Do the Nonsmoking Daughters of Smokers Tend to Marry Smokers? Implications for Epidemiological Research on Environmental Tobacco Smoke: The IARC Collaborative Study[1]

Elio Riboli,[2] Nancy J. Haley,[3] Jean Trédaniel, Rodolfo Saracci, Susan Preston-Martin, Dimitrios Trichopoulos, Heiko Becher, J. David Burch, Elizabeth T. H. Fontham, Yu-Tang Gao, Surinder K. Jindal, Linda C. Koo, Loïc Le Marchand, Nereo Segnan, Hiroyuki Shimizu, Giorgio Stanta, Anna H. Wu-Williams, and Witold Zatonski

International Agency for Research on Cancer, 150 cours Albert-Thomas, 69372 Lyon Cedex 8 [E. R., R. S.] and Hôpital Saint Louis, 1 avenue Claude Vellefaux, 75475 Paris Cedex 10 [J. T.], France; American Health Foundation, Valhalla, New York 10595, [J.H.]; Department of Preventive Medicine, University of Southern California, School of Medicine, Los Angeles, California 90033 [S. P-M., A. H. W-W.]; Harvard School of Public Health, Boston, Massachusetts 02115 [D. T.]; Division of Epidemiology, German Cancer Research Centre, Im Neuenheimer Feld 280, 6900 Heidelberg 1, Germany [H. B.]; National Cancer Institute of Canada Epidemiology Unit, Toronto, Ontario M58 1A8, Canada [J. D. B.]; Department of Pathology, Louisiana State University Medical Center, New Orleans, Louisiana 70112-1393 [E. T. H. F.]; Shanghai Cancer Institute, 2200 Xie Tu Road, Shanghai, 200032, People's Republic of China [Y-T.G.]; Department of Chest Diseases, Postgraduate Institute of Medical Education and Research, Chandigarh 160012, India [S. K. J.]; Department of Community Medicine, University of Hong Kong, Li Shu Fan Building, 5 Sassoon Road, Hong Kong [L. C. K.]; Cancer Center of Hawaii, University of Hawaii, Honolulu, Hawaii 96813 [L. L. M.]; Unit of Cancer Epidemiology, Department of Oncology, San Giovanni Hospital A. S., 10123, Turin [N. S.], and Istituto di Anatomia, Università di Trieste, Ospedale Maggiore, 34125 Trieste [G. S.], Italy; Gifu University, School of Medicine, Department of Public Health, 40 Tsukasa-machi, Gifu, GIFU500, Japan [H. S.]; and Unit of Epidemiology, Institute of Oncology, Wawelska Street 15, 00973 Warsaw, Poland [W. Z.]

Abstract

The IARC collaborative study on exposure to environmental tobacco smoke (ETS) involved collecting interview data and biochemical indicators of exposure from 1369 nonsmoking women in 13 centers in 10 countries. Information on childhood and adulthood exposure to other people's smoke and duration of this exposure from both parents and spouse was gathered at the interview. Of the 900 women whose husbands smoked (current or exsmokers), 71.3% had one or both parents who smoked (predominantly the father), whereas among the 277 women married to never-smokers, only 60.3% had at least one parent who smoked. The odds ratio for the daughter of a smoker to marry a smoker was, therefore, 1.64 (95% confidence interval = 1.24–2.17; $P > 0.001$), and there was an exposure-response relation between the number of years of childhood exposure to ETS from the parents and the likelihood of being married to a smoker. These results show that nonsmoking women married to smokers are more likely to have been exposed to tobacco smoke pollution during their whole life. Because the duration of exposure is known to be important in the genesis of lung cancer, some of the excess risk of lung cancer in nonsmoking women married to smokers may be due to exposure to ETS from parents during childhood.

Introduction

During the 1980s, research into tobacco-related diseases gained new momentum as investigations into the long-term health effects of involuntary exposure to ETS[4] emerged. The initial studies suggested an association between ETS and pulmonary cancers (1–5), with more recent research implicating ETS exposure with a variety of disease states, including cardiovascular disease (6, 7) and adult nonneoplastic respiratory diseases (8). There is also cumulative evidence that ETS is harmful for children (4, 9).

Many case-control and cohort studies have examined the relationship between spousal smoking behavior and lung cancer development. However, of concern in all studies on lung cancer in nonsmoking persons is the possible misclassification of an active or exsmoker as a never-smoker. Inclusion of such subjects could lead to inflated incidence rates of lung cancer in self-reported nonsmokers.

The IARC collaborative study on ETS exposure in nonsmoking women collected questionnaire data and biochemical indicators of exposure on 1369 women at 13 centers in 10 countries. According to the study design, approximately 50% of the women were married to smokers and 50% were employed outside the home. A primary objective of the study was to examine sources of ETS exposure in these women and correlate them with urinary excretion of cotinine, a major metabolite of nicotine (10). A secondary aim was to evaluate possible misclassification of subjects as nonsmokers when they might be active users of tobacco products (11).

On the basis of considerations of the potential relevance of ETS exposure early in life and concerns about possible confounding in the estimation of cancer risk due to concordance of smoking patterns between the husband and the parents of nonsmoking women, we examined the relationship between smoking status of the husbands of the women in this 10-country study and the smoking status of the parents during the childhood years when these women lived with their parents.

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[2] To whom requests for reprints should be addressed.
[3] Present address: Met Life Laboratory, Metropolitan Life Insurance Company, 4 Westchester Plaza, Elmsford, NY 10523.

[4] The abbreviations used are: ETS, environmental tobacco smoke; OR, odds ratio; CI, confidence interval.

Table 1 Distribution of 918 study subjects married to a current smoker or exsmoker, according to cumulative number of years of exposure to ETS from their husbands

Smoking status of husband	Yrs of exposure to ETS from husband				Total
	0	1–10	11–20	>20	
Current smoker					
No.	6	78	152	329	565
%	(1.1%)	(13.8%)	(26.9%)	(58.2%)	
Exsmoker					
No.	286	19	17	31	353
%	(81.0%)	(5.4%)	(4.8%)	(8.8%)	
Total no.	292	97	169	360	918

Subjects and Methods

Thirteen centers located in Ontario, Canada (Toronto), People's Republic of China (Shanghai), Greece (Athens), Germany (Bremen), Hong Kong, India (Chandigarh), Italy (Turin and Trieste), Japan (Sendai), Poland (Warsaw), and in the United States (Los Angeles, CA; New Orleans, LA; and Honolulu, HI) took part in the study and provided a minimum of 100 participants each. If feasible, 50% of the women were to be currently married to a smoker and 50% married to a nonsmoker; within each of these categories, 50% were to be women currently employed outside the home.

To be eligible for interview, women had to report abstinence from any tobacco product for at least 2 years. Each subject was interviewed according to a standardized questionnaire translated into seven languages. The details of the questionnaire interview procedures have already been reported (10). A spot urine sample was also taken at the time of interview. This sample was collected and shipped as described and analyzed for cotinine and creatinine at the Clinical Biochemistry Laboratory of the American Health Foundation (Valhalla, NY; Ref. 12). The methods and procedures used for the analyses have also been reported previously, as well as the distributions of the cotinine:creatinine ratios and their correlations with recent exposure to ETS as derived from the questionnaire interview (10). For the purposes of the present paper, information has been extracted from the questionnaire interview on the number of years the women spent with a smoking husband and the duration of childhood exposure to the smoking habits of both parents.

Statistical Analysis. Data on smoking habits of father, mother, and current husband (or person living in a marital-type relation) were used as categorical variables for cross-tabulations. Years of exposure to ETS from parents were computed by subtracting from the date the subject left the parental home, the year the father or the mother started smoking (whichever first) or the subject's date of birth if the parent(s) already smoked before her birth. The cumulative years of exposure to ETS from parents were then categorized in four levels (0, 1–10, 11–20, and 20+ years) for cross-tabulations. Because subjects with missing values for given variables were excluded from the analysis of that particular variable, the total number of subjects varies slightly between Tables 1 and 3.

ORs and 95% CIs were calculated to estimate the likelihood for women whose parent(s) smoked to marry a smoker rather than a nonsmoker.

Results

The combined study from 13 centers in 10 countries included 1369 women who provided questionnaire data and urine samples. Detailed questions about recent exposure to ETS were emphasized in the interview to correlate them with the levels of biomarkers of recent exposure analyzed in urine (10). Forty-seven subjects were considered separately because of their relatively high urinary levels (50 ng cotinine/mg creatinine), which are compatible with their being active smokers (11). They are not included in this report.

Of the 1200 subjects, married or living in marital status, for whom data on their husbands' smoking habits were available, 47% lived with a current smoker, whereas 29.4% reported that their husband was an exsmoker. As shown in Table 1 (restricted to 918 subjects married to a current or exsmoker), the majority of women married to (or living with) current smokers had been exposed to their husbands' smoke for >20 years, whereas 81% of those married to exsmokers reported no exposure during their life together. Only 23.7% were married to never-smokers. This was fairly consistent across centers.

Additional analyses in Table 2 were restricted to 1177 subjects for whom data on smoking status of both husband and parents were available. When asked about exposure during childhood, 31.3% of women reported that neither of their parents had smoked (Table 2). If only one parent had smoked it was usually the father rather than the mother (53.2 *versus* 3.6%). In 12% of households, both parents had smoked during the years the women had lived in their parents' homes.

Table 2 further examines the smoking status of the women's parents according to the smoking status of their husbands. When the husband was a smoker, 71.3% of women had at least one parent who smoked. In contrast, if the husband was not a smoker, only 60.3% of women had at least one parent who smoked. This gives an OR of 1.64 (95% CI = 1.24–2.17; $P > 0.001$) for daughters of smokers to be more likely to marry smokers than daughters of nonsmokers.

Because our study included women from a wide range of ethnic and cultural backgrounds, we considered it important to determine whether this OR varied by broad cultural regions. Centers were divided into three regions, namely Europe (Bremen, Germany; Athens, Greece; Trieste and Turin, Italy; and Warsaw, Poland), Asia (Sendai, Japan; Shanghai, People's Republic of China; Hong Kong; and Chandigarh, India) and the North American (New Orleans, LA; Los Angeles, CA; Honolulu, HI; and Toronto, Ontario, Canada). The tendency for women to marry a smoker if either or both of their parents were smokers was more evident for the European and Asian centers than for those in North America. Elevated ORs of 1.80 (95% CI = 1.10–2.94) and 1.73 (95% CI = 1.12–2.66) were found for Europe and Asia, respectively, whereas no increase (OR = 1.08; 95% CI = 0.60–1.94) was noted for North America. These ORs were, however, not statistically different, and the test for heterogeneity indicated that three region-specific ORs were compatible with the pooled OR adjusted over the three regions (OR = 1.56; 95% CI = 1.17–2.07).

To determine whether duration of childhood exposure played a role in determining the husbands' smoking status, the number of years women reported living with one or both smoking parents was analyzed by the smoking status of the husband. This analysis was restricted to 1128 subjects for whom data on duration of exposure to ETS from parents were available. Table 3 shows that the majority of women with parents who smoked were exposed for >10 years to ETS from their parents, and that there is an exposure-response relationship between the number of years of childhood exposure and the likelihood of being married to a smoker (test for trend, $P = 0.001$).

Table 2 Distribution of study subjects according to smoking status of husband and parents, and ORs for a woman of being married to a smoker if both or either of her parents smoked. OR was adjusted for age.

Smoking status of husband	Smoking status of parents					Total
	Both	Father only	Mother only	Both or either[a]	Neither[a]	
Ever-smoker						
No.	107	500	35	642	258	900
%	(11.9%)	(55.7%)	(4.0%)	(71.3%)	(28.7%)	(100%)
Never-smoker						
No.	34	126	7	167	110	277
%	(12.3%)	(45.5%)	(2.5%)	(60.3%)	(39.7%)	(100%)
Total						
No.	141	626	42	809	368	1177
%	(12.0%)	(53.2%)	(3.6%)	(68.7%)	(31.3%)	(100%)

[a] Both or either *versus* neither: OR: 1.64 (95% CI = 1.24–2.17); χ^2 = 12.03; P = 0.001.

Table 3 ORs for a woman of being married to a smoker relative to a nonsmoker, depending on the years of exposure to ETS from her parents

Smoking status of husband		Yrs of exposure to ETS from parents				Total
		0	1–10	11–20	>20	
Ever-smoker (current or exsmoker)	No.	258	75	286	239	858
	%	(30.1%)	(8.7%)	(33.3%)	(27.9%)	(100%)
Never-smoker	No.	110	22	79	59	270
	%	(40.7%)	(8.1%)	(29.3%)	(21.9%)	(100%)
Total No.		368	97	365	298	1128
OR		1.0	1.45	1.54	1.73	

[a] χ^2 for trend = 10.266; P = 0.001.

Discussion

The results of this international study suggest that nonsmoking women are more likely to be married to smokers if one or both of their parents smoked during their childhood years. Nonsmoking women married to smokers are, therefore, more likely to have been exposed to tobacco smoke pollution not only during adulthood but also during childhood. There is evidence that ETS is harmful for children. It is associated, in particular, with lower respiratory tract infections, fluid in the middle ear, symptoms of upper respiratory tract irritation, some reduction in lung function, increased frequency and severity of symptoms in asthmatic children, and occurrence of asthma in children who have not displayed symptoms previously (4). The potential carcinogenic effect of ETS in children has not yet been clarified.

Four studies have investigated the risk of lung cancer in relation to ETS exposure in childhood. Correa *et al.* (13) found elevated risk for individuals whose mothers smoked, even after adjustment for active smoking. However, in much smaller studies, neither Wu *et al.* (14), Koo *et al.* (15), nor Pershagen *et al.* (16) observed any higher lung cancer risk associated with ETS exposure from parents. Finally, Janerich *et al.* (17) found that household exposure to 25 or more smoker-years (determined by multiplying the number of years in each residence by the number of smokers in the household) during childhood and adolescence doubled the risk of lung cancer, whereas exposure to a spouse's smoking was associated with no increase in risk.

Findings from biochemical studies show that children whose parents smoke are exposed to the components and potential carcinogens of cigarette smoke during both gestation and childhood (18). Studies in animals suggest that some effects of exposure in early life may not be apparent until adult life (19). Therefore, it seems biologically plausible that individuals exposed to tobacco smoke during childhood may be at an increased risk of developing cancer, and that the effects of exposures early in life, occurring during a period of rapid cell proliferation and differentiation, *i.e.*, a time of potentially increased vulnerability, may be greater than the effects of similar levels of exposure later in life (20, 21). The etiological role of the duration of smoke exposure on lung cancer risk has been re-emphasized recently (22).

Our results, based on very detailed ascertainment of ETS exposure, indicate that there is an association between spousal and parental smoking; thus, they suggest that exposure to ETS from parents may explain a fraction of the increased risk for lung cancer observed among nonsmoking women married to smokers.

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