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ORIGINAL CONTRIBUTIONS

Prevalence of People Reporting Sensitivities to Chemicals in a Population-based Survey

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To describe the prevalence and correlates of reports about sensitivities to chemicals, questions about chemical sensitivities were added to the 1995 California Behavior Risk Factor Survey (BRFS). The survey was administered by telephone to 4,046 subjects. Of all respondents, 253 (6.3%) reported doctor-diagnosed "environmental illness" or "multiple chemical sensitivity" (MCS) and 643 (15.9%) reported being "allergic or unusually sensitive to everyday chemicals." Sensitivity to more than one type of chemical was described by 11.9% of the total sample population. Logistic regression models were constructed. Hispanic ethnicity was associated with physician-diagnosed MCS (adjusted odds ratio (OR) = 1.82, 95% confidence interval (CI) 1.21–2.73). Female gender was associated with individual self-reports of sensitivity (adjusted OR = 1.63, 95% CI 1.23–2.17). Marital status, employment, education, geographic location, and income were not predictive of reported chemical sensitivities or reported doctor diagnosis. Surprising numbers of people believed they were sensitive to chemicals and made sick by common chemical exposures. The homogeneity of responses across race-ethnicity, geography, education, and marital status is compatible with a physiologic response or with widespread societal apprehensions in regard to chemical exposure. *Am J Epidemiol* 1999;150:1–12.

asthma; multiple chemical sensitivity; tobacco smoke pollution

There is great controversy over the notion of a disorder in which the victim develops wide-ranging symptoms to many unrelated chemicals at conventionally subtoxic exposure levels, but through toxicologic mechanisms (1–13). The notion implies that many common chemical exposures are pathologic (i.e., that structure or function are altered) for a subset of people and, in order for the pathology to occur, processes of sensitization and/or amplification occur. Proponents of this concept call the phenomenon multiple chemical sensitivity (MCS), environmental illness, 20th century disease, environmental hypersensitivity, or other names. Other investigators have advised labeling the condition "idiopathic environmental intolerance" (14). For ease of reference, we will refer to the phenomenon as MCS in this paper.

This controversy has large political, social, and psychological costs. MCS's existence could theoretically alter, on a fundamental level, society's relation to chemicals (15). Despite the fact that there is little substantive research supporting a toxicologic explanation for this condition, and that medical researchers disagree vigorously about its nature and etiology, MCS is rapidly becoming an established diagnosis on the basis of public belief and political fiat. Workers compensation claims for this diagnosis have been successful. The Department of Housing and Urban Development has provided housing assistance to persons with reported chemical sensitivities. MCS sufferers have sought their inclusion under the Americans with Disabilities Act (16, 17).

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Abbreviations: MCS, multiple chemical sensitivity; BRFS, Behavioral Risk Factor Survey; CASRO, Council of American Survey Research Organizations.

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Most of the literature describing people who report symptoms attributed to low level chemical exposure comes from occupational or environmental clinics or personal accounts. There is little peer-reviewed literature that has demonstrated sufficiently strong objective correlates of reported symptoms, nor is there literature demonstrating a new mechanism for symptom causation from chemical exposure despite some creative speculation about exposure routes in the body, sensitive tissues, and amplification processes (18–30). As a result, causal hypotheses for MCS range widely between psychological and physiological mechanisms.

As state health department officials, we are frequently asked about chemical sensitivities following chemical spills, during hazardous waste site remediation, during "sick building" investigations, and concerning pesticide exposures at the agricultural/residential interface. To help us develop ways to study MCS, we convened an advisory committee of national experts representing the full spectrum of opinion on this controversy. Within this diverse group, consensus was reached about the lack of information on the population prevalence of people who report sensitivity to a chemical, or many chemicals, or who report a physician diagnosis of MCS, and the demographic or other variables associated with these reports. We determined that a staged approach to studying the MCS phenomenon by first obtaining descriptive epidemiology of reported chemical sensitivities, then, formulating hypotheses about the condition, and, finally, testing these and existing hypotheses on carefully selected cohorts, would be the most rigorous and productive approach.

In this paper, we report the results of stage one, a population-based interview study, to our knowledge the largest such study ever conducted, of respondents' reports of sensitivities to chemicals.

MATERIALS AND METHODS

Questions regarding chemical sensitivity were constructed, pilot tested, and placed on the 1995 Behavioral Risk Factor Survey (BRFS), an annual telephone survey of randomly selected adults which collects information on a wide variety of health-related behaviors. The survey has been conducted since 1984. Details about the BRFS instrument and SAS dataset construction can be found in the *California Behavioral Risk Factor Survey SAS Dataset Documentation and Technical Report* (31).

Data are collected monthly from a random sample of California adults (age >17 years) who live in households with telephones using a screened sample of telephone numbers purchased from a commercial sampling firm. The data collection instrument is a questionnaire of three parts: a relatively fixed core set of questions (some rotate on an alternate year basis), a set of topical modules developed by the Centers for Disease Control and Prevention, and a set of questions designed by the California Department of Health Services to address issues of local interest and concern. Fifteen questions, some with a branching structure, about chemical sensitivities were included in the 1995 questionnaire, which had 203 total questions.

Two response rates are calculated for the BRFS, an "upper-bound" rate and a Council of American Survey Research Organizations (CASRO) rate. The upper-bound response rate indicates the proportion of eligible households contacted which resulted in a completed interview. For 1995, this rate was 70 percent. The CASRO rate assumes that some numbers that could not be reached because they resulted in busy signals or unanswered rings represent eligible households. This rate was 52 percent.

In order to assess the representativeness of the sampling process, the cumulative 1984–1995 sample was compared with California Department of Finance population estimates for the 1990 census year on several important variables. These included race and ethnicity, sex, educational level, household income, and age. Special weighting factors, albeit quite small, were developed for extrapolating the sample results to the general population.

Data analysis

We did a descriptive analysis of the 15 chemical sensitivity questions. Responses were cross-tabulated with asthma and hay fever status, and with various demographic factors, including sex, ethnicity, income, and geographic location. Symptom patterns, reported age at onset, reports of conditions restricting daily activities, doctor diagnosis of chemical sensitivity, and self-reported sensitivity to chemicals were examined in greater detail. Comparisons were also made between reported chemical sensitivity and the number of exposure scenarios which respondents said would make them sick. Finally, logistic regression was used to model the association between various demographic and health variables with physician-diagnosed and self-reported chemical sensitivity.

RESULTS

There were 4,046 respondents to the 1995 BRFS survey. Of these, 55.1 percent were female; 63 percent were White (not Hispanic); 5.6 percent were Black (not Hispanic); and 23.8 percent were Hispanic. According to the California Department of Finance, the 1995 California population, age 18 years and above, was 23,997,268, of whom 50.2 percent were female; 57.4

percent were White (not Hispanic); 6.6 percent were Black (not Hispanic); and 25.5 percent were Hispanic.

Table 1 presents the responses to 13 of the chemical sensitivity questions included on the BRFS. Results are shown for the total sample and for asthmatic versus nonasthmatic respondents. Overall, a surprising 6.3 percent of respondents reported doctor-diagnosed environmental illness or multiple chemical sensitivity. Even more surprisingly, 15.9 percent stated they were unusually sensitive to everyday chemicals. The majority of this group claimed they were sensitive to a "few different chemicals" (49.6 percent) or a "lot of chemicals" (25.3 percent). Only 19.1 percent said they were bothered solely by one or one type of chemical. Over half (51.2 percent) reported taking special precautions at home because of their chemical sensitivities. A smaller, but substantial, number of the "sensitives" (20.7 percent) said they had trouble shopping in stores or eating in restaurants due to chemical sensitivities.

As might be expected, environmental tobacco smoke was the exposure scenario most likely to make respondents "very sick" (7.6 percent of the total sample). Small numbers reported being made "very sick" by cologne, aftershave, or perfumes (1.8 percent of the total sample). In all, 8.3 percent of all respondents reported a health impairment (not necessarily related to chemical sensitivities) that restricted their performance of everyday activities.

It is noteworthy that 143 (56.5 percent) of the 253 respondents who reported a doctor's diagnosis of MCS or environmental illness, reported that they considered themselves unusually sensitive to everyday chemicals. Of those 143 who had both a doctor diagnosis of chemical sensitivity and a perception of unusual sensitivity to chemicals, 25 or 0.6 percent of the sample reported having a restrictive health problem. These relations and the reported number of cases for each subset are illustrated in figure 1.

Asthma and chemical sensitivities

Many investigators speculate that people with asthma experience unusual sensitivities to everyday chemicals. Others suggest that asthma is itself an expression of MCS. Whatever the etiology, our findings do suggest an association between asthma and perceived chemical sensitivity. Overall, 461 of the total BRFS respondents reported ever experiencing or being told by a doctor that they had asthma (11.4 percent). Nineteen percent of asthmatics compared with 4.6 percent of non-asthmatics reported being told by a doctor that they had environmental illness or MCS (table 1). Similarly, self-reported allergy or sensitivity to everyday chemicals was reported by 31.5 percent of asthmatics versus 13.9 percent of non-asthmatics. Not surprisingly, more asthmatics than non-asthmatics reported being made very sick by the exposure scenarios. They also more frequently reported conditions which restricted their ability to perform everyday activities (13.7 percent of asthmatics compared with 7.6 percent of non-asthmatics). There were, nonetheless, a substantial number of respondents without asthma who report sensitivities, so respondents did not confuse asthma with "environmental disease."

Demographic characteristics

Clinic-based reports of chemical sensitivity generally indicate that middle class White females seek medical care for chemical sensitivities most frequently. In terms of ethnicity, as shown in table 2, when unadjusted by other variables, non-Hispanic Whites, Hispanics, Blacks, and Asians are quite similar with respect to doctor-diagnosed and perceived sensitivity to chemicals. Overall, a higher percentage of females did report doctor-diagnosed sensitivities (7.7 percent vs. 4.5 percent) and perceived chemical sensitivities (16 percent vs. 6.9 percent). The unadjusted relation of income to reports of chemical sensitivities (as depicted three different ways in figure 2) is not linear. A report of sensitivity to more than one chemical is most frequent in the income category <$10,000. In mild contrast, a report of a doctor diagnosis of MCS occurs more frequently in the higher income ranges. Additional logistic regression analyses (not shown) using dummy variables for the income categories reflected the same pattern seen in the crude analysis. None of this variation was statistically significant.

Figure 3 shows the geographic distribution of cases, defined by doctor-diagnosis, perceived sensitivity to more than one chemical, and sensitivity to one or more of the exposure scenarios for the 13 California telephone area codes. Reported sensitivities are distributed fairly homogeneously throughout the state.

Age at onset and incidence

In all, 569 respondents answered that the exposure scenarios presented in questions 170–174 (excluding tobacco smoke) made them "very sick" or "a little sick." These respondents were asked to recall the age when they first noticed this sensitivity. A histogram of reported ages of onset in 10-year intervals is displayed in figure 4. Most respondents (76.7 percent) reported age at onset at 30 years or less. By converting age at onset into year at onset, we were able to examine the yearly incidence for reported sensitivity. The average annual incidence over the past 5 years—a time interval presumed to have less recall bias—was 14.4 cases, reflecting a rate of 0.36 percent. In California, this figure would represent 85,000 new cases annually.

TABLE 1. Response frequencies for selected questions about chemical sensitivities added to the 1995 California Behavior Risk Factor Survey administered to 4,046 adults (age >17 years): total sample*, asthmatics†, and nonasthmatics‡

Question	Response	Total sample (%)	Asthmatics (%)	Nonasthmatics (%)
163. "Have you ever been told by a doctor that you had environmental illness or multiple chemical sensitivity?"	"Yes"	6.3	19.0	4.6
164. "Do you consider yourself allergic or unusually sensitive to everyday chemicals like those in household cleaning supplies, paints, perfumes, soaps, garden sprays, or things like that?"	"Yes"	15.9	31.5	13.9
165. "Are you unusually sensitive to one chemical or one type of chemicals, a few different chemicals, or a lot of chemicals?"	"One or one type" "A few different" "A lot of chemicals" "Unknown"	19.1 49.6 25.3 5.9		
166. "Because of your chemical sensitivites, do you need to follow a special diet?"	"Yes"	10.0	14.5	8.7
167. "Because of your chemical sensitivities, do you take special precautions in your home or with your home furnishings?"	"Yes"	51.2	63.5	47.5
168. "Because of your chemical sensitivities, do you have trouble shopping in stores or eating in restaurants?"	"Yes"	20.7	30.3	17.9
169. "Because of your chemical sensitivities, have you ever lost or had to give up a job or occupation?"	"Yes"	8.9	16.6	6.6
Next, I'm going to read a short list of products or situations. Please tell me if you have no problem with them, if they bother you, if they make you a little sick, or if they make you very sick. By sick, I mean they give you a headache, an upset stomach, make you dizzy, or if you don't know for sure, please tell me that.				
170. "Cologne, aftershave, or perfume"	"Very sick"	1.8	4.6	1.5
171. "Walking down the detergent aisle at the grocery store"	"Very sick"	0.7	2.2	0.5
172. "Going into a beauty salon or barber shop"	"Very sick"	0.8	2.6	0.6
173. "Walking into a room with brand new carpets"	"Very sick"	0.7	2.0	0.5
174. "Reading freshly printed newspaper"	"Very sick"	0.4	1.5	0.3
175. "Sitting in a room where someone else is smoking"	"Very sick"	7.6	18.0	6.2
178. "Do you have a health problem or impairment that restricts your ability to do ordinary daily activities such as bathing, shopping, or working?"	"Yes"	8.3	13.7	7.6

* Total, n = 4,046.
† Asthmatics, n = 461.
‡ Nonasthmatics, n = 3,585.

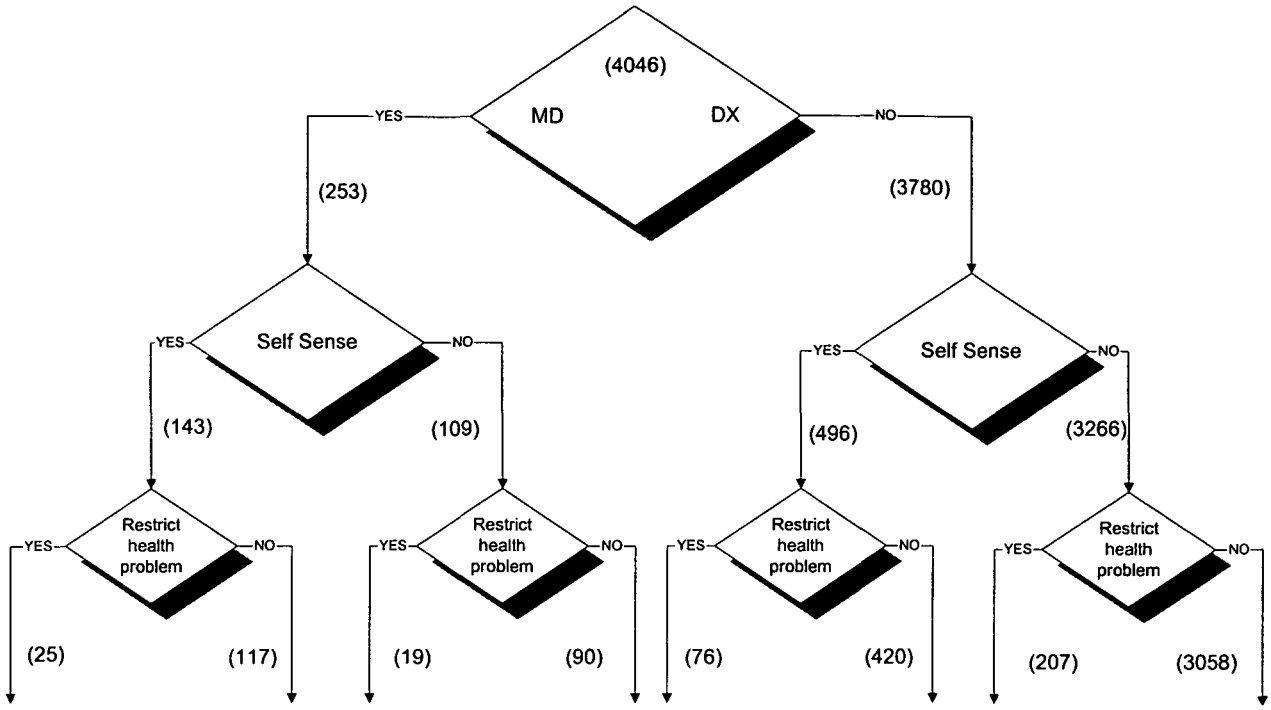

FIGURE 1. Chemical sensitivities study among 4,046 adults (age >17 years) in the 1995 California Behavior Risk Factor Survey: doctor diagnosis by perceived sensitivities by restrictive health problem. MD, doctor; DX, diagnosis.

Symptom patterns

The same 569 respondents who reported that one or more exposure scenarios made them "very sick" or "a little sick" were also asked, "Do you usually have the same set of symptoms to the things that bother you or do you have different symptoms to different things?" Over 60 percent reported that they experienced the same symptoms, while 37.1 percent reported having different symptoms to different things.

Table 3 displays the association between the number of chemicals to which the respondent reported sensitivity (Question 165) and the number of exposure scenarios in which the respondent reported becoming "a

TABLE 2. Doctor diagnosis and perceived sensitivity to more than one type of chemical by Hispanic origin, race, and sex: survey of 4,046 California adults (age >17 years) who answered questions about chemical sensitivities, 1995

Hispanic origin and race	Sex	No. in sample	Doctor diagnosis		Perceived sensitivity to >1 chemical	
			No.	%	No.	%
White, not Hispanic	Male	1,167	45	3.86	65	5.57
	Female	1,385	107	7.73	207	14.95
Black, not Hispanic	Male	97	8	8.25	7	7.22
	Female	129	7	5.43	26	20.16
Asian, not Hispanic	Male	89	2	2.25	6	6.74
	Female	99	7	7.07	17	17.17
Native American, not Hispanic	Male	37	5	13.51	7	18.92
	Female	41	5	12.20	9	21.95
Hispanic, all races	Male	410	21	5.12	39	9.51
	Female	552	44	7.97	92	16.67
Refused, not known	Male	17	0	0.00	2	11.76
	Female	23	2	8.70	5	21.74
Total		4,046	253		482	

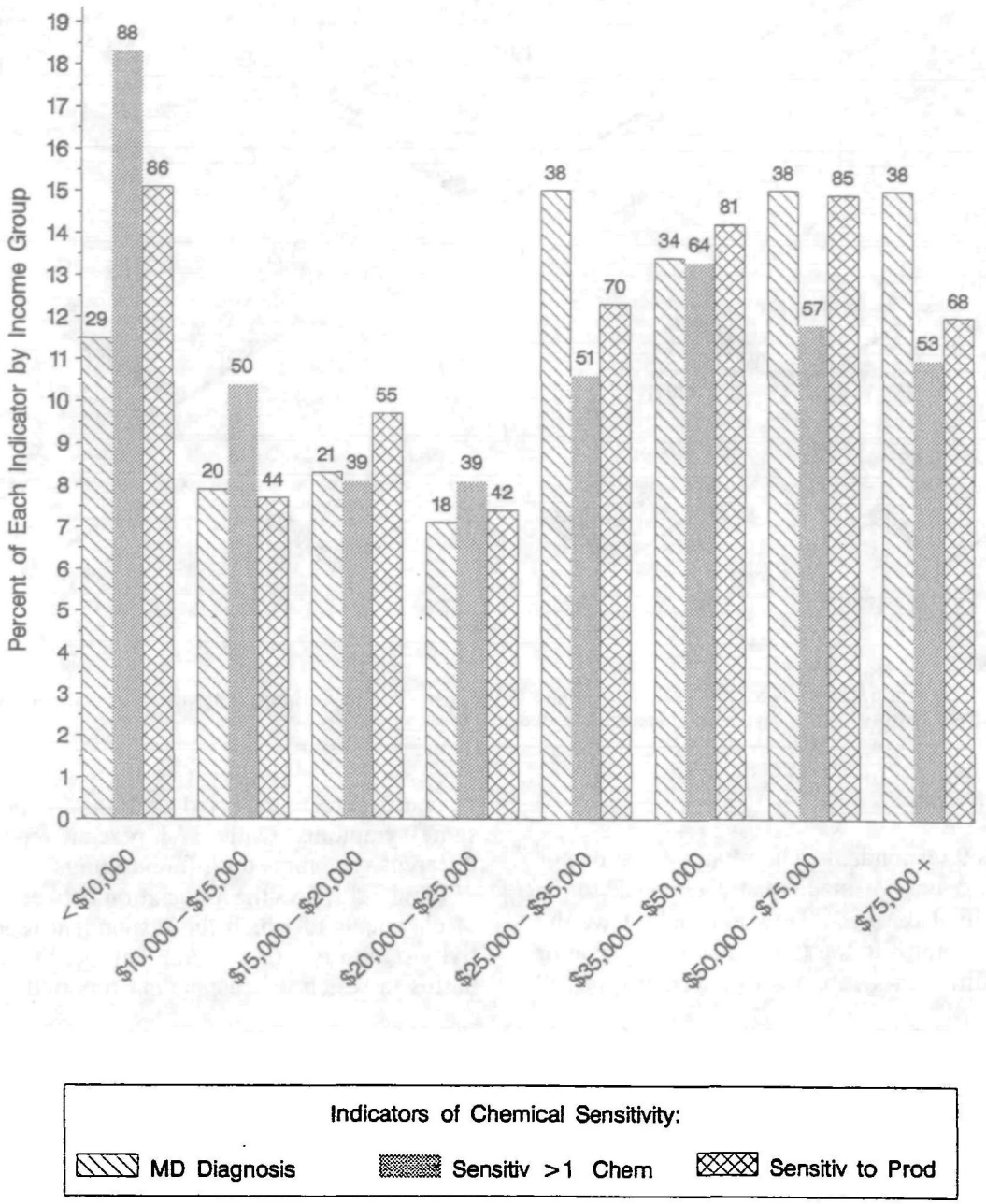

FIGURE 2. Three indicators of chemical sensitivity by income distribution among adults (age >17 years) in the 1995 California Behavior Risk Factor Survey. Doctor (MD) diagnosis, $n = 253$. Sensitivity to >1 chemical, $n = 482$. Sensitivity to products, $n = 569$.

little sick" or "very sick." Subjects who reported sensitivity to one or fewer chemicals, and asthma or hayfever sufferers, who did not experience chemical sensitivities, reported being made ill by relatively few of the exposure scenarios.

This is in contrast to respondents who reported allergy or unusual sensitivity to "a few" or "a lot" of chemicals. For example, 20.9 percent of those who said they were sensitive to "a lot" of chemicals also said they were made sick by three or more exposure scenarios. If extrapolated to the total California population, this 0.8 percent of the sample would represent more than 200,000 persons. Unfortunately, however, a report of sickness to three or more exposure scenarios is not an effective screening tool. Based on our data, using three or more reported scenarios as a proxy for self-reported sensitivity would have a specificity of 99.4 percent, but a sensitivity of only 14.5 percent.

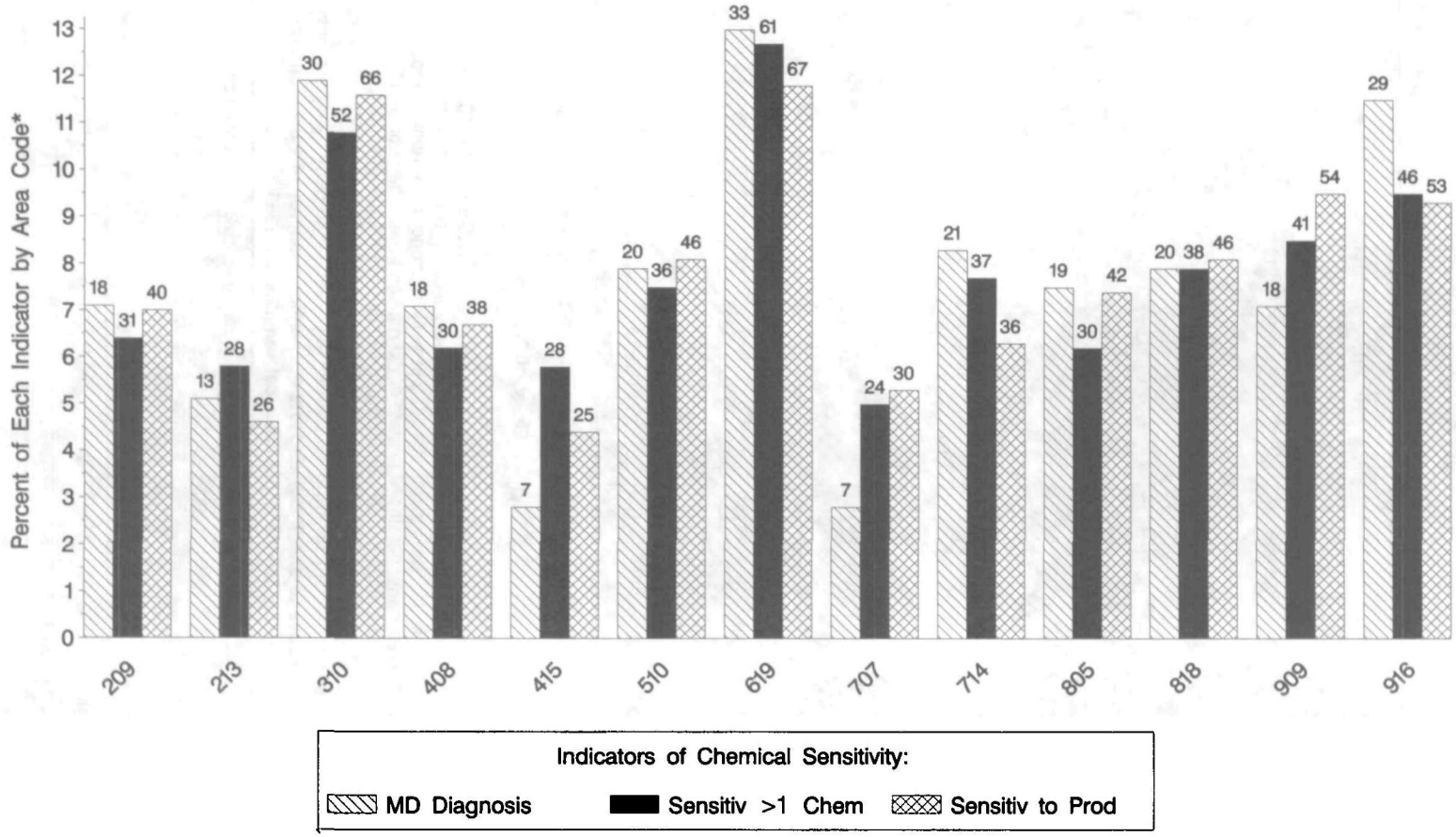

FIGURE 3. Three indicators of chemical sensitivity by telephone area code among adults (age >17 years) in the 1995 California Behavior Risk Factor Survey. *Doctor (MD) diagnosis, $n = 253$. Sensitivity to >1 chemical, $n = 482$. Sensitivity to products, $n = 569$.

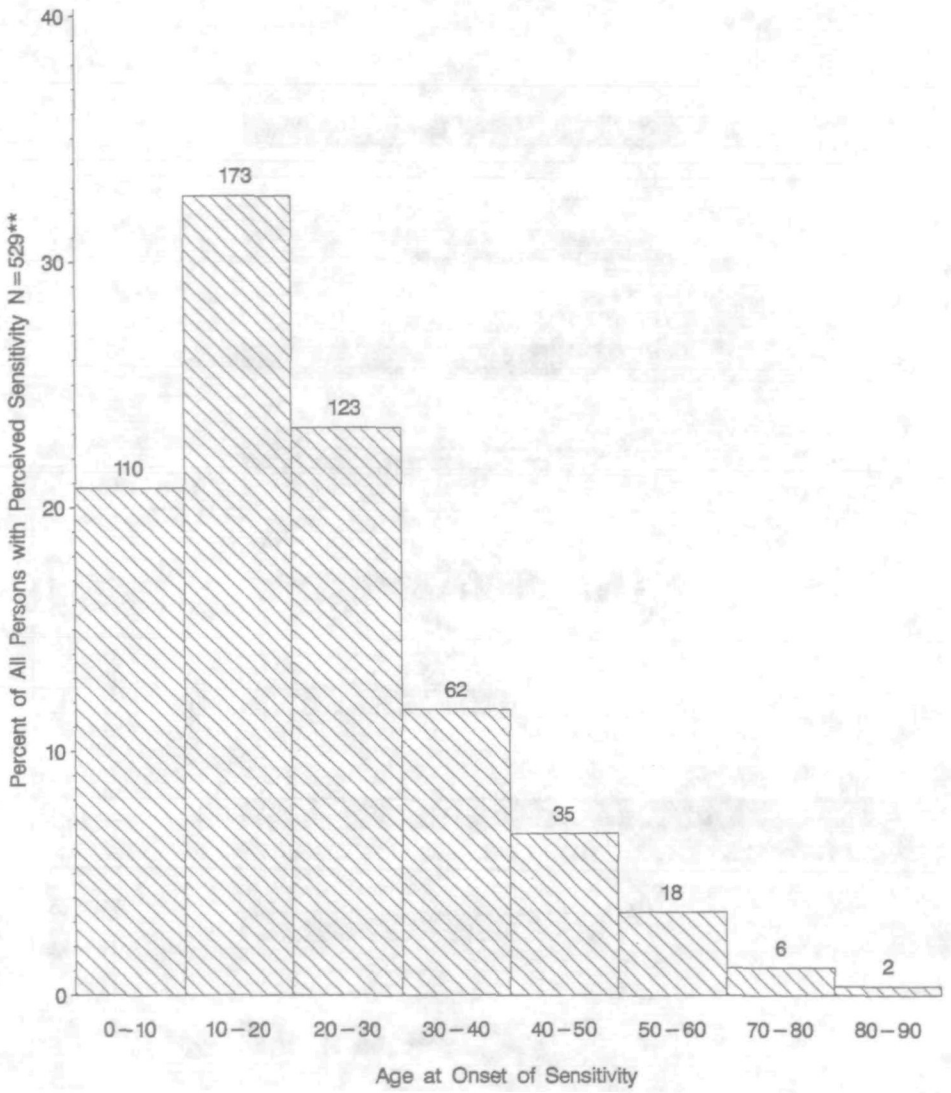

FIGURE 4. Age at onset of sensitivity* to everyday products among adults (age >17 years) in the 1995 California Behavior Risk Factor Survey. *Sensitivity to everyday products is defined as being made sick or very sick by exposure to perfume, detergent, hair, carpet, or newsprint. Age at onset of sensitivity is only asked if respondents indicated sensitivity to one of the above exposures. **n = 569 for sensitivity to products; n = 529 for age at onset. Some respondents refused to state or did not know their age at onset of sensitivity.

TABLE 3. Distribution of number of triggering scenarios* in persons who deny being sensitive and those who claim to be sensitive to one, a few, and lots of chemicals: survey of 4,046 California adults (age >17 years) who answered questions about chemical sensitivities, 1995

Sensitive to:	% Reporting triggering scenarios, by no. of reported scenarios			
	0 Scenarios	1 Scenario	2 Scenarios	≥3 Scenarios
0 chemicals (n = 3,381)	91.6	6.4	1.4	0.6
One chemical (n = 123)	72.4	19.5	4.9	3.2
A few different chemicals (n = 319)	55.8	21.0	11.9	11.3
A lot of different chemicals (n = 163)	41.1	23.3	14.7	20.9
Don't know (n = 38)	71.0	13.2	15.8	0.0
Asthma only (n = 107)	83.2	9.3	2.8	4.7
Hay fever only (n = 1,497)	82.6	10.2	3.6	3.5

* Triggering scenarios defined using "A little sick (or worse)" as cutpoint.

Logistic regression coefficients for various reported outcomes

Logistic regression models were created to examine adjusted predictors of doctor-diagnosed environmental illness/multiple chemical sensitivity and perceived chemical sensitivity to more than one type of chemical. Odds ratios and confidence intervals are shown in table 4. Hispanic ethnicity was associated with physician-diagnosed MCS (adjusted odds ratio (OR) = 1.82, 95 percent confidence interval (CI) 1.21–2.73). Female gender was associated with individual self-reports of sensitivity (adjusted OR = 1.63, 95 percent CI 1.23–2.17). Marital status, employment, education, geographic location, and income were not predictive of reported chemical sensitivities or reported doctor diagnosis.

DISCUSSION

Efforts to estimate the population prevalence of chemical sensitivities have been limited. Meggs et al. (32) determined that 33 percent (336 out of 1,027 individuals who lived in rural eastern North Carolina) reported chemical sensitivities. In their study, chemical sensitivities were defined by affirmatively responding to getting sick after smelling chemical odors like those of perfume, pesticides, fresh paint, cigarette smoke, new carpets, or car exhaust. Bell et al. (33) also have approached the question of chemical sensitivity prevalence by determining the proportion of young adult college students who have self-reported cacosmia (i.e., feeling ill from chemical odors). Approximately 15 percent of their cohort reported feeling ill from smelling multiple common environmental chemicals. Odor is a sensory characteristic of chemicals and is poorly correlated with toxicity (34). Thus, these estimates of chemical sensitivity based on reports of illness due to odors have little validity. Kippen et al. (35) have proposed measuring chemical sensitivity prevalence using a questionnaire which asks whether each of 122 common substances caused symptoms. While most of the substances had associated odor and irritant characteristics, subjects were not asked to describe the qualities of the chemicals that made them symptomatic. After administering this instrument to a limited range of clinic populations, they reported a positive predictive value for multiple chemical sensitivity (as defined by their research protocol) of 26 percent and a negative predictive value of 98 percent (35). There are no studies published on the use of this instrument in the general population.

We began this study with the expectation that chemical sensitivity sufferers might be described by at least four dimensions, each with a range of potential responses. We attempted to ask questions about the number of chemicals to which respondents believe they are sensitive, the range and severity of symptoms attributed to chemical exposure, the functional impairment caused by the sensitivity, and the life-style changes instituted due to a perception of chemical sensitivity. The present instrument approached these dimensions crudely due to time constraints. We suggest that the 25 individuals (0.6 percent of the sample) who reported a perception of unusual sensitivity to chemicals, a physician's diagnosis of chemical sensitivity, and a health problem that restricts their daily activities might be the closest to those described as MCS sufferers in medical clinic settings. We hope to ask more detailed questions about each of the aforementioned dimensions in a future study with expectations of gaining greater discrimination and insight into this condition.

As noted earlier, clinic-based studies of multiple chemical sensitivities have suggested that middle to upper middle class white females were more likely to present at a clinic for evaluation. Bell et al. (36) stated that women outnumber men as EI (environmental illness) patients by a ratio of 2:1. Ashford and Miller (37) reported that 70–80 percent of individuals who are not part of an exposed cohort (e.g., industrial workers or tight building occupants) are female; 50 percent are 30–50 years old and usually white, middle to upper middle class, and professionals.

Our study of a California population-based sample indicates that reports of doctor-diagnosed multiple chemical sensitivity and self-assessed unusual sensitivity to chemicals are distributed more homogeneously across racial/ethnic, geographic, education, marital status, and employment status categories. This homogeneous distribution of reports of chemical sensitivity might suggest a universal etiology or mechanism by which this perception occurs. A physiologic mechanism might explain this kind of universal report. If such reports were due to shared cultural or sociologic characteristics, one might expect greater variability in reporting by geographic, race/ethnicity, income, or education categories. However, given the cultural homogenizing effects of the media, the economy, and the educational system, commonly shared psychosocial mechanisms could account for these findings as well.

Of the 253 people who reported doctor-diagnosed environmental illness/MCS, the 109 people (a surprising 43.5 percent) who also did not report unusual chemical sensitivity are difficult to explain. There may have been some difficulty in understanding the questions which resulted in the apparent disagreement between the patient's report of a physician's diagnosis

TABLE 4. Adjusted odds ratios (OR) of physician-diagnosed multiple chemical sensitivity (MCS) and reported sensitivity to more than one type of chemical*: survey of 4,046 California adults (age >17 years) who answered questions about chemical sensitivities, 1995

BRFS† no.	Predictor variable	Physician-diagnosed MCS‡		Reported sensitivity¶	
		Adjusted§ OR	95% CI†	Adjusted§ OR	95% CI
0	Gender	1.05	0.74–1.48	1.63	1.23–2.17
1	Health status (5 categories)	1.14	0.97–1.35	1.14	1.00–1.30
7	Poor health days (no. in past month)	1.02	1.00–1.04	1.00	0.99–1.03
41	Exercise (in past month)	1.13	0.75–1.70	0.91	0.67–1.24
51	Ever smoked (>100 cigarettes)	1.12	0.82–1.54	0.95	0.73–1.23
72	Drinks alcohol	1.17	0.83–1.64	1.09	0.84–1.43
82	Age (in years)	1.00	0.98–1.01	1.00	0.99–1.02
83	Hispanic	1.82	1.21–2.73	1.18	0.84–1.66
84	Race				
	Black	1.38	0.74–2.61	1.40	0.84–2.32
	Asian	0.90	0.42–1.93	1.26	0.70–2.26
	Other	1.55	0.84–2.87	1.50	0.88–2.56
	White	– #		– #	
85	Marital status				
	Divorced	1.22	0.78–1.90	1.22	0.83–1.77
	Widowed	0.57	0.24–1.35	0.52	0.29–0.93
	Separated	0.74	0.32–1.69	1.11	0.61–2.02
	Never married	0.56	0.33–0.93	1.04	0.70–1.54
	Unmarried couple	0.93	0.44–1.98	0.80	0.41–1.57
	Married	– #		– #	
86	Children age <18 years living in household	0.94	0.81–1.10	0.99	0.88–1.12
91	Education (8 categories)	1.12	1.00–1.25	0.88	0.81–0.97
92	Employment status				
	Self-employed	0.94	0.56–1.58	1.02	0.66–1.59
	Unemployed	0.50	0.22–1.12	0.82	0.47–1.44
	Homemaker	0.94	0.52–1.69	1.09	0.70–1.69
	Student	0.43	0.14–1.32	0.84	0.41–1.72
	Retired	0.92	0.46–1.81	1.14	0.67–1.93
	Unable to work	1.07	0.49–2.34	0.79	0.41–1.54
	Employed	– #		– #	
94	Income (8 categories)	1.04	0.95–1.14	0.96	0.89–1.03
161	Asthma	2.56	1.80–3.63	1.53	1.10–2.14
162	Hay fever	2.22	1.57–3.16	1.94	1.49–2.52
170 to 174	Sickness from chemicals	2.91	1.99–4.27	8.14	6.14–10.8
175	Sensitive to ETS†	1.44	1.01–2.06	2.01	1.51–2.66
178	Restrictive condition	1.32	0.76–2.27	1.68	1.09–2.60
163	Physician-diagnosed MCS			3.50	2.44–5.04
164 to 165	Reported sensitivity to > 1 chemical	3.53	2.45–5.10		

* Total number of respondents with non-missing values for all predictor values = 3,577.
† BRFS, Behavior Risk factor Survey; CI, confidence interval; ETS, environmental tobacco smoke.
‡ Physician-diagnosed MCS: $n = 226$.
§ Odds ratios were adjusted for all the other variables shown in the table.
¶ Self-reported sensitivity to more than one chemical: $n = 427$.
# Reference category.

and their self-perceptions. They may have been reporting an old diagnosis or one related to chemicals other than everyday household chemicals. Then again, there may be real disagreement between doctors and some patients who have not yet attributed their symptoms to chemical sensitivity. However, if more than 6 percent of the general population reports a physician diagnosis of MCS, then doctors are making that diag-

nosis in the smaller clinic population much greater than 6 percent of the time. While this is not the experience of the authors, it could be confirmed through a survey of physicians or examination of ambulatory care surveys.

Particularly surprising are the extrapolated large numbers of people in California who report unusual sensitivities to many chemicals and who would be made very sick by common everyday exposures. For example, 163 (4 percent) of the sample reported unusual sensitivity to a lot of chemicals. This would represent 967,000 people of the 24,000,000 people in California over age 18 years. In addition, a range of 0.4 percent to 1.8 percent of the total sample reported being made very sick by "reading freshly printed newspaper" to "cologne aftershave or perfume," respectively. This, in turn, would represent between 96,000 and 432,000 people in California who report being made "very sick" by these common exposures. Finally, the 0.6 percent of the total sample who reported a doctor-diagnosis of MCS, sensitivity to chemicals, and a restrictive health condition corresponds to 144,000 Californians.

Responses to these screening questions are very provocative, but do not offer an opportunity to explore in greater detail the subjective basis for these reports or their functional consequences and correlates. We did not ask questions to differentiate between those people who reported sensitivities on the basis of a consistent response to exposures versus those who reported sensitivities on the basis of a belief that chemicals are bad for one's health. We did not try to ascertain if there were sensory characteristics, such as odor or taste, or irritancy, that were associated with the report of sensitivity. We also did not explore the temporal relation between exposure and symptoms and how the respondent came to attribute symptoms to chemicals.

In conclusion, a surprisingly large number of respondents to a population-based survey reported a doctor's diagnosis of environmental illness or MCS. An even larger number reported allergies or unusual sensitivity to everyday chemicals. The sample represents a very large number of Californians who are adversely affected by common chemical exposures.

The homogeneity of responses across race/ethnicity, geography, education and marital status and the lack of trend by income are compatible with a physiologic response or with rather widespread societal apprehensions to chemical exposure. The physiologic response could be toxocologic in origin or could be compatible with a conditioned aversive response to sensory characteristics of the chemicals. Describing this phenomenon and resolving the controversies about its hypothesized etiologies will not be easy.

We believe careful subsampling of this kind of population-based sample and administering more detailed questions and selected biomedical and neuropsychological tests will yield useful insights.

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REFERENCES

1. American Academy of Allergy and Immunology EC. Clinical ecology. J Allergy Clin Immunol 1986;78:269–71.
2. American Academy of Allergy. Position statements—controversial techniques. J Allergy Clin Immunol 1981;67:333–8.
3. American College of Physicians. Clinical ecology. Ann Intern Med 1989;111:168–78.
4. American Medical Association CoSA. Clinical ecology. JAMA 1992;268:3465–7.
5. Anderson JA, Chai H, Claman HN, et al. Position statements: clinical ecology. J Allergy Clin Immunol 1986;78:269–71.
6. Ashford NA, Miller CS. Chemical sensitivity: a report to the New Jersey State Department of Health. Trenton, NJ: New Jersey State Department of Health, December 1989.
7. Bell IR. Environmental illness and health: the controversy and challenge of clinical ecology for mind-body health. Advances, Institute for the Advancement of Health 1987;4:45–55.
8. Brown RS, Lees-Haley PR. Fear of future illness, chemical AIDS, and cancerphobia: a review. Psychol Rep 1992;71: 187–207.
9. Casanova-Roig R. Clinical ecology, multiple chemical sensitivity (M.C.S.): the debate. (Letter). Bol Asoc Med P R 1991; 83:553–6.
10. Davidoff AL, Fogarty L. Psychogenic origins of multiple chemical sensitivities syndrome: a critical review of the research literature. Arch Environ Health 1994;49:316–25.
11. Sandler H. Multiple chemical sensitivity: myth or reality? Occupational Hazards 1993;55:53.
12. Shorter E. Multiple chemical sensitivity: pseudodisease in historical perspective. Scand J Work Environ Health 1997; 23(suppl 3):35–42.
13. Wolf C. Multiple chemical sensitivities. Is there a scientific basis? Int Arch Occup Environ Health 1994;66:213–16.
14. Staudenmayer H. Multiple chemical sensitivities or idiopathic environmental tolerances: psychophysioogic foundation of knowledge for a psychogenic explanation. J Allergy Clin Immunol 1997;99:434–7.
15. Dyer RS, Sexton K. What can research contribute to regulatory decisions about the health risks of multiple chemical sensitivity? Regul Toxicol Pharmacol 1996;24:139–151.

16. California Senate Subcommittee on the Rights of the Disabled. Multiple chemical sensitivity and environmental illness. Sacramento, CA: Senate Publications, 1992.
17. Gots RE. Multiple chemical sensitivities—public policy. (Editorial). J Toxicol Clin Toxicol 1995;33:111–13.
18. Antelman SM. Time-dependent sensitization in animals: a possible model of multiple chemical sensitivity in humans. Toxicol Ind Health 1994;10:335–42.
19. Bascom R. Differential responsiveness to irritant mixtures. Possible mechanisms. Ann N Y Acad Sci 1992;30:225–47.
20. Bell IR. Neuropsychiatric aspects of sensitivity to low level chemicals: a neural sensitization model. Toxicol Ind Health 1994;10:277–312.
21. Cone JE, Sult TA, Shusterman D. Acquired intolerance to solvents following pesticide/solvent exposure in a building: a new group of workers at risk for multiple chemical sensitivities? Health effects of indoor odorants. Toxicol Ind Health 1992;8: 29–39.
22. Doty RL, Deems DA, Frye RE, et al. Olfactory sensitivity, nasal resistance, and autonomic function in patients with multiple chemical sensitivities. Arch Otolaryngol Head Neck Surg 1988;114:1422–7.
23. Friedman MJ. Neurobiological sensitization models of posttraumatic stress disorder: their possible relevance to multiple chemical sensitivity syndrome. Toxicol Ind Health 1994;10: 449–62.
24. Levin AS, Byers VS. Environmental illness: a disorder of immune regulation. Occup Med 1987;2:669–81.
25. Meggs WJ. Neurogenic inflammation and sensitivity to environmental chemicals. Environ Health Perspect 1993;101:234–8.
26. Miller CS. Possible models for multiple chemical sensitivity: conceptual issues and role of the limbic system. Toxicol Ind Health 1992;8:181–202.
27. Newlin DB. Drug sensitization, substance abuse, and chemical sensitivity. Toxicol Ind Health 1994;10:463–80.
28. Randolph T. Specific adaptation. Ann Allergy 1978;40: 333–45.
29. Siegel S, Kreutzer R. Pavlovian conditioning and multiple chemical sensitivity. Environ Health Perspect 1997;105: 521–6.
30. Simon GE, Daniell W, Stockbridge H, et al. Immunologic, psychological, and neuropsychological factors in multiple chemical sensitivity. A controlled study. Ann Intern Med 1993; 119:97–103.
31. California Behavioral Risk Factor Survey SAS Dataset Documentation and Technical Report. Sacramento, CA: Cancer Surveillance Section, California Department of Health Services, March 1996.
32. Meggs WJ, Dunn KA, Bloch RM, et al. Prevalence and nature of allergy and chemical sensitivity in a general population. Arch Environ Health 1996;51:275–82.
33. Bell IR, Schwartz GE, Peterson JM. Self-reported illness from chemical odors in young adults with clinical syndromes or occupational exposures. Arch Environ Health 1993;48:6–13.
34. Shusterman D. Critical review: The health significance of environmental odor pollution. Arch Environ Health 1992;47: 76–87.
35. Kipen HM, Hallman W, Kelly-McNeil, et al. Measuring chemical sensitivity prevalence: a questionnaire for population studies. Am J Public Health 1995;85:574–7.
36. Bell IR, Schwartz GE, Peterson JM, et al. Self-reported illness from chemical odors in young adults without clinical syndromes or occupational exposures. Arch Environ Hlth 1993; 48:6–13.
37. Ashford NA, Miller CS. Multiple chemical sensitivity. Health Environ Dig 1993;6:1–11.