Spontaneous Abortions in an Industrialized Community in Finland

KARI HEMMINKI, MD, PENTTI KYYRÖNEN, MSc, MARJA-LIISA NIEMI, CANDPOLSCI, KARI KOSKINEN, MD, MARKKU SALLMÉN, MSc, AND HARRI VAINIO, MD

Abstract: Spontaneous abortions were analyzed in an industrialized Finnish community according to the occupation and workplace of both the women and their husbands. Information about spontaneous abortions and births was obtained from the hospital discharge register, and data about the women and their families were collected from census files. When compared with all women employed outside the home, women who worked at a textile plant (factory A, a clothing manufacturer) had an increased rate of spontaneous abortion (16.7 per cent vs 11.4 per cent). The rate of spontaneous abortions among women employed at factory A differed according to the husband's workplace. The odds ratio for women employed at factory A whose husbands worked at a large metallurgical factory was 3.8, whereas the odds ratio for women whose husbands worked elsewhere was 1.2. Between 1973 and 1976, the rate of spontaneous abortions in this town was consistently lower for the summer period (May–August) than for the other periods of the year. (*Am J Public Health* 1983; 73:32–37.)

Introduction

Because of the frequency and partial mutational etiology of spontaneous abortion, it has been suggested that spontaneous abortion be included in health surveillance.[1–3] Many studies of spontaneous abortions consider occupational[4–16] or life-style exposures, notably, tobacco[17–18] and alcohol.[19–21] Adverse effects of environmental exposures have usually been monitored in response to concern about their adverse effects on reproduction.[7,13] In such cases, obtaining unbiased data on spontaneous abortions or exposures is difficult.

In Finland, the high frequency of hospitalization for spontaneous abortion and the national hospital discharge register offer good opportunities for studying spontaneous abortions.[15,16] By linking this discharge data to objective exposure data, an effective means of investigating matters of public concern becomes available. Such a scheme of data linkage is described here.

Materials and Methods

We studied the effects of occupational and other environmental factors on the frequency of spontaneous abortions in a single Finnish community, Kokkola, a town with over 30,000 inhabitants. The crude birth rate of the town in 1975 was higher (20.3 per 1,000 total population) than that of the other towns in the same province (16.6 per 1,000). About 45 per cent of the population, a relatively large percentage for Finland, is employed in industry. Men are employed chiefly in metal, leather, and chemical industries, and women work mainly in the textile industry. We have previously noted that the frequency of hospitalized spontaneous abortion in Kokkola and in the surrounding area exceeds that of other parts of Finland. The metallurgical industry of Kokkola emits cadmium and other heavy metals, and a sulfur factory discharged sulfur dioxide into the air until shut down in 1977.

The Finnish National Board of Health maintains a computerized hospital discharge registry of all the patients discharged from hospitals. The registry contains a personal identification number* and information on diagnosis and treatment, date of discharge, hospital of treatment, and residential community. From the registry, we obtained information on all women from Kokkola who had been treated for spontaneous abortion (diagnoses nos. 643 and 645), for induced abortion (diagnoses nos. 640–642), or who gave birth (diagnoses (650–662) between 1974 and 1977. Diagnoses were based on the 8th revised version of the International Classification of Diseases.

A patient was only included once if she had been discharged from hospital twice within four months with any diagnosis used. If diagnosis no. 645 (other abortion) was used with a preceding spontaneous or induced abortion, the case was excluded. This involved less than 1 per cent of the total number of spontaneous abortions. Seven patients were also excluded because of incorrect diagnosis (diagnosis no.

From the Institute of Occupational Health, Helsinki, Finland. Address reprint requests to Kari Hemminki, MD, Special Investigator, Institute of Occupational Health, Haartmaninkatu 1, SF-00290, Helsinki 29, Finland. Dr. Vainio is department chief, and the remaining authors are researchers, all at the Institute. This paper, submitted to the Journal March 15, 1982, was revised and accepted for publication August 10, 1982.

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*Date of birth and social security number.

645 had been misused as a code for threatened abortion). After these corrections, the data comprised 3,261 pregnancies, 2,377 of which were births.

Because of underreporting, the births covered 94 per cent of all the officially recorded births in Kokkola between 1974 and 1977. All births are hospitalized in Finland. The laws permitting induced abortions are liberal in Finland. Illegal abortions are believed to be few, as indicated by infrequent hospitalization with diagnoses nos. 644 (unspecific abortion, self-induced or spontaneous) and 642 (criminal or unspecific induced abortions).

Hospital register information was obtained largely from the hospital of Kokkola, which does not treat outpatients. Thus our coverage of spontaneous abortions, leading to medical contacts, should be complete. We have not analyzed the reliability of the hospital discharge data in the Kokkola hospital.**

Some women (about 10 per cent) in the Kokkola series had two or more spontaneous abortions. Multiple cases were not excluded since there was no reason to believe that women with multiple spontaneous abortions are unevenly distributed between various occupations. In all the observations to be reported, multiple spontaneous abortions were ruled out as a possible confounder.

Information on the occupations and workplaces of both the women and their husbands, the number of children, and place of residence were collected from the national population and housing census carried out at the end of 1975, using their personal identification numbers.*** The information was obtained for 83 per cent of women identified from hospital discharge data. Based on the hospital discharge registry, we sampled 15 per cent of the women we could not trace, and found that 25 per cent of this sample had an incorrect identification number and could not be traced through the census. Another part of the women for whom data were not available probably either moved from Kokkola before the census, or moved to Kokkola after the census. The analysis of the women that could not be traced showed a higher rate of spontaneous abortion (12.7 per cent) than those women whom we were able to trace (9.8 per cent).

We define the rate of spontaneous abortions as the number of spontaneous abortions divided by the number of total births (live births + stillbirths + induced abortions + spontaneous abortions).[15,16] The ratio of spontaneous abortions is defined as the number of spontaneous abortions divided by the number of births (live births and stillbirths). Two different proportions for spontaneous abortions were calculated because of the large number of induced abortions in Finland. However, when the rates and the ratios agreed with one another well, only the rates are given. The rate of induced abortions was 16 per cent in Kokkola, comparable to that of all towns in the province (17 per cent). The rate of induced abortions was also analyzed to assure that induced abortions would not have been misclassified as spontaneous abortions.

Statistical significance of the rates and ratios, and their homogeneity for trend were determined with χ^2 test; the binomial test was used when there were fewer than 100 pregnancies or fewer than 20 spontaneous abortions. Homogeneity of odds ratios in the analysis of the stratified data was tested by a procedure based on the logarithms of odds ratios.[23]

Results

Figure 1 shows the effect of parity (i.e., the number of children born before the studied pregnancy) on spontaneous abortion rates and ratios in four age groups. Increasing parity increased the risk of spontaneous abortion only among those under age 25 (with relatively few pregnancies for the 2 and 3+ parity data points).

There were seasonal changes in the rates of spontaneous abortion. The rates given in Figure 2 were calculated per pregnancies that had started three months earlier. The rates

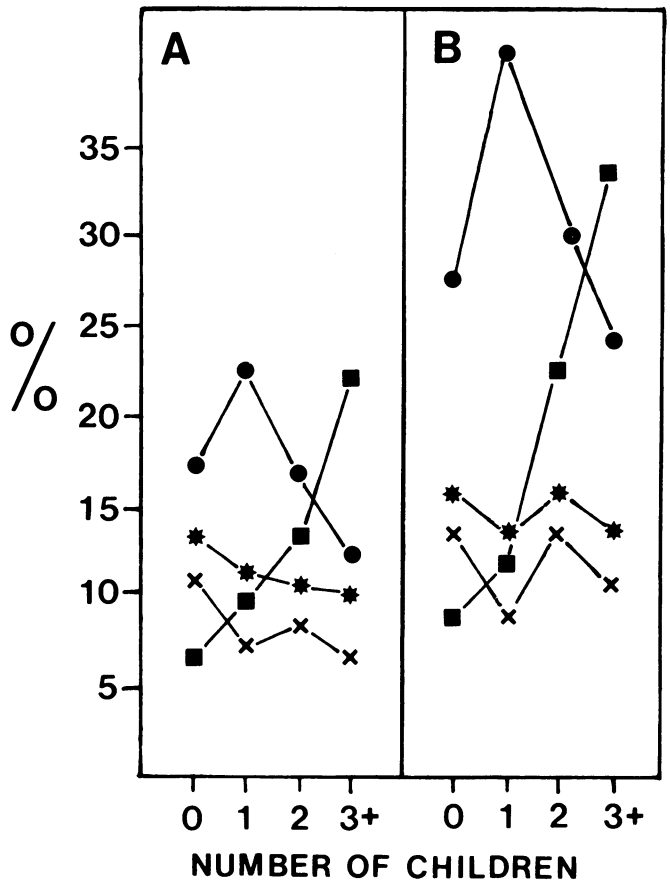

FIGURE 1—Rate (A) and Ratio (B) of Spontaneous Abortion for Kokkola Women According to Parity during 1974–1977
KEY: ■ = <25 years of age
X = 25–29 years of age
*** = 30–34 years of age**
● = ≥35 years of age

**In a comparable hospital, the diagnoses in the hospital discharge register agreed with hospital records in 90 per cent of the cases, and the mean gestational length of hospitalized spontaneous abortions was 12 weeks and that of outpatients 10 weeks.[22]

***Date of birth and social security number.

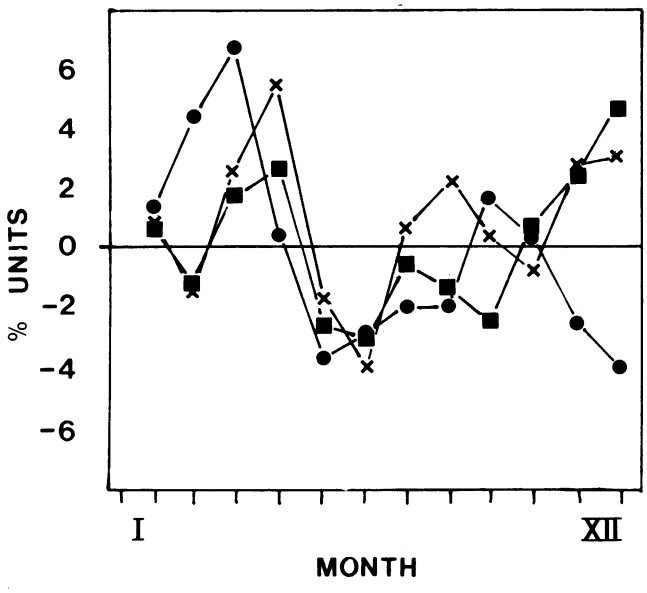

FIGURE 2—The Standardized Monthly Rates of Spontaneous Abortion among Kokkola Women as Two-Month Moving Averages 1974 through 1976 (see text)
Key: X = 1974
■ = 1975
● = 1976
Mean rate of each year = 0, corresponding to a rate of 10.1 per cent

were 3 to 6 percentage units above average in March and April and dropped in June and July by 3 to 4 percentage units below average. These changes were constant for the three years studied. By contrast, there was more variation in the rates for the end of the year. The difference in the rate of spontaneous abortion between the three four-month periods of the year was almost significant ($p < 0.10$) for 1974, 1975, and 1976 (Table 1).

We investigated the rates and ratios of spontaneous abortion according to the occupation of both the women and their husbands (Table 2). The rate for all the women of Kokkola was 9.5 per cent and the ratio was 12.9 per cent. Industrial workers had the highest rate (12.2 per cent), but their rate did not differ significantly from the rate for all economically active (working) women. The rate and ratio of spontaneous abortion for working women were significantly higher than the respective rate and ratio of economically inactive women.

The husband's occupation was associated with a high frequency of spontaneous abortion in the category of transport and communication workers. The highest frequency of spontaneous abortions in this category was noted for the occupational group employed on the railways whose wives had a mean age of 30.3 years, so that age could explain the higher frequency of spontaneous abortion.

The workplace and detailed job description are analyzed in Table 3. For the women, two workplaces stood out—a clothing factory where the seamstresses had a spontaneous abortion rate of 20.4 per cent, and a leather goods factory where only three spontaneous abortions occurred but the rate was 50 per cent. In these cases, the ages of the women could not explain the high rates, and the frequency of induced abortions was similar to that of all working women. The wives of men working in the leather industry also had a slightly increased rate of spontaneous abortion.

Further analysis of the occupation of both the women and their husbands revealed an interesting association (Table 4). The rate of spontaneous abortion for a woman textile worker married to a man employed at a large metallurgical factory was 21.7 per cent. If a woman working at factory A (where clothes are made) was married to a worker of that particular metallurgical factory, her rate as 28.6 per cent. To ensure that this high rate of abortions was not due to multiple spontaneous abortions of one woman, we calculated another rate where the number of women with spontaneous abortions was divided by the number of women who had been pregnant. This rate for a woman working at factory A was 31.0 per cent if her husband was working at the metallurgical factory, but 14.3 per cent if her husband was working elsewhere. The combination of wife working at factory A and husband employed at that particular metallurgical factory was unique in that, for the women, no other textile plant and, for the men, no other metal plant led to such high frequencies of spontaneous abortion (Table 4). Nevertheless, the entire textile industry had a tendency toward higher rates of spontaneous abortion if the husband was employed at that particular metallurgical factory (16.0 per cent) when compared with husbands employed elsewhere (10.5 per cent). Almost all the women working at factory A were seamstresses, but their husbands' occupations at the metallurgical factory varied.

TABLE 1—Seasonal Variation in the Occurrence of Spontaneous Abortions in Kokkola in 1974–1976

Period of the Spontaneous Abortion	Number of Spontaneous Abortions	Number of Pregnancies	Rate of Spontaneous Abortions
January–April	85	722	11.8
May–August	59	713	8.3
September–December	72	711	10.1
TOTAL	216	2146	10.1

$X_2^2 = 4.84$ ($p < 0.10$) for homogeneity of the periods.

TABLE 2—Frequencies, Rates, and Ratios of Spontaneous Abortions According to Occupations of Women and Their Husbands in Kokkola, 1974–1977

Occupation	By Woman's Occupation				By Husband's Occupation			
	Number of Spontaneous Abortions	Number of Pregnancies	Rate (ratio) of Spontaneous Abortions		Number of Spontaneous Abortions	Number of Pregnancies	Rate (ratio) of Spontaneous Abortions	
Technical, scientific humanistic and artistic work	33	335	9.9	(12.3)	34	381	8.9	(10.7)
Administrative, managerial and clerical work	44	372	11.8	(16.0)	14	111	12.6	(16.9)
Sales work	17	156	10.9	(16.2)	17	152	11.2	(14.4)
Transport and communication	5	52	9.6	(12.8)	30	214	14.0*	(19.5)*
Industrial production	56	460	12.2	(18.0)	104	1119	9.3	(11.7)
Services	36	298	12.1	(18.8)	6	69	8.7	(10.9)
Other occupations	3	22	13.6	(18.8)	5	87	5.7	(6.8)
Economically active women	194	1695	11.4**	(16.1)**				
Economically inactive women	63	1003	6.3	(8.0)				
TOTAL	257	2698	9.5	(12.9)	210	2133	9.8	(12.4)

*$p < 0.05$ as compared with other women. The hypothesis of homogeneity for the rates and the ratios was not rejected.
**$p < 0.001$ as compared with all economically inactive women.

Discussion

This study relied upon linkage of two data systems: the hospital discharge register and the 1975 census records. Such linkages may be particularly helpful when attempting to address questions of environmental influences on health, especially when interview studies may present problems with ascertainment bias. The present linkage of the data was technically successful, as 83 per cent of the women who had been pregnant could be traced from the population census, although the losses of women who could not be traced may have caused small bias in the series analyzed. If present, such a bias would decrease the observed differences because the women we could not trace were likely to belong to the relevant occupational groups.

Female textile workers did not differ from other working women according to age, parity, or previous abortions (between years 1974 and 1977), making these variables an unlikely source of bias. Our previous studies on the possible selection of patients for hospital care in the case of spontaneous abortions have shown only minor differences due to social class or to distance from the residence of the patient to

TABLE 3—Frequency and Rate of Spontaneous Abortions and Women's Mean Age for Some Occupational Groups at Kokkola Factories in 1974–1977

Factory/Occupation	Number of Spontaneous Abortions	Number of Pregnancies	Rate of Spontaneous Abortions	Women's Mean Age
WOMAN				
Textile factory A	21	126	16.7*	25.7
(seamstresses, etc.)	(19)	(93)	(20.4)	(25.1)
Other textile factories	25	242	10.3	27.0
(seamstresses, etc.)	(13)	(147)	(8.8)	(26.0)
Chemical industry	1	15	6.7	27.5
Metal industry	6	72	8.3	28.5
Leather factory B	3	6	50.0*	27.5
Other leather factories	9	77	11.7	27.9
Other industries	129	1157	11.1	27.8
TOTAL	194	1695	11.4	27.6
HUSBAND				
Chemical industry	8	98	8.2	
Metallurgical industry	59	556	10.6	
Metal industry	8	119	6.7	
Textile industry	6	72	8.3	
Leather industry	6	34	17.6	
Other industries	123	1254	9.8	
TOTAL	210	2133	9.8	

*$p < 0.05$ as compared to the total frequencies. The hypothesis of homogeneity was not rejected.

TABLE 4—Frequency Rate and Odds Ratio of Spontaneous Abortions According to Some Combinations of Various Factories or Industries Employing the Women and Their Husbands

Woman	Husband	Number of Spontaneous Abortions	Number of Pregnancies	Rate	Odds Ratio	p-value[1]	X^2-value	(p-value)[2]
Textile industry	Metallurgical factory	20	92	21.7	3.0	$p < 0.01$		
Other industries	Metallurgical factory	22	262	8.4				
Textile industry	Other factories	23	208	11.1	0.9			
Other industries	Other factories	94	793	11.9				
TOTAL		159	1355	11.7			10.43	($p < 0.05$)
Factory A	Metallurgical factory	12	42	28.6	3.8	$p < 0.05$		
Other factories	Metallurgical factory	30	312	9.6				
Factory A	Other factories	8	62	12.9	1.2			
Other factories	Other factories	109	939	11.6				
TOTAL		159	1355	11.7			11.43	($p < 0.01$)
Textile industry[3]	Metallurgical factory	8	50	16.0	2.1	$p < 0.10$		
Other industries[3]	Metallurgical factory	22	262	8.4				
Textile industry[3]	Other factories	15	146	10.5	0.8			
Other industries[3]	Other factories	94	793	11.9				
TOTAL		139	1251	11.1			3.30	NS

[1]p-value for the homogeneity of odds ratios.
[2]X^2-value (p-value) for homogeneity of the subgroups.
[3]Factory A excluded.

the nearest hospital.[22] As the present study compared textile workers to other workers, bias due to a differential degree of hospitalization seems unlikely.

Seasonal variation was found in the rate of spontaneous abortion, with peak rates occurring during the spring, and low rates during the summer. This is contrary to the whole of Finland, where no such seasonal variation could be found for the period 1973–1975 (Niemi and Kyyrönen, an unpublished observation). The data fail to explain the cause of the seasonal variation observed. In the United States, based on hospitalized cases, monthly differences were noted for the number of spontaneous abortions, but when adjusted for number of conceptions, the difference disappeared.[24] The difference we observed remained even after such adjustment.

We found, as previously that working (economically active) women, particularly those working in industry, were hospitalized because of spontaneous abortion more often than other women in the community.[15] No such clear occupational correlations were found for the paternal occupation if it was analyzed without consideration of the maternal occupation. It should be noted that the occupational information referred to the end of 1975, whereas pregnancies were collected from years 1974 to 1977.

Many Kokkola women are employed in the textile industry, and the rate of spontaneous abortion was elevated in the textile industry. Not only did the increased rate focus on one specific textile plant (factory A, the largest of the textile plants), it also focused on the seamstresses of factory A. The local employer and employee representatives, who were interviewed in a standardized way on the telephone, said that the work at Kokkolas textile factories is done mostly as piecework. There is no shiftwork. Noise levels were the primary complaint; other complaints related to working conditions, e.g., the dust of the raw materials and the dryness of the air at the factories.

An interesting interaction of risks was noted for certain couples. Couples where the woman worked at factory A and the husband was employed at a large metallurgical factory had a very high rate of spontaneous abortion (over 30 per cent). The high rate of spontaneous abortion consistently noted for factory A was largely explained by the combination of seamstresses married to men employed at the metallurgical factory. One possible reason for this interaction, in addition to a chance, is a selectional one. Another possibility is a paternal effect, however, which this study could not identify. The metallurgical factory works with zinc and cobalt. In addition to these metals, exposures may include sulfur dioxide, hydrogen sulfide, arsene, and cadmium. A Swedish study has also described many types of reproductive problems in a metallurgical facility.[7,25,26] Many of the couples lived in one particular residential area, but this area did not have an atypical rate of spontaneous abortion. Within this residential area, the factory A seamstresses and metallurgical factory worker couples could be distinguished from other couples by their higher spontaneous abortion rates.

REFERENCES

1. Carr DH: Detection and evaluation of pregnancy wastage. *In:* Wilson JG, Fraser FC (eds): Handbook of Teratology, Vol 3. New York: Plenum Press, 1977, pp 189–213.
2. Kline J, Stein Z, Strobino B, Susser M, Warburton D: Surveillance of spontaneous abortions: power in environmental monitoring. Am J Epidemiol 1977; 106:345–350.
3. Hemminki K, Sorsa M, Vainio H: Genetic risks caused by occupational chemicals. Scand J Work Environ Health 1979; 5:307–327.

4. Strandberg M, Sandbäck K, Axelson O, Sundell L: Spontaneous abortions among women in hospital laboratory. Lancet 1978; i:384–385.
5. Sanotskii IV: Aspects of the toxicology of chloroprene: immediate and long-term effects. Environ Health Perspect 1976; 17:85–93.
6. Infante PF, Wagoner JK, McMichael AJ, Waxweiler RJ, Falk H: Genetic risks of vinyl chloride. Lancet 1976; i:734–735.
7. Nordström S, Beckman L, Nordenson I: Occupational and environmental risks in and around a smelter in Northern Sweden. III. frequencies of spontaneous abortion. Hereditas 1978; 88:51–54.
8. Vessey MP, Nunn JF: Occupational hazards of anaesthesia. Br Med J 1980; 281:696–698.
9. Sullivan FM, Barlow SM: Congenital malformations and other reproductive hazards from environmental chemicals. Proc R Soc Lond B 1979; 205:91–110.
10. Hansson E, Jansa S, Wande H, Källén B, Östlund E: Pregnancy outcome for women working in laboratories in some of the pharmaceutical industries in Sweden. Scand J Work Environ Health 1980; 6:131–134.
11. Haas JF, Schottenfeld D: Risks to the offspring from parental occupational exposures. J Occup Med 1979; 21:607–613.
12. Strobino BR, Kline J, Stein Z: Chemical and physical exposures of parents: effects on human reproduction and offspring. Early Human Develop 1978; 1/4:371–399.
13. Kavoussi N: The effect of industrialization on spontaneous abortion in Iran. J Occup Med 1977; 19:419–423.
14. Hemminki K, Franssila E, Vainio H: Spontaneous abortions among female chemical workers in Finland. Int Arch Occup Environ Health 1980; 45:123–126.
15. Hemminki K, Niemi M-L, Saloniemi I, Vainio H, Hemminki E: Spontaneous abortions by occupation and social class in Finland. Int J Epidemiol 1980; 9:149–153.
16. Hemminki K, Niemi M-L, Koskinen K, Vainio H: Spontaneous abortions among women employed in the metal industry in Finland. Int Arch Occup Environ Health 1980; 47:53–60.
17. Kline J, Stein ZA, Susser M, Warburton D: Smoking: a risk factor for spontaneous abortion. N Engl J Med 1977; 297:793–796.
18. Himmelberger DU, Brown BW, Cohen EN: Cigarette smoking during pregnancy and the occurrence of spontaneous abortion and congenital abnormality. Am J Epidemiol 1978; 108:470–479.
19. Fielding J, Yankauer A: The pregnant drinker. (editorial) Am J Public Health 1978; 68:836–838.
20. Harlap S, Shiono PH: Alcohol, smoking, and incidence of spontaneous abortions in the first and second trimester. Lancet 1980; i:173–176.
21. Kline J, Shrout P, Stein Z, Susser M, Warburton D: Drinking during pregnancy and spontaneous abortion. Lancet 1980; i:176–180.
22. Niemi M-L, Hemminki K, Sallmén M: Application of hospital discharge register for studies on spontaneous abortions. *In:* Occupational Hazards and Reproduction. Washington DC: Hemisphere Publishing Co. 1983.
23. Fleiss JL: Statistical methods for rates and proportions, 2nd Ed. New York: John Wiley & Sons, 1981, pp 165–168.
24. Warren CW, Gold J, Tyler CW, Smith JC, Paris AL: Seasonal variation in spontaneous abortions. Am J Public Health 1980; 70:1297–1299.
25. Nordström S, Beckman L, Nordenson I: Occupational and environmental risks in and around a smelter in northern Sweden: V. spontaneous abortions among female employees and decreased birth weight in their offspring. Hereditas 1979; 90: 291–296.
26. Nordström S, Beckman L, Nordenson I: Occupational and environmental risks in and around a smelter in northern Sweden. VI. congenital malformations. Hereditas 1979; 90:297–300.

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International Symposium on Poliomyelitis Control

An international symposium on poliomyelitis control will be held March 14–17, 1983 at the Pan American Health Organization, Washington, DC. The symposium will be sponsored by the Fogarty International Center of the US National Institutes of Health, along with other national and international organizations.

The symposium will address the current impact of paralytic poliomyelitis in the world; the characteristics of available vaccines; and the mechanisms of action of the different vaccines in terms of their potential for broad scale control of the disease.

For registration and further information, contact:

Dr. E. C. Chamberlayne
Fogarty International Center
Building 16A, Room 205
National Institutes of Health
Bethesda, MD 20205

Second Nepalese Congress of Pediatrics

The Nepal Pediatric Society (NEPAS) announces the Second Nepalese Congress of Pediatrics to be held February 17–20, 1984 in Kathmandu, Nepal.

All doctors working with children are cordially invited to attend. The first day will be a precongress workshop on Pediatric Education for Health Personnel in Nepal. The remaining three days will be devoted to Health Care for Rural Children—the theme of the Congress.

Persons wanting to attend the Congress or read a paper should contact Dr. Remesh K. Adhiksri, Organizing Secretary, Second NEPAS Congress, Nepal Pediatric Society, POB No. 2668, Kathmandu, Nepal.