administered to four different seasonal cohorts. Data for the four cohorts were obtained in the spring of 2002, summer of 2002, fall of 2002, and winter/spring of 2003, respectively. The number of cases in each seasonal cohort varied somewhat, but the rates of a positive response to the key chemical hypersensitivity question in each cohort (10.16%, 10.36%, 11.4%, 16%) were all within the desired confidence interval.

## Results

After the data from each cohort were assessed and deemed statisti-

cally congruent with the others, the data from all four cohorts were aggregated to produce cumulative averages. The aggregate data showed that 14.1% of the respondents report being medically diagnosed with asthma, and 2.5% report being diagnosed with multiple chemical sensitivities (Table 1). Additionally, 11.2% of the sample report hypersensitivity to common chemicals.<sup>32</sup> Of those with asthma, 27.2% also report being hypersensitive to chemicals, and 7.4% report also being diagnosed with MCS (Table 2). This indicates that individuals who report being diagnosed with asthma and also report having hypersensitivity to chemical make up 3.8% of the entire sample. Of those diagnosed with MCS, however, 42% report also being diagnosed with asthma.

When respondents who reported asthma were asked if air fresheners made it difficult to breathe (a common symptom of MCS), 29.7% said yes. Additionally, 37.2% of those who report asthma said that they find scented products irritating (also a common MCS symptom).

The demographic characteristics of respondents who report asthma conform to those of the respondents who report chemical hypersensitivity, with the exception of a gender distribution variance. There is a female bias in the entire sample (38.8% male, 61.2% female). The gender distribution of those who report asthma parallels the sample (39.5% male, 60.5% female); however, there is a greater distribution of females reporting chemical hyper-

TABLE 1

Prevalence of Asthma Diagnosis, Chemical Hypersensitivity, and Multiple Chemical Sensitivity (MCS) Diagnosis

	Yes	No	Don't Know	Decline
	Percent (no.)	Percent (no.)	Percent (no.)	Percent (no.)
Asthma diagnosis	14.1 (148)	85.7 (902)	0.3 (3)	0 (0)
Hypersensitive to chemicals	11.2 (117)	85.9 (899)	2.6 (27)	0.3 (3)
MCS diagnosed	2.5 (26)	96.6 (1018)	0.8 (8)	0.2 (2)

TABLE 2

Crosstabulation: Respondents With Asthma Diagnosis Also Reporting Chemical Hypersensitivity, Multiple Chemical Sensitivity (MCS) Diagnosis, Find Air Fresheners Bothersome, or Find Scented Products Irritating

	Been Diagnosed With Asthma			
	Yes Percent (no.)	No Percent (no.)	Don't Know Percent (no.)	Decline Percent (no.)
Also hypersensitive to chemicals	27.2 (40)	68 (100)	4.1 (6)	0.6 (1)
Also diagnosed with MCS	7.4 (11)	90.5 (134)	2 (3)	0 (0)
Also find air fresheners bothersome	29.7 (44)	64.9 (96)	5.4 (8)	0 (0)
Also find scented products irritating	37.2 (55)	37.2 (55)	25.6 (38)	0 (0)

sensitivity (13.8% male, 86.2% female).

## Discussion

This study indicates that chemical hypersensitivity and asthma have a significant degree of overlap. This provides additional evidence that MCS has a potential association with some forms of asthma. It is particularly significant that of those diagnosed with asthma, 27.2% also reported being hypersensitive to chemicals, and that of those diagnosed with MCS, 42% reported also being diagnosed with asthma. Although asthma and chemical hypersensitivity are not always linked, these findings indicate that etiology and dynamic commonalities clearly exist. That only 7.4% of the asthmatics also reported being diagnosed with MCS, despite the much larger percentage that report chemical hypersensitivity, suggests that medical personnel frequently overlook this connection.

The prevalence rates found in this study conform to the findings of the preceding population studies. The 14.1% of this study's sample that reports asthma is consistent with the estimates in the other studies. The 11.2% national prevalence of chemical hypersensitivity found in this study, given the confidence interval of  $\pm 3\%$ , is statistically congruent with the regional studies that used similarly worded questions and found regional prevalence rates of 12.6% and 15.9%. The 31.1% of the entire sample that found scented products on other people to be irri-

tating also supports the MCS prevalence rate of 33% found in the regional study that used a broader definition of chemical hypersensitivity.

Additionally, that 29.7% of the entire sample said that air fresheners make it difficult to breathe and that 37.2% found scented products worn by others irritating are noteworthy findings which deserve more extensive investigation.

That more than one fourth of all asthmatics also report chemical hypersensitivity indicates that this connection deserves substantially more study. Future research needs to examine the etiology of the asthma more closely. Additional inquiries should categorize reported asthma into groupings that specify if it is adult-onset, the result of a toxic exposure, and if it is with or without latency. This will illustrate if there is a propensity for specific types of asthma to be linked with chemical hypersensitivity. Additional research should also investigate if chemical hypersensitivity and asthma developed from the same exposure and if RADS has a more extensive connection to MCS than occupational asthma with latency.

## References

- Centers for Disease Control and Prevention. Asthma prevalence and control characteristics by race/ethnicity—United States. *MMWR Morb Mortal Wkly Rep.* 2002;57:145–148.
- Ross GS. Clinical characteristics of chemical sensitivity: an illustrative case history of asthma and MCS. *Environ*

*Health Perspect.* 1997;105(suppl 2):437–441.

- Meggs WJ. Multiple chemical sensitivities—chemical sensitivity as a symptom of airway inflammation. *J Toxicol Clin Toxicol.* 1995;33:107–110.
- Miller C, Ashford N, Doty R, et al. Empirical approaches for the investigation of toxicant-induced loss of tolerance. *Environ Health Perspect.* 1997;105:515–519.
- Ashford NA, Miller CS. *Chemical Exposures: Low Levels and High Stakes.* New York: Van Nostrand Reinhold; 1998.
- Rea WJ, Bell IR, Suits CW, Smiley RE. Food and chemical sensitivity after environmental chemical exposure: case histories. *Ann Allergy.* 1978;41:101–110.
- Bel EH. Clinical phenotypes of asthma. *Curr Opin Pulm Med.* 2004;1:44–50.
- deBono J, Hudsmith L. Occupational asthma: a community based study. *Occup Med.* 1999;49:217–219.
- Gustafsson D, Andersson K. Effects of indoor environmental factors on development of atopic symptoms in children followed up to 4 years of age. *Paediatr Perinat Epidemiol.* 2004;18:17–25.
- Chan-Yeung M, Malo JL. Occupational asthma. *N Engl J Med.* 1995;333:107–112.
- Brooks SM. Occupational asthma. *Toxicol Lett.* 1995;82–83:39–45.
- Alberts WN, Brooks SM. Reactive airways dysfunction syndrome. *Curr Opin Pulm Med.* 1996;2:104–110.
- Chan-Yeung M. Occupational asthma. *Environ Health Perspect.* 1995;103(suppl 6):249–252.
- Piririla PL, Nordman H, Korhonen OS, Winblad I. A thirteen-year follow-up of respiratory effects of acute exposure to sulfur dioxide. *Scand J Work Environ Health.* 1996;223:191–196.
- Meggs W. Hypothesis for induction and propagation of chemical sensitivity based on biopsy studies. *Environ Health Perspect.* 1997;105(suppl 2):473–478.
- Overstreet DH, Djuric V. Links between

- multiple chemical sensitivity and asthma in a rat model of cholinergic hypersensitivity; a brief review. *Toxicol Ind Health*. 1999;15:517-521.
17. Meggs WJ. Multiple chemical sensitivity—chemical sensitivity as a symptom of airway inflammation. *J Toxicol Clin*. 1995;33:107-110.
  18. Mitchell F, ed. *Multiple Chemical Sensitivity: A Scientific Overview*. Atlanta: US Department of Health and Human Services, Public Health Services Agency for Toxic Substances and Disease Registry; 1995.
  19. Kreuzer R, Neutra RR, Lashuay N. Prevalence of people reporting sensitivities to chemicals in a population-based survey. *Am J Epidemiol*. 1999;150:1-12.
  20. Caress SM, Steinemann AC. The prevalence of multiple chemical sensitivities in a population based study. *Am J Public Health*. 2004;94:746-747.
  21. Voorhees R. *Results of Analyses of Multiple Chemical Sensitivities Questions*. New Mexico Behavioral Risk Factor Surveillance Systems. New Mexico Department of Health, Office of Epidemiology; 1997:25.
  22. Mooser SB. The epidemiology of multiple chemical sensitivities (MCS). *Occup Med*. 1987;2:663-681.
  23. Bell IR, Schwartz GE, Peterson JM, Amend D. Self-reported illness from chemical odors in young adults without clinical syndromes or occupational exposures. *Arch Environ Health*. 1993;48:6-13.
  24. Bell IR, Walsh ME, Goss A, Gersmeyer, Schwartz GE, Kanof P. Cognitive dysfunctions and disabilities in geriatric veterans with self-reported intolerance to environmental chemicals. *J Chron Fatig Synd*. 1997;2:5-42.
  25. Meggs WJ, Dunn KA, Bloch RM, Goodman PE, Davidoff AL. Prevalence and nature of allergy and chemical sensitivity in a general population. *Arch Environ Health*. 1996;51:275-282.
  26. Chan-Yeung M, Malo JL. Occupational asthma. *N Engl J Med*. 1995;333:107-112.
  27. Centers for Disease Control and Prevention. Asthma prevalence and control characteristics by race/ethnicity—United States, 2002. *MMWR Morb Mortal Wkly Rep*. 2004;57:145-148.
  28. Chrischilles E, Ahrens R, Kuehl A, et al. Asthma prevalence and morbidity among rural Iowa schoolchildren. *J Allergy Clin Immunol*. 2004;113:66-71.
  29. McLean DE, Bowen S, Drezner K, et al. Asthma among homeless children: undercounting and undertreating the underserved. *Arch Pediatr Adolesc Med*. 2004;158:244-249.
  30. O'Sullivan E, Rassel GR. *Research Methods for Public Administrators*. White Plains, NY: Longman Publishers; 1995:135.
  31. Liu X, Mason M, Krebs K, Sparks L. Full-scale chamber investigation and simulation of air freshener emissions in the presence of ozone. *Environ Sci Technol*. 2004;38:2802-2812.
  32. Caress SM, Steinemann AC. A national population study of the prevalence of multiple chemical sensitivities. *Arch Environ Health*. 2004;59:513-515.