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THE RELIABILITY OF PASSIVE SMOKING HISTORIES REPORTED IN A CASE-CONTROL STUDY OF LUNG CANCER[1]

GAYLENE E. PRON, J. DAVID BURCH, GEOFFREY R. HOWE, AND ANTHONY B. MILLER

Pron, G. E., J. D. Burch (NCIC Epidemiology Unit, U. of Toronto, Toronto, Ontario, Canada M5S 1A8), G. R. Howe, and A. B. Miller. The reliability of passive smoking histories reported in a case-control study of lung cancer. *Am J Epidemiol* 1988;127:267–73.

A test-retest design has been used to examine the reliability of passive smoking histories reported in personal interviews. A total of 117 control subjects initially interviewed in a lung cancer case-control study conducted in metropolitan Toronto, Canada, between 1983 and 1984 were reinterviewed on average six months later. Responses to initial screening questions used to detect a person's exposure to passive smoke were more reliable for residential than for occupational exposure. Respondents also more reliably reported residential exposure to spouse's passive smoke than to the passive smoke of others at home. Quantitative measures of exposure to passive smoke, i.e., number and duration of exposure, were even less reliably reported. Nonsmoking respondents gave the most reliable information. The low reliability of self-reported duration of exposure to passive smoke is consistent with the inability of several studies to detect a significant dose-response relation with lung cancer risk when measures of dose that depend solely on duration are used.

lung neoplasms; occupations; questionnaires; retrospective studies; tobacco smoke pollution

A number of toxic substances, including carcinogens, have been identified in both secondhand (exhaled smoke) and sidestream smoke (smoke emitted from a burning cigarette between active puffs) (1, 2). In particular, sidestream smoke has been shown to contain greater concentrations of some toxic chemicals, e.g., dimethylnitrosamine, naphthalene, benzo(*a*)pyrene, and toluene, than mainstream smoke (smoke actively inhaled) (3). These observations have raised concerns that exposure to passive smoke could be a major contributor to lung cancer among nonsmokers. A number of epidemiologic studies have been conducted with mixed results. A cohort study in Japan (4) and three case-control studies, one in Greece (5) and two in the United States (6, 7), found a significant increased risk of lung cancer among female nonsmokers married to smokers. A recent case-control study (8), also carried out in the United States, suggested that both female smokers and nonsmokers married to active smokers were at increased risk for cancer (all sites combined), although the numbers were insufficient to examine individual cancer sites. The American Cancer Society

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[1] NCIC Epidemiology Unit, McMurrich Building, University of Toronto, Toronto, Ontario, Canada M5S 1A8. (Reprint requests to Prof. J. D. Burch.)

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cohort study (9) and a case-control study in California (10) found a nonsignificant relative risk of about 1.2; in another case-control study (11), no difference between cases and controls was found. An analysis that incorporated data on lung cancer risk with passive smoking from 13 different epidemiologic studies estimated a summary relative risk of 1.4 (95 per cent confidence interval 1.19–1.54) (12).

There are a number of possible reasons for these inconsistent results. The use of smoking by a spouse as the only index of passive smoke exposure could lead to a substantial misclassification bias if subjects are exposed at work or at home from household members other than their spouses. The use of hospital controls in case-control studies can be a major source of bias for studies of active smoking, and if passive smoke exposure is associated with diseases that lead to hospitalization, studies of passive smoking would also be biased. Finally, there is the possibility that subjects may provide unreliable information on their passive smoke exposure, since this is obviously a more difficult exposure to measure than that of active smoking.

We have attempted to overcome and assess these difficulties in a case-control study of lung cancer and passive smoking. Lifetime residential and occupational passive smoking histories were requested, population-based controls were used, and a special study was conducted to estimate the reliability of passive smoking histories by means of repeat interviews among a subset of control subjects. This paper reports the results of the reliability study and considers the implications of the results for studies of passive smoking.

Materials and Methods

A test-retest design was employed to examine the reliability of information reported on passive smoking in personal interviews. Respondents in this reliability study were chosen from among controls in a case-control study of lung cancer and passive smoking conducted in metropolitan Toronto. Eligible cases for the lung cancer study consisted of all females newly diagnosed with primary lung cancer in the study area between April 1981 and March 1985. A total of 410 female cases were interviewed together with an equal number of age-matched male subjects randomly selected from lung cancer cases occurring in the same area during the same time period. A total of 780 age- and sex-matched controls, randomly selected from municipal population lists for the same geographic area, were also interviewed. All controls interviewed in 1983 and 1984 were approached six months after their initial interview and were asked if they would agree to be reinterviewed. Of the 147 controls approached for reinterview, 117 (80 per cent) were reinterviewed, 6 (4 per cent) had moved outside the area, and 24 (16 per cent) refused. The study sample consisted of 54 males and 63 females with ages ranging between 33 and 78 years. Among male subjects, 11 (20 per cent) reported on the first interview that they were lifetime nonsmokers, 27 (50 per cent) that they were ex-smokers, and 16 (30 per cent) that they were current smokers. Among female subjects, the numbers were 42 (67 per cent), 13 (21 per cent), and 8 (13 per cent), respectively.

Four specially trained female interviewers conducted the interviews in the homes of the respondents. For each subject, the initial interview and the reinterview were conducted by a different interviewer. This procedure eliminated the possibility that an interviewer could simply record information that she remembered from a previous interview. It was also hoped that the use of different interviewers would ensure that the motivation and participation of the subjects in a reinterview procedure would remain similar.

An identical questionnaire was used on both the initial interview and the reinterview. After active smoking data had been obtained, exposure to passive smoking was ascertained by a series of questions relating to residential and occupational sources of exposure. Residential exposure was deter-

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mined by asking an initial screening question, "Have you ever lived in the same household as a regular smoker?" Those who responded positively were asked to identify all such regular smokers and to give the first and last year in which they lived in the same household as the subject. Occupational exposure was also assessed by an initial screening question, "Have you ever worked in a place where you were more or less continually exposed to the tobacco smoke of other people?" Subjects responding positively were then asked to identify each such place of work, the first and last year they worked there, and the number of persons who regularly smoked around them.

The reliability of continuous measures of passive smoke exposure was assessed by the product-moment correlation coefficient. For categorical variables, the kappa statistic, a measure of agreement which is corrected for chance, was used, and for ordered polytomous categorical variables, a weighted kappa statistic (13) was computed. *P* values quoted were two-sided.

Results

The distribution of responses to the question of whether the respondent had ever lived in a house with a regular smoker is shown in table 1 by sex and active smoking status of the respondents themselves and by combinations of sex and smoking status. The agreement generally was good, with all subgroups having similar values of kappa. The corresponding results for exposure to occupational passive smoke are shown in table 2. The prevalence of exposure to passive smoke at work was lower than that of exposure to residential passive smoke, and the kappa values were also lower. The difference between kappas for residential (kappa = 0.66) and occupational (kappa = 0.46) exposure to passive smoke reported by all respondents was not significant ($p = 0.09$). There appeared to be more variation in kappa values among subgroups for exposure at work than at home, although most differences for the former groups were not statistically significant. Although the kappa value for occupational exposure reports was significantly different ($p = 0.04$) for male smokers and nonsmokers, the kappa value for reports by male nonsmokers was based on only nine individuals. The highest kappa value for occupational exposure reports was for female nonsmokers, and the highest kappa value for residential exposure reports was for male nonsmokers.

Passive smoking exposures, classified by the number of residential smokers and number of job sites reported, are shown in

Table 1

Reliability of response to question on exposure to residential passive smoke, by sex and smoking status of control respondents, lung cancer case-control study, Toronto, Canada, 1983–1984

Sex and smoking status*	First interview–second interview responses					Kappa	Standard error
	Yes/yes (*n*)	Yes/no (*n*)	No/yes (*n*)	No/no (*n*)	Total		
Both sexes	84	10	4	19	117	0.66	0.084
Females							
All	46	4	4	9	63	0.61	0.124
Never smokers	28	3	2	7	40	0.66	0.141
Ever smokers	18	1	2	2	23	0.50	0.250
Males							
All	38	6	0	10	54	0.70	0.110
Never smokers	6	1	0	2	9	0.73	0.247
Ever smokers	32	5	0	8	45	0.69	0.123

* Subjects in this and subsequent tables were classified as never smokers if they had reported never smoking tobacco products on both interviews and ever smokers if they had reported smoking tobacco products on either or both interviews.

TABLE 2

Reliability of response to question on exposure to occupational passive smoke, by sex and smoking status of control respondents, lung cancer case-control study, Toronto, Canada, 1983–1984

Sex and smoking status	First interview/second interview responses*					Kappa	Standard error
	Yes/yes (n)	Yes/no (n)	No/yes (n)	No/no (n)	Total		
Both sexes	39	15	16	45	115	0.46	0.083
Females							
All	18	8	6	30	62	0.53	0.109
Never smokers	12	5	2	20	39	0.63	0.126
Ever smokers	6	3	4	10	23	0.37	0.195
Males							
All	21	7	10	15	53	0.35	0.128
Never smokers	3	1	4	1	9	−0.05	0.262
Ever smokers	18	6	6	14	44	0.45	0.135

* The responses of one male (smoker) subject who had reported that he did not know if he had been exposed to occupational passive smoke and of one female (never smoker) subject who had never worked were omitted from this table.

table 3. Kappa values estimated from subgroups of the respondents are summarized in table 4 for these variables. Again, kappa values for occupational exposure were generally lower than those for residential exposure. There appears to be more variability among subgroups from this analysis as compared with tables 1 and 2, reflecting the finer subdivision of the data. In particular, for occupational exposure, there was a statistically significant difference for kappa for female smokers and nonsmokers ($p < 0.01$). Results for residential exposures classified by the relationship of the smoker to the respondent are shown in table 5. The reliability of reported exposure to spouse's smoke was high for both sexes. Exposure to maternal smoke was more reliably reported than exposures to smoke of the father, siblings, children, and other relatives. A similar pattern was observed when respondents were analyzed by sex and smoking status (not shown).

In an attempt to further quantify exposure, duration was calculated for residential exposure (table 6). It should be noted that for some relationships, not all reports were necessarily independent, i.e., one person could report more than one other relative, although this lack of independence should not materially bias the estimate of the correlation coefficient. The kappa value

TABLE 3

Distribution of reports on the number of resident smokers and job sites from passive smoking histories by control subjects, lung cancer case-control study, Toronto, Canada, 1983–1984*

No. of resident smokers

Second interview	First interview				
	0	1	2	3+	Total
0	19	7	1	2	29
1	2	15	13	10	45
2	1	5	5	6	17
3+	1	4	3	15	26
Total	23	31	27	36	117

Weighted kappa = 0.55
Standard error = 0.071

No. of job sites

Second interview	First interview				
	0	1	2	3+	Total
0	45	10	4	2	61
1	9	16	6	1	32
2	4	7	1	1	13
3+	3	3	0	4	10
Total	61	36	11	8	116

Weighted kappa = 0.37
Standard error = 0.101

* Resident smoker is any person the respondent reported living with who was a regular smoker.

(kappa = 0.52, standard error = 0.088) for the reports of duration of passive smoking was similar to the Pearson correlation coefficient ($r = 0.45$, 95 per cent confidence interval 0.29–0.58). Correlation coefficients for the reported durations of exposure to passive smoke were generally similar for the various resident smokers. The correla-

TABLE 4

Reliability of reports on the number of resident smokers and job sites, by sex and smoking status of control respondents, lung cancer case-control study, Toronto, Canada, 1983–1984

Sex and smoking status	No. of resident smokers reported		No. of job sites reported	
	Weighted kappa	Standard error	Weighted kappa	Standard error
Both sexes	0.55	0.071	0.37	0.101
Females				
All	0.52	0.093	0.54	0.126
Never smokers	0.60	0.094	0.76	0.095
Ever smokers	0.37	0.222	0.18	0.183
Males				
All	0.57	0.101	0.21	0.153
Never smokers	0.81	0.147	−0.08	0.296
Ever smokers	0.52	0.116	0.26	0.169

TABLE 5

Reliability of the types of reported resident smokers, by their relationship to the control respondents, lung cancer case-control study, Toronto, Canada, 1983–1984*

Relationship	First interview/second interview responses				Total	Kappa	Standard error
	Yes/yes (n)	Yes/no (n)	No/yes (n)	No/no (n)			
Wife	22	1	2	28	53	0.89	0.064
Husband	37	1	2	21	61	0.89	0.059
Children	8	17	10	82	117	0.24	0.106
Mother	9	4	1	103	117	0.76	0.103
Father	33	27	6	51	117	0.44	0.077
Sibling	9	6	5	97	117	0.57	0.117
Other (relatives)†	2	7	7	101	117	0.16	0.137
Other (nonrelatives)‡	1	13	6	97	117	0.02	0.093

* The responses for exposure to the tobacco smoke of spouses were restricted to ever married subjects—61 of 63 females and 53 of 54 males.

† Other (relatives) includes grandfather, stepfather, father-in-law, son-in-law, brother-in-law, mother-in-law, uncle, and aunt.

‡ Other (nonrelatives) includes boarder, friend, residence roommate, persons in armed forces, rooming house residents, and landlady.

TABLE 6

Reliability of the duration of exposure to residential passive smoke reported for different resident smokers by control subjects, lung cancer case-control study, Toronto, Canada, 1983–1984

Type of resident smoker	Interviews		No. of paired reports	Correlation coefficient	95% confidence interval
	First	Second			
All	24*	21	115	0.45	0.29–0.58
Spouse	27	22	58	0.25	−0.01–0.48
Wife	26	21	22	0.37	−0.06–0.68
Husband	27	22	36	0.20	−0.14–0.50
Parent	25	23	40	0.48	0.20–0.69
Mother	24	22	8	0.69	−0.03–0.94
Father	25	24	32	0.46	0.13–0.70
Other relatives†	13	10	17	0.59	0.15–0.83

* Mean duration (years) of exposure.

† Other relatives include son, daughter, brother-in-law, sister, brother, and uncle.

tion coefficient for the duration of exposure to maternal passive smoke, although higher than for other resident smokers, was based on only eight reports. Reliability for the reported durations of exposure did not vary substantially when the reports were analyzed by the sex and smoking status of the respondent. Correlation coefficients were, however, higher for reports by nonsmoking respondents (table 7). In general, the reliability of this measure of extent of exposure is noticeably lower than the reliability of the qualitative responses shown in table 5.

Discussion

To our knowledge, this is the first study to assess the reliability of information reported on passive smoke exposures in personal interviews. Test-retest estimates of reliability suggest that misclassification of such exposures may be extensive. Responses to an initial screening question used to detect a person's exposure to passive smoke were more reliable for exposure at home than at work. Exposure to spouse's smoke was more reliably reported than exposure to smoke of various other residents in subsequent residential histories. Quantitative measures of exposure to passive smoke, i.e., number and duration of exposures, were even less reliably reported. Generally, nonsmokers gave more reliable information on all measures of passive smoke than smokers. It is of interest to note that for active smoking (details not presented), respondents in this study reliably reported the occurrence (kappa = 0.91, standard error = 0.038) and duration ($r = 0.84$, 95 per cent confidence interval 0.74–0.91) of their own cigarette smoking habits, and the difference between correlation coefficients for active and passive smoking duration was statistically significant ($p < 0.001$) (14).

It is relevant that reliability is a measure of repeatability and not validity, and even if results were completely reliable, there would be no guarantee against misclassification bias in epidemiologic studies. Previous studies (4–6), however, that have obtained risk estimates for lung cancer around 2.0, using exposure to spouse's smoke as the index of exposure, appear to be credible, since that measure of exposure is reliably reported. Nevertheless, the amount of misclassification bias that could result from the degree of unreliability measured in this study for spouse's passive smoke cannot account for the risk estimates for lung cancer around 1.0 found in other studies (9, 10).

To date, studies investigating dose-response relations between exposure to passive smoke and subsequent incidence of lung cancer have had discrepant results. Comparisons between study results are complicated because various measures of intensity or duration, or both, have been employed as indices of dose for different passive smoke exposures, e.g., to smoke of the spouse and to that of the parent. Sig-

Table 7

Reliability of the duration of exposure to residential passive smoke, by sex and smoking status of control subjects, lung cancer case-control study, Toronto, Canada, 1983–1984

Sex and smoking status	No. of paired reports*	Correlation coefficient	95% confidence interval
Both sexes	115	0.45	0.29–0.58
Females			
All	62	0.46	0.24–0.64
Never smokers	41	0.54	0.28–0.73
Ever smokers	21	0.31	−0.14–0.65
Males			
All	53	0.44	0.19–0.63
Never smokers	12	0.62	0.07–0.88
Ever smokers	41	0.36	0.06–0.60

* All resident smokers.

nificant dose-response relations have only been observed in studies that have primarily employed intensity measures of dose, i.e., number of cigarettes per day (4), or intensity and duration measures of dose, i.e., pack-years (6), total number of cigarettes (7), or number of cigarettes over the years of marriage (5). Duration-related measures of dose, i.e., years lived with a smoker (11), or years of exposure to spouse's smoke (7), did not result in significant dose-response relations. The low reliability of durations of exposure to passive smoke reported in this study suggests that it would be difficult to detect significant dose-response relations with measures of dose that depend solely on duration.

The results of this study suggest that improvements in the reliability of measurement of exposures to passive smoke are needed for future studies. It should be noted that when improvements in reliability are impossible, increasing sample size is an alternate strategy to deal with the effects of random error associated with exposure status on risk estimates. Passive smoking appears to be a complex experience, although inconsistent responses by some respondents in this study may be partly attributable to the open-ended format of questions used to obtain information on exposures. An alternate method to measure passive smoking which would use specific probes for various exposures, e.g., to smoke of a spouse, parent, or sibling, to aid subjects' recall of their exposures may result in more reliable information. The unreliability of duration measures of dose used in this study, e.g., years lived with a person who smoked, suggests that other measures of dose should be employed for the study of exposures to passive smoke.

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