4208

INDOOR AIR QUALITY, LUNG FUNCTION, AND CHRONIC BRONCHITIS SYMPTOMS IN BEIJING, CHINA—A SURVEY IN THE WINTERTIME

S. Yamaguchi **N. Shimojo** **L. Wang**

ABSTRACT

In the authors' first report on the risk factors in chronic obstructive pulmonary malfunction and "chronic bronchitis" symptoms in the Beijing district, it was disclosed that the obstructive lung function was significantly more prevalent in rural areas than in residential and industrial areas (Yamaguchi et al. 1989).

Suspected risk factors that contribute to the occurrence of "obstruction" together with "persistent cough and phlegm"—cigarette smoking, socioeconomic status, and chest illness in the past—were clearly confirmed.

However, the above-mentioned study was carried out in the summertime. The indoor air pollution of rural areas in the wintertime is taken up as one of the hidden risk factors for the obstruction of lung functions.

Health consequences of ambient air and indoor air quality (SO_2, NO_2, SPM) of the "obstruction" and "persistent cough and phlegm" in the present study were not significantly demonstrated. Obviously, an appropriate estimation of the temporality or relationship in time for the justification of a cause-effect relationship is almost impossible, particularly by a cross-sectional epidemiological study.

Results of the present study, however, will be valuable if the accumulation of other data available in such a different but related study and the more reliable epidemiologic findings show similar results.

INTRODUCTION

A cross-sectional epidemiological study on the risk factors in chronic obstructive pulmonary malfunction and chronic bronchitis symptoms in the Beijing district—a joint study between Japan and China—was carried out in August 1986 (Yamaguchi et al. 1989).

Possible risk factors identified that will cause malfunction of the lung, together with chronic bronchitis symptoms, pointed out in the study were cigarette smoking, lower socioeconomic status, and a previous history of chest illness (Table 1). A cross-sectional study can observe only survivors at a certain period of time and subsequent consequences of the cause-and-effect relationship sometimes will be left unsolved.

The China study was carried out in the summer of 1986. Ambient air quality in the Beijing district was available only by GEMS report (Global Environmental Monitoring System), which was published in 1983. The GEMS report did not cover any information on indoor air quality. As a result of the summer 1986 study, it was clear that the obstruction of lung function was significantly more prevalent in rural areas than in industrial and residential areas, where the surrogate ambient air quality regarding sulfur dioxide (SO_2), carbon monoxide (CO), and suspended particulate matter (SPM) was worse than in rural areas (Figures 1-3). If the obstruction of lung function as well as "chronic bronchitis" symptoms can be induced by air pollutants produced by combustion of fossil fuels, indoor air quality in rural areas in the wintertime should be studied because in rural areas in the wintertime, large amounts of coal are consumed for heating and cooking in the houses.

TABLE 1
ASSOCIATION BETWEEN RISK FACTORS AND "CHRONIC BRONCHITIS" SYMPTOMS OR "OBSTRUCTION"

		"Chronic Bronchitis" Symptoms Adjusted Rate		"Obstruction" Adjusted Rate	
Area	Residential	9.08	N.S. (Residential–Rural); N.S. (Residential–Industrial)	7.41	** (Residential–Rural); ** (Residential–Industrial)
	Rural	14.72	N.S. (Rural–Industrial)	21.04	** (Rural–Industrial)
	Industrial	16.40		13.37	
Sex	Male	13.48	N.S.	13.26	N.S.
	Female	13.62		15.01	
Age	40–	13.55	N.S. (40–/50–); N.S. (40–/60+)	10.53	* (40–/50–); ** (40–/60+)
	50–	12.70	N.S. (50–/60+)	12.24	** (50–/60+)
	60+	14.89		22.88	
SES	High	11.89	**	12.00	**
	Low	16.47		15.77	
Past Chest Illness	Yes	22.18	*	19.85	**
	No	5.88		9.07	
History in the past (Parent's Resp.Dis)	Yes	16.47	**	15.00	N.S.
	No	12.30		13.78	
Smoking	Never	8.52	* (Never–Ex-smoker); ** (Never–1-9); ** (Never–10+)	9.74	** (Never–Ex-smoker); ** (Never–1-9); ** (Never–10+)
	Ex-smoker	12.55		17.44	
	1 - 9	17.88		17.48	
	10+	18.95		17.70	

** P<0.01 N.S.: not significant
* P<0.05

Therefore, in the winter of 1988 (February through March), a series of measurements of SO_2 and nitrogen dioxide (NO_2) were carried out in the houses in a rural Beijing area to determine the present status of indoor air quality (Figure 4). Since the socioeconomic situation has not changed for several years, it is presumed that the lifestyles of rural inhabitants have not changed during this time period. Therefore, it is assumed that the indoor air quality as of February through March 1988 has changed little over the past several years and can be used to estimate the dose retrospectively from the concentration.

S. Yamaguchi is director and professor, Institute of Community Medicine, Tsukuba University, Ibaraki, Japan; **N. Shimojo** is associate professor, Institute of Community Medicine, Tsukuba University, Ibaraki, Japan; **L. Wang** is professor, Department of Environmental Health, School of Public Health, Beijing Medical University, People's Republic of China.

METHOD

Human Subjects

Among samples included in the summer 1986 survey in the Beijing rural area, 42 samples were taken at random—26 males and 16 females—with an average age for males of 53.5 ± 7.0, and for females of 51.8 ± 12.9 years. Human subjects were the members of the 1986 study who have responded with their answers to the British MRC questionnaire (BMRC 1976). They were used for the 24-hour measurement of NO_2 by personal monitoring device and the measurement of SO_2 indoor dose, respectively (Table 2).

Measurement of NO_2 and SO_2

For the measurement of NO_2, Yanagisawa's personal sampler was employed (Yanagisawa and Nishimura 1980). NO_2 absorbed in filter paper was determined by a colorimetric absorption method. The reagents used for this method were sulfanilic acid and N-(1-naphthyl)-ethylenediamine 2HCl.

Sulfur dioxide was measured by the alkali-filter paper method (Wang's method). Filter paper soaked with K_2CO_3 was exposed in a room for 24 hours. Then the filter paper was put in a dilute HCl solution. The solution was heated and 10% $BaCl_2$ was added and allowed to stand until the $BaSO_4$ was completely precipitated. $BaSO_4$ was then col-

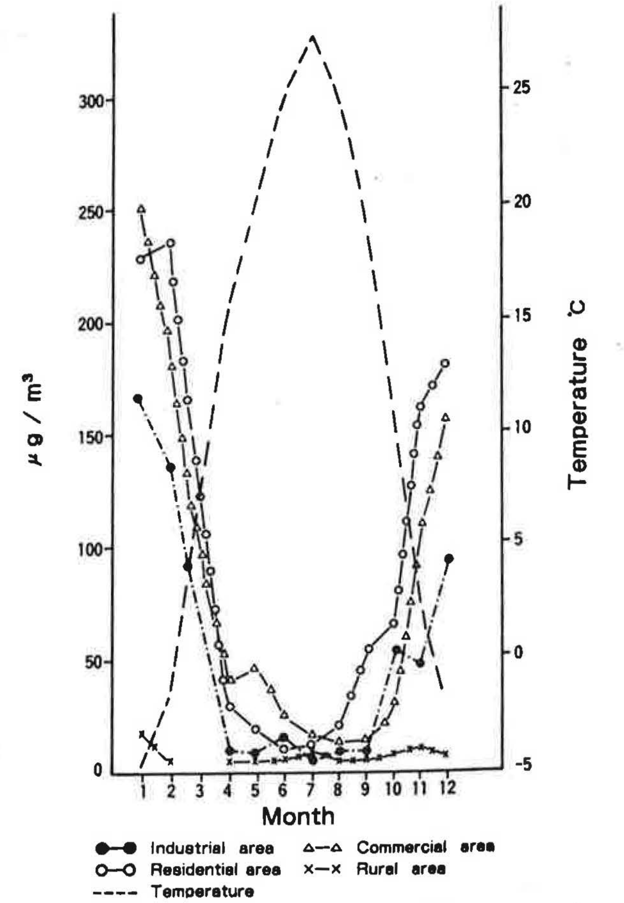

Figure 1 Annual trend of monthly average SO_2 concentration

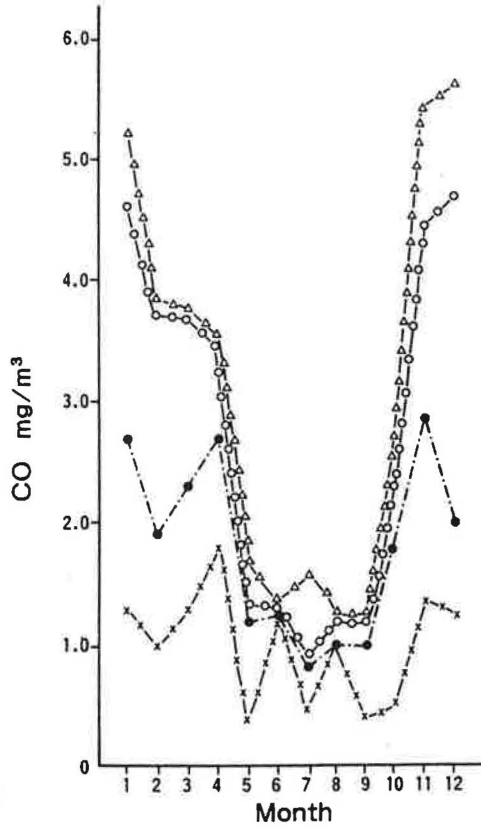

Figure 2 Annual trend of monthly average amount of CO in Beijing district (1981)

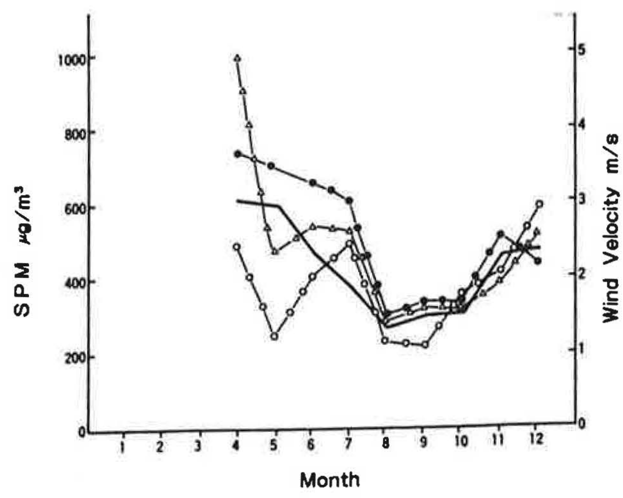

Figure 3 Annual trend of monthly average of SPM in Beijing district (1981)

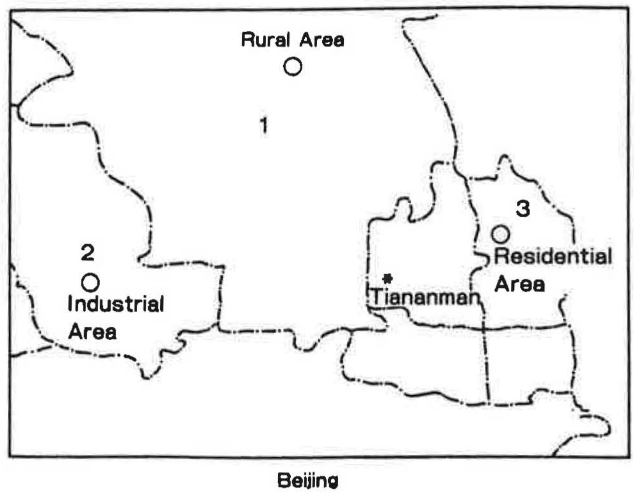

Figure 4

TABLE 2

Relationship between Lung Function, Persistent Cough, Phlegm and Concentration of Indoor NO_2, SO_2

OBS	(ppb)	NO_2 (mg/m³, 0℃)	SO_2 ($mgSO_3/100cm^2/day$)	Q_3Q_6	$FEV_{1.0\%}$	OBSTRUCTION	SEX
1	70.87	0.145	0.753	2	77.2	2	1
2	69.21	0.142	0.537	2	80.0	2	1
3	154.79	0.317	2.421	2	74.9	2	2
4	30.04	0.061	1.365	2	66.8	1	1
5	15.67	0.033	*	1	79.7	2	1
6	148.78	0.305	2.188	2	68.1	2	1
7	114.84	0.235	1.983	2	61.9	1	1
8	156.70	0.322	2.534	2	77.6	2	1
9	303.30	0.621	4.258	2	77.4	2	2
10	100.89	0.207	2.314	2	58.9	1	2
11	71.39	0.146	0.610	2	68.3	2	2
12	85.99	0.177	1.255	4	82.2	2	2
13	189.15	0.388	3.365	4	68.9	2	1
14	200.24	0.411	2.544	2	68.7	2	1
15	193.32	0.396	1.918	2	73.8	2	2
16	86.40	0.177	1.757	2	*	*	1
17	83.89	0.172	0.814	1	66.1	1	1
18	63.69	0.131	1.245	1	51.5	1	1
19	46.94	0.100	0.315	2	94.3	2	1
20	83.31	0.171	5.763	2	69.2	2	1
21	43.63	0.089	0.250	1	72.0	2	1
22	14.74	0.031	0.000	3	64.7	1	2
23	55.00	0.112	1.137	4	64.1	1	2
24	10.83	0.022	0.053	4	80.4	2	1
25	45.80	0.094	0.232	1	41.6	1	1
26	86.70	0.178	0.420	2	77.7	2	1
27	40.17	0.083	0.700	3	71.1	2	1
28	91.68	0.187	1.480	2	45.8	1	2
29	191.58	0.392	7.226	2	80.5	2	2
30	12.96	0.026	0.169	2	83.3	2	2
31	26.03	0.053	1.806	1	57.8	1	1
32	247.03	0.506	3.620	1	74.6	2	1
33	79.92	0.164	3.530	2	75.0	2	2
34	160.94	0.330	6.216	2	73.7	2	1
35	110.06	0.226	*	2	72.6	2	2
36	82.17	0.169	0.622	2	77.8	2	1
37	150.34	0.308	0.979	2	79.1	2	2
38	215.47	0.441	3.051	2	80.9	2	1
39	16.72	0.034	0.099	1	75.7	2	2
40	19.44	0.040	0.397	2	79.9	2	2
41	71.72	0.147	*	2	79.1	2	1
42	108.94	0.223	1.670	4	69.6	2	1

Q_3Q_6 : 1 (Q_3Q_6 : YES) 2 (Q_3Q_6 : NO) 3 (Q_3 : YES, Q_6 : NO) 4 (Q_3 : NO, Q_6 : YES)
$FEV_{1.0\%}$: 1 : < 68 % (OBSTRUCTION) 2 : ≥68 %
SEX : 1 : MALE 2 : FEMALE

Q_3 : Do you cough like this on most days for as much as three months each year (in the winter) ?

Q_6 : Do you bring up phlegm like this on most days as much as three months each year (in the winter) ?

TABLE 4

Relationship between indoor concentration of NO_2, SO_2 (wintertime, 1988) and history of persistent cough and phlegm production (summertime, 1986) (Q_3Q_6 BMRC) (Male + Female)

	N	NO_2 (ppb)	N	SO_2 ($mgSO_3/100cm^2/day$)
Q_3Q_6 : yes	8	67.81 ± 76.10	7	1.15 ± 1.25
Q_3Q_6 : no	27	114.96 ± 67.24	25	2.21 ± 1.92
Q_3 : yes, Q_6 : no	2	27.46 ± 17.98	2	0.35 ± 0.49
Q_3 : no, Q_6 : yes	5	89.98 ± 66.52	5	1.50 ± 1.20

Q_3 : Do you cough like this on most days for as much as three months each year (in the winter) ?
Q_6 : Do you bring up phlegm like this on most-days as much as three months each year (in the winter) ?
SO_2 : calculated as SO_3

lected by filtration and $AgNO_3$ was added and washed with warm distilled water until Cl^- was removed. Precipitated $BaSO_4$ was then dried at 120° to 130°C and its weight measured. The detection limit by this method is 0.05 mg SO_3/100 cm²/day. An electroconductivity method was used at the GEMS monitoring station. However, for the Beijing field study this time, the necessary facilities for the electroconductivity method were not available.

RESULTS

Indoor Air Quality in the Wintertime

Table 3 shows the results of the measurements of the indoor concentrations of NO_2 in the wintertime compared with the summer study. Average NO_2 concentration of samples taken in rural houses was 98.84±70.9 ppb, significantly higher than that of the summer samples (12.46±4.16 ppb), while the concentration in ambient air was not significantly higher than that of the summer (48.94±33.86 ppb: winter vs. 15.76±9.89 ppb: summer).

According to the GEMS report, the concentration of SO_2 in ambient air in the rural area (1981) near Beijing was 21 g/m³ in the winter (January) and 6 g/m³ in the summer (July).

TABLE 3

Comparison of concentration of NO_2, in ambient and indoor air and $FEV_{1.0\%}$ (Beijing, Rural)

	Mean ± SD	N
NO_2 (winter, indoor)	98.84 ± 70.09 (ppb)	42
NO_2 (summer, indoor)	*12.46 ± 4.16 (ppb)	101
NO_2 (winter, ambient)	48.94 ± 33.86 (ppb)	4
NO_2 (summer, ambient)	15.76 ± 9.89 (ppb)	10
**$FEV_{1.0\%}$ (Male)	71.45 ± 10.62 %	25
**$FEV_{1.0\%}$ (Female)	72.28 ± 9.87 %	16
**$FEV_{1.0\%}$ (Male + Female)	71.77 ± 10.22 %	41

* : Test of Difference : winter vs. summer, indoor. $P < 0.01$
**$FEV_{1.0\%}$: Less than 68 % of $FEV_{1.0\%}$ summertime study.

TABLE 5

Relationship between indoor concentration of NO_2, SO_2 (wintertime, 1988) and $FEV_{1.0\%}$ (Male+Female) (summertime, 1986)

	N	No_2 (ppb)	N	SO_2 ($mgSO_3/100cm^2/day$)
1 : $FEV_{1.0\%}$ < 68	10	62.66 ± 34.19	10	1.24 ± 0.73
2 : $FEV_{1.0\%}$ > 68	31	*110.91 ± 75.97	28	2.05 ± 1.98

*Test 1 vs. 2 : $P < 0.05$
"obstruction : < 68 % one second percent of FEV"
SO_2 : calculated as SO_3

Indoor Air Quality and Health Effects

As far as the relationship between the persistent cough and phlegm production in addition to the obstructive lung function among inhabitants in rural areas and indoor air quality (NO_2, SO_2) is concerned, as was shown in Tables 4 and 5, a significant correlation or dose response relationship was not observed.

CONCLUSION

In general, the use of air quality standards for ambient air assumes that some level of both emissions and concentration of pollutants is permissible, with both low enough so as not to cause significant health effects.

However, except in extraordinary episodes, like the London episode in 1952, when 4000 excess deaths were estimated among inhabitants in the greater London area who may have been exposed to 4460 g/m³ SPM and 3830 g/m³ SO_2 (highest 24-hour values) (data from the British Ministry of Health) (Lawther et al. 1970; Ministry of Pensions and National Insurance 1965), no data were obtained on the critical concentrations of many chemical pollutants in ambient air at which adverse health effects are precisely evident (i.e., not as subjective complaints but as clinical findings obtained by the best medical diagnostic techniques).

If contamination has occurred by multiple noxious agents, the degree of contribution of each substance to the health consequences postulated will not be clarified.

In this study, as far as the consequent health effects are concerned in the environment containing NO_2 and SO_2 at the concentrations mentioned above, no definite conclusion could be afforded. Risk factors other than chemical air pollutants and their degree of probability found in the summer study will be discussed elsewhere.

REFERENCES

BMRC. 1976. "Questionnaire of respiratory symptoms." Approved by Medical Research Council's Committee on Research into Chronic Bronchitis. London: British Medical Research Council.

GEMS. 1983. Global environmental monitoring system (in Chinese). On the five cities in China (1981). Beijing: Department of Health, Division of Preventive Medicine, People's Republic of China.

Lawther, P.J.; Waller, R.E.; and Henderson, M. 1970. "Air pollution and exacerbations of bronchitis." *Thorax*, Vol. 25, pp. 525–539.

Ministry of Pensions and National Insurance. 1965. "Report on enquiry into the incidence of incapacity for work in different areas and occupations." London: WMSO.

Yamaguchi, S., et al. 1989. "Risk factors in chronic obstructive pulmonary malfunction and 'chronic bronchitis' symptoms in Beijing district: a joint study between Japan and China." *J. Epidemiology and Community Health*, Vol. 43, No. 1, pp. 1–6. London: British Medical Association.

Yanagisawa, Y., and Nishimura, H. 1980. "NO_2 personal sampler: for the measurement in living environment." *Jap. J. of Air Pollution*, Vol. 15, No. 8, pp. 316–323.

DISCUSSION

Carl N. Lawson, LRW Engineers, Tampa, FL: Do you find any stress-related problems in your lung studies?

S. Yamaguchi, Institute of Community Medicine, The University of Tsukuba, Japan: It depends upon the nature of "stress." However, we did not feel any "stress" in our study.