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Smoking Control

Prevalence and Patterns of Environmental Tobacco Smoke Exposures Among California Teachers

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Abstract

Purpose. *This study describes the prevalence and patterns of environmental tobacco smoke (ETS) exposure in a large, well-defined cohort of professional, female school employees in California.*

Design. *This is a cross-sectional study based on survey responses from members of the California Teachers Study (CTS) cohort.*

Subjects. *The analyses focused on lifetime nonsmokers (N = 61,899) in the CTS cohort who responded to detailed questions on lifetime ETS exposures in the home, workplace, and other social settings.*

Measures. *Demographic characteristics, smoking status, and ETS exposure were based on self-reported data from two mailed surveys. Prevalence estimates within the cohort were compared with those from the California Behavioral Risk Factor Survey and the California Adult Tobacco Survey.*

Results. *ETS exposures were highest for never smokers born in the 1930s (78% in the home, 66% in the workplace, and 48% in other social settings) and steadily declined among participants born in later years. ETS exposure from spousal smoking peaked during the 1950s (37%). In the 1980s, the workplace (28%) replaced the household (19%) as the primary exposure setting.*

Conclusions. *Consideration of these patterns in the prevalence of ETS exposures is important in the interpretation and design of tobacco-related health studies. (Am J Health Promot 2004;18[5]:358–365.)*

Key Words: Environmental Tobacco Smoke, Passive Smoking, Prevalence, Historical Patterns, Prevention Research

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PURPOSE

Research has clearly demonstrated that exposure to environmental tobacco smoke (ETS) is a public health hazard.[1–5] In 1992, the U.S. Environmental Protection Agency classified ETS as a Group A (known human) carcinogen.[5] However, substantial and important gaps in knowledge remain, particularly regarding the prevalence of ETS and its role in diseases other than lung cancer.

Numerous published studies have provided estimates of population ETS exposures at single points in time. All reports to date have been cross sectional and limited to an evaluation of concurrent prevalence, providing little information on temporal ETS-exposure trends. National ETS-exposure estimates have ranged from 63% in a 1979 to 1980 survey[6] to 37% in National Health and Nutrition Examination Survey (NHANES) III data collected between 1988 and 1991.[7] Notable race and ethnicity, gender, and age-group differences in ETS exposure have been observed. In a 1983 study, Friedman et al.[6] noted that ETS exposure was strongly related to age, with a peak of 78.2% for individuals in their 20s and a decline to 13.9% for those aged 80 and above. Among participants in the NHANES III, the percentage of men reporting ETS exposure was slightly lower than women.[7] In the American Cancer Society's Cancer Prevention Study II, a substantially larger proportion of female participants (59%) than male participants (21%) reported spousal ETS exposures.[8] Prevalence studies conducted to date also

have not considered the relative contribution of various settings to overall ETS exposures. Such information would be helpful in interpreting results from historical ETS health studies. Furthermore, comprehensive information on current and historical ETS-exposure prevalence is critical to conducting risk assessments, developing targeted prevention programs, and evaluating the effectiveness of past prevention strategies.

Although current and temporal ETS-exposure patterns have not been fully explored, numerous epidemiologic studies have investigated the carcinogenic and respiratory effects of ETS.[1] However, many such studies (especially those examining cancer outcomes) have been limited by crude exposure measures, relying predominantly on spousal smoking as the index of exposure. Thus, research has focused on adult exposures, and little information has been collected characterizing exposure during childhood or in settings outside the home. The inability of these studies to consider all potential ETS-exposure routes, coupled with the relatively sparse prevalence data on ETS sources, makes interpreting ETS health studies problematic.

Data collected as part of the California Teachers Study (CTS) offer a unique opportunity to address some uncertainties in the literature concerning both ETS-exposure levels and associations with disease. Designed to study questions regarding breast cancer etiology, other cancers, and chronic diseases, the CTS includes a cohort of over 133,000 professional, female school employees in California who completed an extensive questionnaire concerning health history, lifestyle factors, and environmental factors. These women represent, in many ways, a cross section of the California female population. The CTS survey data include extensive lifetime histories of ETS exposure during childhood and each subsequent life decade for exposures in the home, at work, and in other settings. Reported lifetime exposure data, in conjunction with the wide age range of the cohort, allowed for the characterization of historical exposure estimates in this population. The purpose of this study was to describe the prevalence and patterns of ETS exposure in this large, well-defined cohort of professional school employees.

METHODS

Design

Ours is a cross-sectional study based on survey responses from the CTS. Baseline information on demographic variables and indicators of active and passive smoking history were collected on the cohort in 1995 (Wave I questionnaire). Because the CTS cohort included a very high prevalence of lifetime never smokers, and because of the current interest in passive smoking, a follow-up (Wave II) questionnaire was mailed in 1997 to collect more detailed information on ETS exposures.

Sample

The CTS was established from respondents to a 1995 mailing sent to all 329,000 active and retired female enrollees in the California State Teachers Retirement System (CalSTRS). Membership in CalSTRS includes California public school employees—kindergarten through community college—who teach, are involved in the selection and preparation of instructional materials, or are supervising persons engaged in those activities. Members are employed in approximately 1160 public school districts, community college districts, county education offices, and State-reporting entities in California. A total of 133,479 (approximately 40% of those approached) chose to join the cohort by completing the baseline questionnaire. CalSTRS printed mailing labels for the recruitment effort so that only those women choosing to join the cohort were identified to the investigators. This limited our ability to assess the representativeness of our cohort members. We were, however, able to compare the age and geographic distribution of CalSTRS members who did and did not join the cohort, and the results were similar.[9] A full description of the CTS cohort is available elsewhere.[9]

More extensive information on source, setting, and timing of ETS exposures was collected 2 years later in a Wave II survey mailed to all cohort members. Our analysis was limited to the 99,387 women (approximately 74% of the cohort) who returned the Wave II survey with valid responses to the ETS questions. Our primary analyses, however, focused on the lifetime never smokers among these women (N = 61,899). A comparison of the basic demographic characteristics and smoking status of the cohort members who did and did not respond to the Wave II survey revealed no substantial differences. Use of data on human subjects in this study was reviewed by the California Health and Human Services Agency Committee for the Protection of Human Subjects and was found to be in compliance with their ethical standards as well as with the U.S. Code of Federal Regulations, Title 45, Part 46, on the Protection of Human Subjects.

Measures

Demographic Variables. We derived demographic characteristics from Wave I survey data. Age was calculated as the difference between the questionnaire fill date and the reported birth date (rounded up to the nearest year). For this analysis, we categorized age into 10-year age groups (20–29 years, 30–39 years, 40–49 years, 50–59 years, and ≥60 years). Wave I respondents were asked to characterize their race and ethnicity, choosing from among 11 race and ethnicity categories: non-Hispanic white, African-American or black, Hispanic, Native American, Chinese, Filipino, Hawaiian, Japanese, Korean, Vietnamese, and Other. Because of the small number of particular respondents, we included Native American women and women of other race and ethnicity into one ''Other'' category and Chinese, Filipino, Hawaiian, Japanese, Korean, and Vietnamese women into one ''Asian/Pacific Islander'' category. Respondents were asked the location of their birth and were given the following options: California, Other U.S. state or Canada, Mexico, South America, Central

America or Caribbean, Asia or Pacific Islands, Eastern Europe or former Soviet Union, Western Europe, Scandinavia or United Kingdom, Middle East or Israel, Africa, and Other. For our analysis, we collapsed these categories into three: California, Other U.S. state or Canada, and Foreign Born.

Smoking Status. We based smoking status on two questions from the Wave I questionnaire. Women were asked if they had ever smoked 100 or more cigarettes during their lifetime and, if so, when they started and stopped smoking. Using this information, we categorized respondents as never, former, or current smokers.

ETS Exposure. Wave II survey data elicited a detailed description of ETS exposures in the home, workplace, and other social settings. Women reported their exposures in these settings for childhood (ages <20 years) and for subsequent life decades. To characterize household exposures, respondents were asked (yes/no), ''During each age period were you ever exposed to tobacco smoke from a household member (i.e., parent, spouse, roommate, etc)?'' For workplace exposures, respondents were asked (yes/no) for each age period, ''Have you ever been exposed to the tobacco smoke of others in your workplace?'' Finally, for exposures from other social settings, respondents were asked (yes/no), ''Have you been exposed to tobacco smoke in a nonwork setting (for example, with friends, commuting, or in other social settings) for 2 or more hours a week on a regular basis?'' for each of the age periods of interest. For household exposures, respondents were further asked to report the exposure source (spouse, parent, other household member). In our analysis, we combined exposures reported for ages ≥20 years to create an ''adulthood'' exposure variable for each source and setting of interest.

To create a historical picture of how ETS-exposure prevalence varied over time, we estimated the ETS-exposure prevalence for each decade of the 20th century by using each woman's age-period–specific lifetime exposure history and birth year. To do this, we first calculated the age of each cohort member at the midpoint of all decades in the century, then we applied each member's reported ETS exposures during that age period of life to that decade in the century.

Statistical Analysis

Initially, we constructed frequency distributions to compare the ETS-exposure groups' demographics. Because of the extremely large sample size, tests for statistical significance are relatively meaningless. Therefore, we calculated exposure-prevalence rates for the various periods and settings of interest and presented them graphically to illustrate patterns and trends in ETS exposures in this cohort of women.

We compared recent exposure-prevalence estimates within the CTS cohort with those from two statewide risk-factor surveys: the California Behavioral Risk Factor Survey (BRFS)[10] and the California Adult Tobacco Survey (CATS).[11] We adjusted exposure-prevalence estimates for both the BRFS and the CATS to the age and race distribution of the CTS population with known race and ethnicity. The wording of questions on the BRFS and the CATS regarding household and workplace tobacco exposures was not exactly the same as on the CTS questionnaires. On the BRFS, prevalence of ETS exposure in the home among never smokers was based on the proportion of respondents who were never smokers but ''did not currently prohibit smoking in their homes.'' On the CATS, workplace-exposure estimates were based on never smokers who reported that someone smoked in the area where they worked during the past 2 weeks.

RESULTS

ETS-exposure data and demographic information were complete for 99,387 women. At the time of the Wave I survey (1995), 2% of the women in this cohort were under age 30, 32% were between age 30 and 50, 26% were between age 50 and 59, and 40% were age 60 and over. Approximately 87% of the women were non-Hispanic white. Among women born more recently, the percentage of non-Hispanic whites was lower, with associated higher proportions of women of color. Whereas earlier birth cohorts came primarily from outside California, the majority of younger study respondents were born in California (data not shown).

Approximately one-third of CTS members had ever smoked, but only 4% were current smokers at baseline. Because most ETS-related health studies focus on nonsmokers, our analyses are focused on the 61,899 lifetime never smokers. Table 1 describes the demographic characteristics associated with ETS exposures among never smokers. The majority of never smokers (86%) reported some ETS exposure during their lifetime. The prevalence of lifetime ETS exposure was lowest among women aged 20 to 29 (67%) and increased to 87% among women aged 40 to 49 but did not continue to increase in older women. Exposure to ETS did not vary greatly by race and ethnicity or birthplace.

Figures 1 and 2 illustrate the lifetime ETS-exposure pattern for each 10-year birth cohort among never smokers within the CTS. Lifetime ETS exposures from all settings were highest among those born in the 1920s through the 1940s (Figure 1). Similarly, childhood exposures (under age 20) were highest among those born during the 1940s (Figure 2). Lifetime and childhood ETS exposures from all settings have declined among successive birth cohorts. For all birth cohorts, household exposures served as the primary setting of both lifetime and childhood ETS exposures. Childhood exposures, in particular, were dominated by ETS exposures in the household. For most birth cohorts, work was the second largest contributor to lifetime ETS exposure. Only among the very old (those born before the 1900s) and the very young (those born during the 1970s) were other social settings equally or slightly more important contributors than the workplace to lifetime ETS exposures.

Figures 3 through 5 show tempo-

Table 1

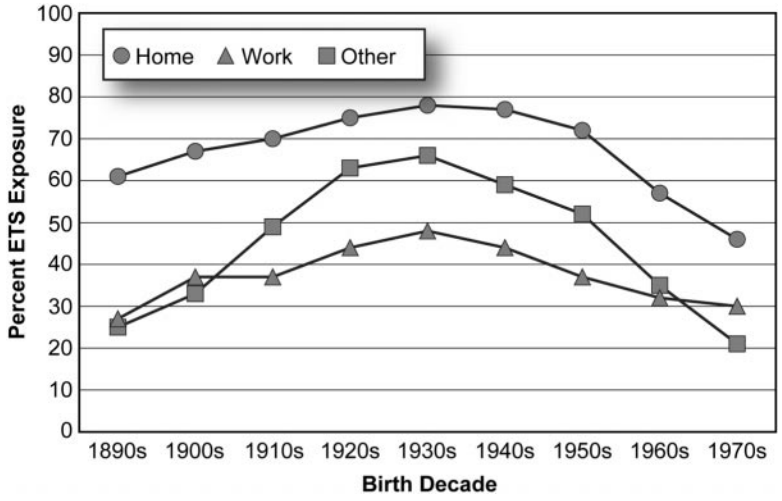
Demographic Variables by Lifetime Environmental Tobacco Smoke (ETS) Exposure Among Never Smokers*

	Lifetime ETS Exposure Among Never Smokers							
	Yes		No		Missing		Total	
Demographic Variable	N	%	N	%	N	%	N	%
Total	53,140	86	7627	12	1132	2	61,899	100
Baseline age† (y)								
20–29	1241	67	599	32	22	1	1862	100
30–39	6818	79	1745	20	104	1	8667	100
40–49	12,601	87	1735	12	153	1	14,489	100
50–59	13,777	89	1337	9	262	2	15,376	100
≥60	18,703	87	2211	10	591	3	21,505	100
Race/ethnicity								
Non-Hispanic white	46,188	86	6591	12	940	2	53,719	100
African American	1232	90	111	8	25	2	1368	100
Hispanic	2190	83	382	15	62	2	2634	100
Asian/Pacific Islander	2091	84	348	14	55	2	2494	100
Other	1044	85	144	12	36	3	1224	100
Missing	395	86	51	11	14	3	460	100
Birthplace								
California	24,432	84	4069	14	468	2	28,969	100
Other U.S. state or Canada	25,530	88	3045	10	537	2	29,112	100
Outside U.S. or Canada	2620	83	436	14	94	3	3150	100
Missing	558	84	77	11	33	5	668	100

* Any lifetime ETS exposure is defined as ever having been exposed to ETS in the home, workplace, or social settings at any time during one's lifetime.
† Reported in the 1995 to 1996 Wave I survey.

Figure 1

Reported Lifetime Environmental Tobacco Smoke (ETS) Exposure by Setting and by 10-Year Birth Cohort



Any lifetime ETS exposure is defined as ever having been exposed to ETS in the home, workplace, or social settings at any time during one's lifetime.

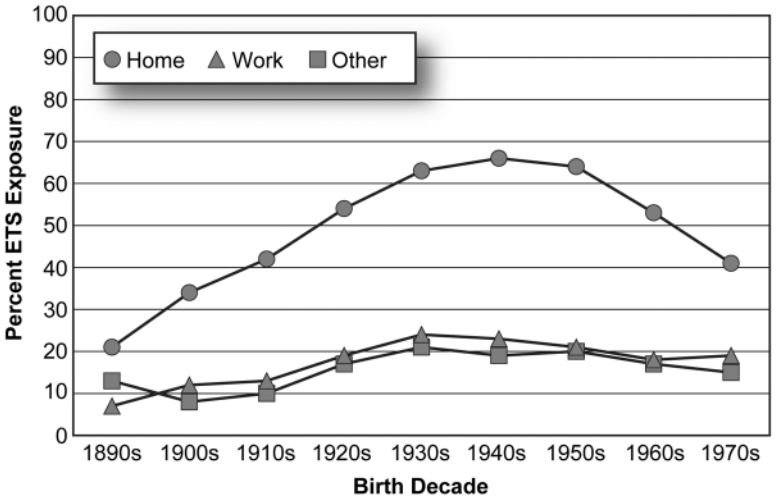
ral patterns in ETS-exposure prevalence. As opposed to Figures 1 and 2, which show how lifetime prevalence of exposure varies with a woman's birth year, Figures 3 through 5 illustrate the estimated prevalence of ETS exposures in the cohort for each decade of the century, given the age structure of the cohort during that decade and the reported age-period–specific exposures. Figure 3 illustrates the relative contribution of ETS-exposure setting (home, work, and other) to total ETS exposures. As can be seen in this figure, household exposures were the primary reported ETS-exposure setting among never smokers before the 1970s. As home exposures have declined, the relative contribution of workplace exposures has increased. During the 1980s, the workplace was the primary setting for ETS exposures. During the 1990s, the prevalence of exposures in the home, at work, and in other settings converged at 10%. This overall pattern was similar across race and ethnicity categories, but the exposure prevalence for this most recent period was higher among African-Americans and Hispanics (data not shown).

Figures 4 and 5 illustrate more detailed temporal trends in reported household ETS exposures. Figure 4 categorizes the source of adult household ETS exposure as spousal or nonspousal (parent or other household member) for each decade. Estimated spousal smoking exposure was highest during the 1940s and 1950s and accounted for most home ETS exposure among never smokers. The trend since the 1950s indicates a steady decrease in adult ETS exposure from both spousal and nonspousal sources, with 10% reporting any ETS exposure in the home during the 1990s.

Figure 5 summarizes the temporal patterns in the prevalence of household ETS exposure during childhood (under age 20) and during adulthood separately. For all periods, household ETS exposures were more prevalent during childhood than during adulthood. Although both adult and childhood household ETS exposures have decreased since the 1950s, the decrease has been more dramatic for adult than for childhood expo-

Figure 2

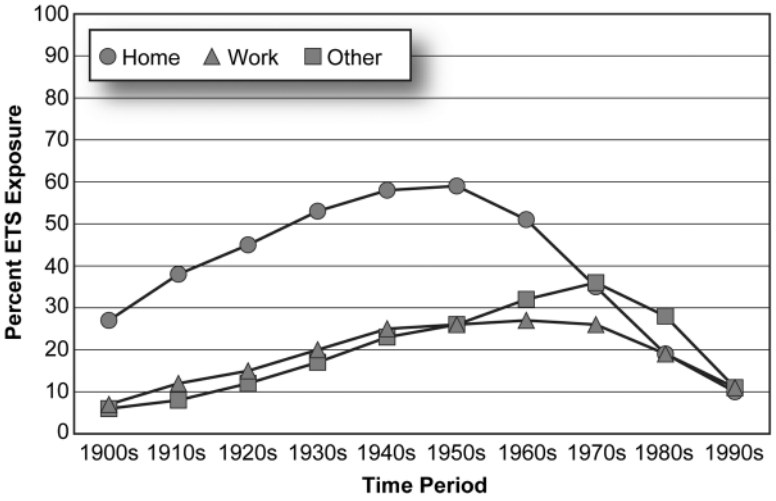
Childhood Environmental Tobacco Smoke Exposure by Setting and by 10-Year Birth Cohort



Exposures occurring before the age of 20.

Figure 3

Temporal Patterns in Estimated Environmental Tobacco Smoke Exposures by Setting



sures. During the 1980s, the prevalence of reported childhood exposures (41%) was more than double that of adult exposures (17%).

The prevalence of current smoking (based on 1995–1996 Wave I survey data) in this cohort of women was only 4%, which was one-fourth of that observed in the statewide BRFS of adult female respondents for the same period (16%). During the 1995 to 1996 period, the proportion of lifetime never smokers (62%) among the CTS cohort was higher than that reported by a demographically comparable sample of California women in the BRFS (55%) for the same years. Among never smokers, respondents to the Wave II survey (1997–1998) reported slightly less recent exposure to ETS at home (10%) than did women from the 1997 to 1998 BRFS (13%) and slightly higher recent exposure in the workplace (11%) than did women in the 1997 to 1998 adult CATS (6%).

DISCUSSION

These analyses revealed a number of interesting temporal and age-related patterns of ETS exposure in our sample of never-smoking women. Consideration of such patterns may help inform the interpretation of previous ETS-related health studies that relied on incomplete ETS-exposure profiles. Furthermore, the temporal patterns of ETS exposure seen in this cohort appear to reflect public health success in decreasing the prevalence of active and passive smoking.

When looking at all ages in the cohort, ETS exposure peaked for those never smokers born during the 1930s and has been decreasing for participants born in later years. This pattern of age-related ETS exposure has also been seen in other studies[6] and was consistent for exposures in the home, at the workplace, and in other social settings. We examined childhood and early adulthood (under age 20) exposure separately and observed that ETS exposure in the home was highest for those born during the 1940s and has decreased for those born in later years. These findings are consistent with the declining prevalence of smoking in the California population.[12]

Our temporal analysis revealed a shift in the relative contribution of different settings to overall ETS exposures. Our study shows that, during the 1940s and 1950s, exposure in the home accounted for over half the ETS exposure among never smokers, the majority of which was from spousal smoking. As home exposures have declined, other exposure settings have made a higher relative contribution. During the 1970s, exposures in the home and workplace each accounted for over one-third of the ETS exposures among never-smoking cohort members.

Figure 4

Temporal Patterns in Estimated Adult Household Environmental Tobacco Smoke Exposures by Source

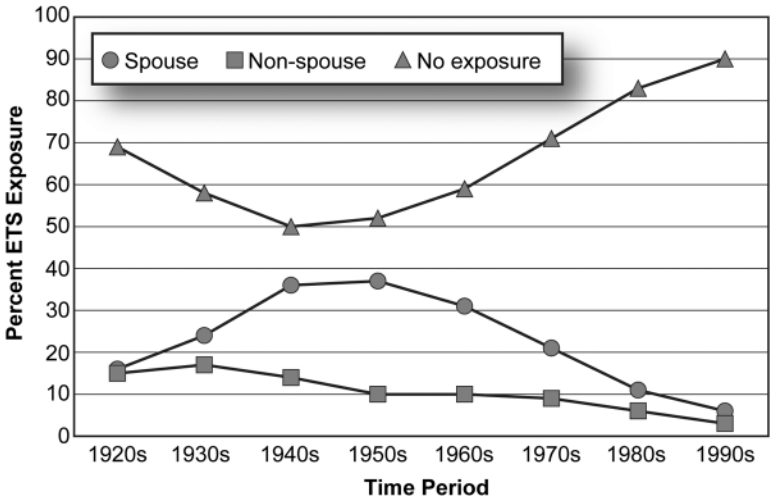
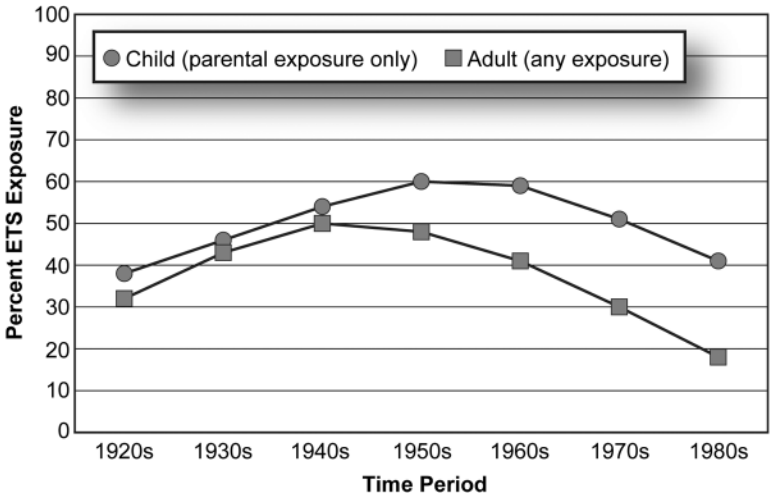


Figure 5

Temporal Patterns of Estimated Household Environmental Tobacco Smoke Exposures by Age at Exposure



Child includes exposures at age <20; adult includes exposures at age ≥20.

Since then, restrictions on workplace smoking have been established,[13] and our data illustrate that, during the 1990s, the prevalence of home, work, and other estimated ETS exposures among never-smoking cohort members have converged at approximately 10%.

Most health studies to date have examined home ETS exposure, particularly from spousal exposure. Our results suggest that earlier studies using the spouse as a proxy for ETS exposure may have characterized overall exposure better than studies of more contemporary birth cohorts using spousal exposure. Furthermore, it appears that, since the 1970s, workplace exposure has contributed more to total ETS exposure. In fact, some studies suggest that exposure levels may have been much higher in workplace than in home settings.[14] Consequently, studies conducted since the 1970s, which have been limited to household ETS sources, likely overlooked a major ETS source and should be interpreted with caution.

The ETS-exposure prevalence in this cohort of women appears lower than that reported from earlier periods and in other populations of women; it is especially lower than that reported in the general U.S. population. Other studies have shown that between 1988 and 1991, 33% of U.S. women reported living with a smoker or working in a smoky environment.[15] In the San Francisco Bay area, 63% of subjects surveyed between 1979 and 1980 reported some ETS exposure.[6] By the early 1990s, a time when California was establishing strict workplace smoking restrictions,[16] only 23% of California women reported workplace ETS exposures, compared with an estimated 75% in other U.S. studies from the same period.[17,18] The prevalence of smoke-free worksite policies for indoor workers during 1999 ranked California as third in the nation, with 77% of workers covered by such policies.[19]

One limitation of our study is that, as a group, CTS members may not be representative of the general female population. Indeed, CTS participants reported a dramatically lower percentage of current smoking (4%) when compared with California women in the BRFS for the same period (16%). Among never smokers, however, recent ETS-exposure prevalence in the cohort was similar to that reported in recent statewide surveys. Because it is an occupational cohort, the CTS is more homogeneous than the statewide population. All members of the cohort have at least a college degree, and all either work or have worked in a public school system. Women enrolled in the CTS cohort, however, represent a very diverse group. They are multiethnic, they represent a broad age range, and they include both native and nonnative Californians. Although

ETS exposures will vary in different occupational settings, the decline in reported workplace exposures in this cohort, coinciding with enactment of statewide legislation to ban smoking in workplaces, provides evidence that the patterns of occupational ETS exposures in this cohort may reflect patterns in the general population. It is impossible to know how well our conclusions concerning ETS exposures in this cohort apply to women working in other occupations. Nevertheless, the temporal patterns and relative importance of different settings illustrated here should be of value in helping shape the picture of how women have historically been exposed to ETS over time.

Another of our study's constraints is that respondents' active and passive smoking histories were derived from self-reports and are not directly measured. However, the problem is not unique to this study. Although a number of biomarkers exist for recent ETS exposures, there are currently no specific biologic markers of long-term historic ETS exposures. And although the validity and reliability of the ETS measures used in our study are unknown, substantial evidence exists that respondents are able to report recent ETS exposures with reasonable accuracy.[1] The reliability of respondents in recalling passive smoking histories, especially for spousal and parental sources, has been demonstrated.[20,21] Reasonable validity for parental and spousal smoking histories, especially for dichotomous exposure values, has also been illustrated in studies that compared histories provided by study subjects with data reported directly from their parents or spouses.[22–24] Additionally, one investigator recently found that ETS-exposure levels measured by personal air monitors were highly consistent with recalled ETS-exposure levels reported several years later (Katherine Hammond, personal communication, 1998).

Still another limitation of our study is that home, workplace, and other ETS exposures were reported by decade rather than by individual years. Asking about exposures in broad categories was necessitated by the study's use of scannable questionnaires; this was the only economically efficient way to study such a large number of women. Thus, exposure was attributed to an entire decade when, in reality, the participant might have been exposed for only a portion thereof.

The CTS cohort offers a number of important strengths for evaluating patterns of ETS exposure. Data collected from the CTS surveys were designed to target important details in sources, settings, and timing of lifetime ETS exposures, offering a comprehensive description of exposure in a way that no other large-scale study has been able to do. Additionally, the unusually high prevalence of lifetime never smokers in this group provides a truly unique opportunity to examine key gaps in the knowledge of ETS exposures and related health effects.

Our study findings can contribute to the design and evaluation of future ETS and health studies. ETS exposure in the home, particularly exposure to a smoking spouse, appears to account for most of the women's ETS exposure before the 1970s. However, for periods during and after the 1970s, studies need to account for the workplace and other social settings as major contributing ETS-exposure sources. On the basis of these data, it is likely that ETS-related health studies that focused on spousal sources of ETS exposure occurring before 1970 captured most ETS exposures with relatively little misclassification. However, later studies that relied only on household ETS sources may have suffered from substantial exposure misclassification, thus providing more biased effect estimates. Similarly, ETS-exposure potential outside the home will be influenced by legislation, such as that introduced during the 1990s in California as well as elsewhere, thereby restricting smoking in the workplace and in public. In designing future ETS studies, the contribution of home, workplace, and social sources of ETS exposure should be considered in the context of these kinds of secular trends.

SO WHAT? Implications for Health Promotion Practitioners and Researchers

Our study revealed a number of interesting temporal and age-related patterns of ETS exposure in this sample of never-smoking women and, as such, offers the first comprehensive picture of historical exposures to ETS in women. If the same patterns and trends of exposure hold true in the general population, findings from our study can help health promotion researchers design and evaluate ETS-related health studies and enhance our understanding of exposure potential from an agent known to cause cancer and other adverse health outcomes.

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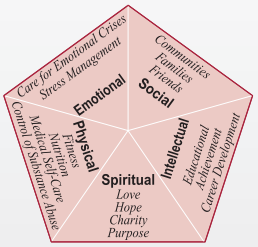

DIMENSIONS OF OPTIMAL HEALTH

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"Health Promotion is the science and art of helping people change their lifestyle to move toward a state of optimal health. Optimal health is defined as a balance of physical, emotional, social, spiritual and intellectual health. Lifestyle change can be facilitated through a combination of efforts to enhance awareness, change behavior and create environments that support good health practices. Of the three, supportive environments will probably have the greatest impact in producing lasting change."

(O'Donnell, *American Journal of Health Promotion,* 1989, 3(3):5.)

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