



Lifetime Exposure to Environmental Tobacco Smoke among Urban Women Differences by Socioeconomic Class

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This study sought to determine cumulative lifetime exposure to environmental tobacco smoke (ETS) among urban women in relation to sociodemographic factors. In a population survey carried out in Geneva, Switzerland, during 1993–1995, a representative sample of 1,883 women aged 35–74 years answered interview questions on lifetime ETS exposure. Exposed women were defined as those who had spent at least 1 hour daily in a smoky environment during 1 or more years. The prevalence of current ETS exposure was 31.0% among 1,458 never or former smokers. Lifetime prevalence was 58.3% among 1,061 never smokers. The home (42.1%) and the workplace (39.6% of employed women) were the most frequent sources of ETS exposure, leisure time activity being a secondary source. Throughout a lifetime, work accounted for the greatest average intensity of exposure (on average, 19 hours of exposure per week), while the longest duration of exposure (on average, 18 years) was in the home. Cumulative lifetime exposure (intensity (in hours/week) × duration) from all sources combined was 308 hours/week-years, which can correspond to 30.8 hours/week over a period of 10 years or 20.5 hours/week over a period of 15 years. Women from low socioeconomic classes had more intense and longer exposures than women from higher socioeconomic classes, mainly because of work exposure. Both the intensity and the duration of lifetime ETS exposure were greater than previously suspected. Reduction of ETS exposure in the workplace should be a public health priority. *Am J Epidemiol* 1998;148:1040–7.

environmental exposure; occupational exposure; prevalence; smoking; social class; tobacco smoke pollution; women

The prevalence of exposure to environmental tobacco smoke (ETS) is high in Western populations. In the Third National Health and Nutrition Examination Survey, 33 percent of a representative sample of US women reported either living with a smoker or working in a smoky environment (1). In the late 1980s, 34 percent and 43 percent of representative samples of German and Polish women, respectively, reported living with a smoker (2), while 41 percent of Spanish women at a pregnancy clinic were currently being exposed to ETS by their husbands (3). In Germany and Poland, 33 percent of working women reported working in a smoky environment (2), and 42 percent of the pregnant Spanish women were being exposed to ETS at their workplace for an average of 1 hour daily (3). In a California survey, 23 percent of working women

had contact with smokers at the workplace (4), but other US studies have reported up to 75 percent of male and female workers' being exposed to smoking in the workplace (5, 6). ETS exposure is not evenly distributed in the population: Persons in lower socioeconomic classes are more frequently exposed (1, 4, 7–10).

Thousands of people die every year from lung cancers attributable mainly to passive inhalation of tobacco smoke (11). Because passive smokers (relative to active smokers) are usually exposed to low doses of carcinogens, it is the cumulative exposure rather than the prevalence of exposed people at a given moment in time that is most informative with respect to risk of disease. Lifetime exposure to ETS has been assessed in a sample of women visiting a US cancer screening clinic (12), but similar information is not currently available for a general population.

A population survey was performed among urban Swiss women to determine their lifetime history of ETS exposure in relation to sociodemographic factors. Assessment of exposure was sufficiently detailed to measure intensity, duration, and cumulative exposure to ETS in the home, at work, and during leisure time.

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Abbreviation: ETS, environmental tobacco smoke.

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MATERIALS AND METHODS

Subjects

Between January 1993 and December 1995, a random sample of the adult female population of Geneva, Switzerland, was selected to represent the 98,000 non-institutionalized female residents of Geneva Canton aged 35–74 years. Subjects were identified from an official list of all canton residents that included name, date of birth, address, and nationality. Random sampling in age-sex-nationality strata was proportional to the corresponding distributions in the Geneva population. Potential subjects were asked by mail to participate in a population survey on “women’s health.” In case of nonresponse after 15 days, they were telephoned up to seven times on different days of the week and at different hours of the day; if necessary, they were sent a second and third letter. A systematic check of the subsequent edition of the official list has shown that over 90 percent of the subjects who were not reached no longer resided in Geneva. On the other hand, subjects who were reached but refused to participate were not replaced. The overall recruitment procedure took up to 2 months for each subject. The participation rate was 70 percent; 1,883 women were included in the study.

In-person interviews were performed in a mobile epidemiology unit where trained interviewers helped the participants to complete a detailed questionnaire about their medical and familial history, sociodemographic factors, health and dietary habits, smoking behavior, and ETS exposure.

The smoking history section of the questionnaire was structured as four calendars. One calendar was dedicated to active smoking, and three separate calendars were dedicated to ETS exposure from three different sources: home, work, and leisure activity. In each calendar, lines corresponded to ages and columns to items that varied according to the type of smoking exposure. ETS exposure between age 10 and the date of the interview was recorded year-by-year. An episode of exposure was defined as a period of at least 1 year during which a subject was exposed to ETS for at least 1 hour daily. The intensity of the exposure was recorded in hours per week and the duration in number of years. Up to four episodes of ETS exposure from each of the three different sources could be recorded for each subject.

In 1996, the reliability of the responses on lifetime ETS exposure was tested in 170 women with breast cancer and 170 controls who had had a first interview in 1992 or 1993 (13). The 170 controls were randomly selected from the sample of 1,883 women analyzed in the present report.

Data analysis

Socioeconomic class was defined by the woman’s longest-held job, coded according to a Swiss adaptation of the criteria in the British Registrar General’s classification of occupations (14, 15). The longest-held job was used as a proxy for the woman’s entire job history. The average duration of lifetime employment among nonsmoking women was 24.7 years, and the longest-held job lasted, on average, 18 years (70 percent of lifetime employment). Class I included academics and professionals; class II, highly skilled workers or managers; class III, skilled workers, both nonmanual (III-NM) and manual (III-M); and classes IV and V, unskilled workers. Education was divided into primary school (≤ 8 years of schooling), secondary school (9–12 years of schooling), and the Swiss baccalaureate level (≥ 13 years of schooling).

Subjects were divided into never smokers (having never smoked or having smoked less than 100 cigarettes in their lifetime) and ever smokers (having smoked at least 100 cigarettes in their lifetime). Ex-smokers were defined as those who had not smoked for at least 1 year at the time of interview.

For each source of ETS exposure (s = home, work, leisure), the duration of exposure (years) was the summation of years of ETS exposure over each episode of exposure:

$$\text{Duration}_s = \sum_i \text{years}_{is},$$

where i = 1–4 episodes of exposure and years_i = number of years of exposure for each episode. Total duration of exposure (years) was the summation of durations across all sources.

For each source s , the cumulative exposure (intensity \times duration, expressed in hours per week multiplied by years (hours/week-years)) was the summation of years of exposure weighted by the number of hours per week of exposure over the i episodes:

$$\text{Cumulative exposure}_s = \sum_i (\text{years}_{is} \times \text{hours/week}_{is}).$$

Total cumulative exposure (hours/week-years) was the summation of cumulative exposure over all sources.

For each source s , the intensity of exposure (hours/week) was an average of hours of exposure per week weighted by the durations of exposure over i episodes:

$$\text{Intensity}_s = \sum_i (\text{years}_{is} \times \text{hours/week}_{is}) / \sum_i \text{years}_{is}.$$

Total intensity of exposure from all sources was expressed as a mean weekly exposure (hours/week). It was the summation of hours of weekly exposure weighted by durations over all sources and episodes

divided by the total duration of exposure:

Total intensity =

$$\sum_s \sum_i (\text{years}_{is} \times \text{hours/week}_{is}) / \text{total duration.}$$

Current (at the time of interview) and lifetime prevalence of exposure were calculated for each source of exposure.

Because of skewed data distributions, the logarithms of intensity, duration, and cumulative exposure were used in statistical analyses. Geometric means were obtained by exponentiation. Least squares means (16) of intensity, duration, and cumulative exposure for each source were adjusted for age, education, social class, and, according to the analysis, duration of employment. Trends in mean intensity, duration, and cumulative exposure across social classes were computed by linear regression with age, education, and duration of employment included as covariates.

The reliability of responses to questions on ETS exposure was assessed by percentage of agreement. Differences in cumulative exposure between subjects with consistent and inconsistent responses were assessed by *t* test. Statistical analyses were carried out with SAS software (1990 version; SAS Institute, Inc., Cary, North Carolina).

RESULTS

Of the 1,883 women who participated in the study, 1,061 (56.3 percent) were never smokers, 397 (21.1 percent) were ex-smokers, and 425 (22.6 percent) were current smokers.

Current exposure to ETS

The prevalence of current exposure to ETS was assessed among the 1,458 women who were not current smokers at the time of the interview. There were 452 women (31.0 percent) who were currently being exposed to ETS and 1,006 who were not being exposed either actively or passively. Table 1 shows that the home and the workplace were the main sites of current exposure, except for the group aged 65–74

years. The prevalence of exposure to ETS at home was greater among women aged 45–64 years, while exposure at work was more prevalent among younger women.

Lifetime exposure to ETS

Lifetime exposure to ETS was assessed among women who had never actively smoked. Among 1,061 never smokers, 619 (58.3 percent) had ever been exposed to ETS—447 (42.1 percent) at home, 331 (31.2 percent) at work (39.6 percent of ever employed women), and 166 (15.6 percent) during leisure time—and 336 (31.7 percent) had first been exposed before age 15 at home (not shown in a table).

Table 2 presents the lifetime prevalence of exposure to ETS or to active smoking by exposure site and age. In women younger than 55 years, having ever been exposed 1) at home only, 2) at work only, and 3) both at home and at work were all equally prevalent. In women aged ≥ 55 years, the exposure incurred at home only was twice that incurred at work only or both at home and at work. Over a lifetime, very few women had been exposed to ETS only during their leisure time. The prevalence of ex-smokers was relatively constant across age groups, but there was a clear trend of increasing prevalence of active smoking among younger women.

Among the 619 women who had ever been exposed to ETS, the mean intensity of ETS exposure over a lifetime was 21.5 hours/week, with a mean duration of 18.9 years (all sources combined), resulting in a mean cumulative exposure of 306.6 hours/week-years (not shown in a table).

Intensity

The intensity of ETS exposure was inversely related to social class (though in a non-statistically significant way), with a difference of approximately 10 hours/week between women from class I and women from class IV+V (*p*-trend = 0.09) (table 3).

Among women ever exposed to ETS at home (*n* =

TABLE 1. Prevalence (%) of current environmental tobacco smoke (ETS) exposure and of current smoking among 1,883 women, by age, Geneva, Switzerland, 1993–1995

Age (years)	No.	No current ETS exposure or active smoking (<i>n</i> = 1,006)	Current exposure to ETS (<i>n</i> = 452)				Current active smoker (<i>n</i> = 425)
			Home ETS exposure only	Work ETS exposure only	Home and work ETS exposure	Leisure ETS exposure only	
35–44	491	43.4	7.9	11.0	1.2	5.5	31.0
45–54	588	48.3	8.7	10.3	1.4	7.0	24.3
55–64	448	55.4	10.5	6.9	1.8	6.7	18.7
65–74	356	73.3	6.5	0.8	0.0	6.5	12.9

TABLE 2. Lifetime prevalence (%) of environmental tobacco smoke (ETS) exposure and of active smoking among 1,883 women, by age, Geneva, Switzerland, 1993–1995

Age (years)	No.	Never exposed to ETS (n = 442)	Ever exposed to ETS (n = 619)				Ex-smoker (n = 397)	Current active smoker (n = 425)
			Home ETS exposure only	Work ETS exposure only	Home and work ETS exposure	Leisure ETS exposure only		
35–44	491	18.3	10.8	7.5	8.4	0.2	23.8	31.0
45–54	588	21.8	10.2	8.2	11.0	1.2	23.3	24.3
55–64	448	24.4	19.5	10.1	9.4	0.9	17.0	18.7
65–74	356	32.4	19.7	6.8	8.2	1.7	18.3	12.9

447), the intensity of exposure (mean = 16.1 hours/week) varied between 15.6 hours/week for women in class II and 19.5 hours/week for never employed women (p -trend = 0.29) (figure 1). In employed women who had ever been exposed ($n = 331$), the intensity of exposure at work (mean = 18.9 hours/week) increased from 5.0 hours/week in class I to 24.3 hours/week in class III (p -trend = 0.05). For women ever exposed during leisure time ($n = 166$), the intensity (mean = 2.8 hours/week) ranged between 1.9 hours/week in never employed women and 3.5 hours/week in women from classes I and IV+V (p -trend = 0.74).

Duration

Table 3 indicates that the duration of exposure to ETS was longer in lower social classes, with a difference of 10 years between women from class I and never employed women (p -trend = 0.009).

Figure 2 shows the duration of ETS exposure by socioeconomic class. The duration of exposure at home (mean = 17.5 years) ranged between 16.8 years in women from class II to 20.2 years in never employed women (p -trend = 0.67). The duration of

exposure at work (mean = 10.0 years) increased from 7.4 years for women in class I to 12.2 years for women in class IV+V (p -trend = 0.04). The duration of leisure time exposure (mean = 21.3 years) ranged from 6.2 years among women in class I to 33.1 years among never employed women (p -trend = 0.21).

Intensity × duration

Cumulative ETS exposure was greater in lower social classes: Women in class I were exposed to ETS for the equivalent of 197.4 hours/week-years, while never employed women were exposed for about 406 hours/week-years (trend $p = 0.02$) (table 3).

Mean cumulative exposure to ETS at home averaged 263.9 hours/week-years. Figure 3 shows that it increased from 246.4 hours/week-years in women from class I to 443.8 hours/week-years in never employed women (p -trend = 0.05). Cumulative exposure

TABLE 3. Environmental tobacco smoke (ETS) exposure among 619 ever exposed women, by social class, Geneva, Switzerland, 1993–1995

Social class*	No.	Intensity of exposure† (hours/week)	Duration of exposure† (years)	Cumulative exposure† (hours/week-years)
I	22	15.3	16.1	197.4
II	102	15.8	18.9	229.6
III (III-NM + III-M)	368	23.8	18.5	322.7
IV + V	95	25.3	19.7	367.5
Never employed	32	15.5	26.0	406.0
p for trend‡		0.09	0.009	0.02

* Class I: academics and professionals; class II: highly skilled workers or managers; class III: skilled workers, both nonmanual (III-NM) and manual (III-M); classes IV and V: unskilled workers.

† Geometric mean.

‡ Adjusted for age, education, and duration of employment.

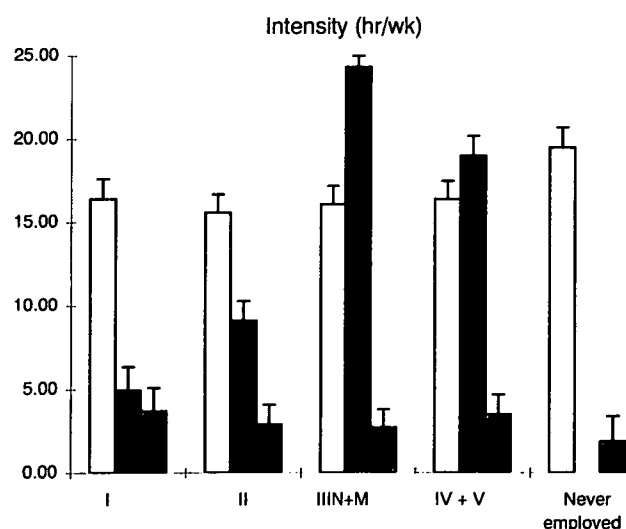


FIGURE 1. Intensity (hours/week) of environmental tobacco smoke (ETS) exposure among 619 women ever exposed to ETS, by source and by social class, Geneva, Switzerland, 1993–1995. Sources of ETS exposure: □, home ($n = 447$); ■, work ($n = 331$); ▤, leisure ($n = 166$). Social classes: class I, academics and professionals; class II, highly skilled workers or managers; class III, skilled workers, both nonmanual (III-NM) and manual (III-M); classes IV and V, unskilled workers. T-shaped bars, standard error of the mean.

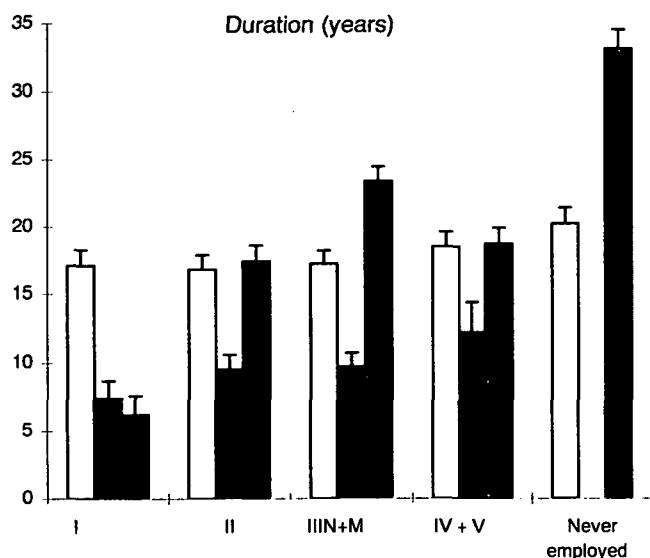


FIGURE 2. Duration (years) of environmental tobacco smoke (ETS) exposure among 619 women ever exposed to ETS, by source and by social class, Geneva, Switzerland, 1993–1995. Sources of ETS exposure: □, home ($n = 447$); ■, work ($n = 331$); ▨, leisure ($n = 166$). Social classes: class I, academics and professionals; class II, highly skilled workers or managers; class III, skilled workers, both nonmanual (III-NM) and manual (III-M); classes IV and V, unskilled workers. T-shaped bars, standard error of the mean.

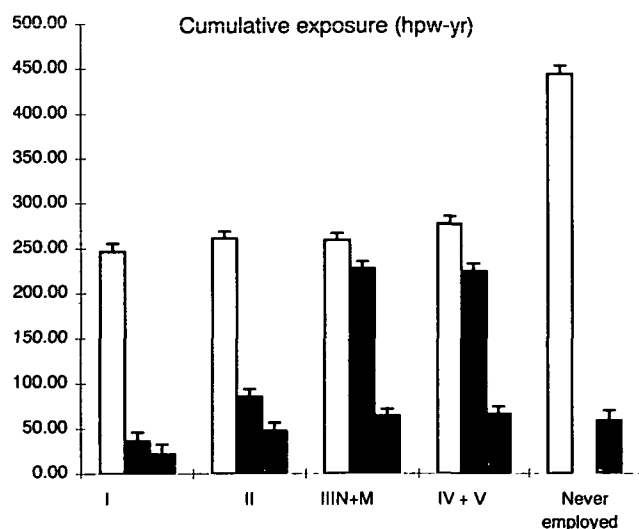


FIGURE 3. Cumulative exposure (hours/week-years) to environmental tobacco smoke (ETS) among 619 women ever exposed to ETS, by source and by social class, Geneva, Switzerland, 1993–1995. Sources of ETS exposure: □, home ($n = 447$); ■, work ($n = 331$); ▨, leisure ($n = 166$). Social classes: class I, academics and professionals; class II, highly skilled workers or managers; class III, skilled workers, both nonmanual (III-NM) and manual (III-M); classes IV and V, unskilled workers. T-shaped bars, standard error of the mean.

at work (mean = 184.1 hours/week-years) was higher in lower social classes (p -trend = 0.03). Cumulative workplace exposure in women from class I (36.4 hours/week-years) and class II (85.4 hours/week-

years) represented, respectively, 15 percent and 33 percent of their cumulative exposure at home. For women in classes III and IV+V, cumulative exposure at work was 227.5 and 226.8 hours/week-years, respectively, which was similar to their cumulative exposure at home. Cumulative exposure during leisure time (mean = 59.5 hours/week-years) varied between 21.7 hours/week-years for women in class I and 65.8 hours/week-years for women in class IV+V (p -trend = 0.28).

Women from classes I and II were, on average, younger (52 years) than women from the other social classes (class III, class IV+V, and unemployed women were aged 54, 55, and 59 years, respectively), but all analyses were age-adjusted.

Among 340 women reinterviewed in 1996 (i.e., 3–4 years after the first interview), the overall percentage of agreement was 77 percent for any exposure to ETS, 82 percent for exposure at home, 78 percent for exposure at work, and 61 percent for exposure during leisure time. The agreement was similar across social classes. The mean lifetime exposure to ETS among women who consistently reported in both interviews that they had ever been exposed was 429.8 hours/week-years for all sources combined, 273.7 hours/week-years for home exposure, 243.6 hours/week-years for work exposure, and 71.4 hours/week-years for leisure time exposure. The corresponding exposures of the women who reported having been exposed to ETS on the first questionnaire but not on the second were significantly lower for all sources: 58.1 hours/week-years for all sites (consistent group vs. inconsistent group: $p = 0.0001$), 174.3 hours/week-years for home exposure ($p = 0.002$), 60.2 hours/week-years for work exposure ($p = 0.0001$), and 77 hours/week-years for leisure time exposure ($p = 0.78$). The lower reported exposure of the inconsistent subjects was similar for the 170 breast cancer cases and the 170 controls.

DISCUSSION

Sources and patterns of exposure

Among female nonsmokers in Geneva, 31 percent reported currently being exposed to ETS for at least 1 hour per day. The home and the workplace were the most frequent sources of exposure. Similar findings were observed in the US Third National Health and Nutrition Examination Survey, where 33 percent of women surveyed reported living with a smoker or working in a smoky environment (1). The prevalence by source across age groups was also similar to US data (1), except perhaps for simultaneous exposure at home and at work, which was less prevalent in Geneva

(1–2 percent) than in the US survey (2.5–4.7 percent).

Nearly 60 percent of female never smokers had been exposed to ETS for at least 1 hour daily during at least 1 year over their lifetime. Among never smokers, 42 percent had ever been exposed at home and approximately 40 percent of the employed women had ever been exposed at work.

On average, cumulative lifetime exposure to ETS was 308 hours/week-years. For a constant exposure, this figure can be interpreted as an average exposure of 20.5 hours/week over a period of 15 years. However, it is likely that for many women, periods of more intense exposure alternate with periods of lower exposure.

Patterns of exposure differed between the workplace and the home. On average, exposure at work was intense (19 hours/week) but of relatively short duration (10 years). This high intensity of exposure at the workplace has been consistently observed (4, 17). The short average duration of workplace exposure can be explained by changes in job activity or coworkers (18) and by job interruptions occurring for familial reasons. In contrast, home exposure was less intense (16 hours/week) but lasted longer (18 years). Living with a smoker during adulthood was the main reason for this longer duration (2, 5).

As a result, the home was the most important source of cumulative exposure to ETS, accounting for approximately 266 hours/week-years. Cumulative exposure at work represented approximately 182 hours/week-years. Exposure incurred during leisure time was the least important, affecting only 16 percent of women. This is much less than the reported 50 percent of pregnant US women who reported being exposed to ETS for at least 1 hour in recreational settings during the week preceding the interview (19). The reason for this discrepancy may be that most women are occasionally exposed to ETS during their leisure time but few are regularly exposed for 1 hour per day during 1 year or more. These women therefore did not satisfy the criterion for ETS exposure in the present survey.

ETS has been associated with increased risks of several different types of cancers: lung cancer (20–29), sinonasal cancer (21), and brain cancer (30, 31). More controversial associations include reported relations with breast cancer (13, 32) and cervical cancer (33). Subjects exposed to ETS also appear to suffer more frequently from cardiovascular diseases (34–40) and from functional lung disorders (41–45).

Although the excess relative risk of lung cancer due to ETS exposure remains low—approximately 20 percent (relative risk = 1.19–1.24) (46, 47)—the present study shows that a large proportion of the general population has experienced intense and long-lasting

ETS exposure. Previous studies have shown increased risk of lung cancer for women exposed to ETS at home (20–22, 24–29). In contrast, ETS exposure at work was less consistently associated with lung cancer (23, 28). Occupational exposure to ETS is difficult to measure (47) and has been less frequently studied than home exposure. We found that the workplace, especially in lower social classes, was associated with a high level of ETS exposure, of short duration but high intensity. If high intensity exposure to ETS over a period of several years is equivalent to lower intensity ETS exposure for longer periods (48), our results are consistent with a carcinogenic role of ETS exposure incurred at work.

Social class effect

Average duration of ETS exposure and cumulative ETS exposure were inversely associated with social class. Most of the social class differences could be explained by exposure at the workplace. Between class I and class IV+V, the intensity of ETS exposure at work increased by a factor of nearly 4. Exposed women with unskilled jobs spent half of the average workday in a smoky environment. The duration of workplace exposure increased by 65 percent between class I and class IV+V. Social class differences were even stronger for cumulative exposure. The observed differences could not be explained by the fact that women from classes I and II were younger, on average, than women from the other classes, since estimated duration and cumulative exposure were adjusted for age (16, 49).

These results are consistent with the poor environments in which low-skilled occupational activities are performed—environments characterized by a high prevalence of smokers and by poor ergonomic conditions pertaining to room size, ventilation, and smoking-restricted areas (50, 51).

In the present study, social class was not related to lifetime level of ETS exposure at home. Current ETS exposure in the home was 8.7 percent among women from class I but was as high as 13.8 percent among women from class IV+V. These social differences in the prevalence of passive smoking may change in the future, because the prevalence of male smokers has decreased faster in higher educational subgroups than in lower ones (52, 53).

Limitations and strengths

The present survey had several limitations. There is no biologic marker with which to assess past ETS exposure. The validity of questionnaire responses on current ETS exposure status is generally good (2), but

it declines when the information requested is detailed and quantitative (23, 54–57). In this study, the percentage of agreement between two interviews performed 3 years apart was 82 percent for home exposure and 78 percent for workplace exposure. The subjects with inconsistent responses reported much lower cumulative exposures, on average, than did subjects with consistent responses, which suggests that lower exposure levels are more affected by unreliable responses. Since the agreement was consistent across social classes, the social gradient of exposure was not caused by reliability bias. The reliability of information on leisure time ETS exposure was low; however, leisure activity was a minor source of exposure, and the poor reliability of data on this source must have affected our results only marginally. These levels of reliability are consistent with those reported by other investigators (56, 57). One year after the first interview, Brownson et al. (57) found 80 percent agreement for home exposure. After 6 months, Pron et al. (56) reported agreement of 73 percent and 88 percent for workplace and home exposure, respectively.

This study also had several strengths. Rigorous criteria were applied in order to obtain a representative sample and to determine ETS exposure. The definition of ETS exposure was restrictive: at least 1 hour per day during at least 1 year. Trained interviewers collected data on the number of weekly hours of exposure through the use of detailed calendars evaluating each year of exposure. These elements were likely to have improved recall of exposure history. The study was carried out in a representative sample with a clear definition of the target population which guaranteed the external validity of the study. Particularly, we observed that the distribution of smoking status among participants was very similar to that among nonparticipants (52). Finally, overreporting of ETS exposure was likely to have been limited by the lack of societal pressure against smokers in Switzerland and the lack of concern among the Swiss public about the risk associated with ETS (41, 58).

Conclusion

This study presents the current situation in Switzerland, where ETS exposure is still very prevalent, but it probably also reflects the situation that existed in the United States several years ago before the recent progress in controlling ETS exposure in public places.

The intensity and duration of ETS exposure in this study was much higher than previously suspected. These findings bring biologic plausibility to the hypothesis that part of the recent rise in the incidence of tobacco-related diseases is due to ETS exposure incurred one or two decades ago (24).

At the workplace, average lifetime exposure to ETS is intense but lasts for few years. In the home, exposure is less intense but lasts longer. Persons in lower social classes are more exposed than those in higher ones, mainly because of exposure at work. Policies limiting ETS exposure at the workplace can substantially reduce the public's level of ETS exposure (4, 17). Since exposure incurred at work appears to be the major factor explaining the variability of ETS exposure in the female population, reduction of ETS exposure in the workplace should be a priority in terms of public health.

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