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Exposure to motor vehicle exhaust and childhood cancer

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Objectives A case-referent study was conducted to test the hypothesis that exposure to motor vehicle exhaust increases the risk of childhood cancer.

Methods Data from a study of residential magnetic field exposure and childhood cancer were used. From a population of 127 000 children living within 300 m of transmission lines in Sweden, 142 cases of childhood cancer were identified, including 39 cases of leukemia and 33 cases of central nervous system tumor. Approximately 4 referents per case were selected at random from the study base. The nitrogen dioxide content of the outdoor air was estimated as an indicator of motor vehicle exhaust. The applied methods give the 99th percentile of the nitrogen dioxide content of the outdoor air for 1-h averages over 1 year.

Results A relative risk estimate of 2.7 [95% confidence interval (95% CI) 0.9—8.5] was found for total cancer at exposure levels of ≥ 50 μg/m^3, related to those with ≤ 39 μg/m^3. At ≥ 80 μg/m^3, the relative risk was estimated at 3.8 (95% CI 1.2—12.1). Elevated, but imprecise risk estimates were found for leukemia and central nervous system tumors.

Conclusions The results indicate an association between childhood cancer and motor vehicle exhaust, although the number of cases was small. These findings and the results of previous studies suggest that further studies of the association between motor vehicle exhaust and childhood cancer are warranted.

Key terms air pollution, benzene, child neoplasms.

There are only a few known risk factors for childhood cancer, for example, ionizing radiation and genetic factors (eg, Down's syndrome). For other suggested risk factors, such as maternal smoking during pregnancy, pre- and postnatal viral infections, and nonionizing radiation, the evidence is contradictory or inconclusive (1).

Engine exhaust contains a large number of chemical compounds, many known or suspected to be carcinogenic, as, for example, benzene and mixtures of polycyclic aromatic compounds (2, 3). Many components of engine exhaust have also been found in tobacco smoke and other combustion products. Nevertheless, the International Agency for Research on Cancer has concluded in its evaluation that there is inadequate evidence for the carcinogenicity of gasoline engine exhaust in humans, limited evidence of human diesel engine exhaust carcinogenicity, and limited evidence for the carcinogenicity of engine exhausts (unspecified as from diesel or gasoline engines) in humans (2).

Children form a group that may be more susceptible to adverse effects caused by carcinogenic compounds in motor vehicle exhaust. There are, however, few epidemiologic studies that have addressed this question (4, 5), and there is not enough evidence to draw conclusions about a causal association or to evaluate the magnitude of an effect. Studies of motor vehicle exhaust exposure in relation to children's health have primarily dealt with respiratory symptoms (6), while cancer studies have often focused on lung cancer among adults (7).

The purpose of this study was to test the hypothesis that exposure to motor vehicle exhaust increases the risk of childhood cancer. Data from a study originally designed to examine the association between residential magnetic field exposure and childhood cancer were used (8).

Subjects and methods

The identification of the study population has already been described in detail elsewhere (8) and will only briefly be summarized in this report. The study base comprised the person-years of everyone aged 15 years or younger who had lived for at least 1 year on property located within 300 m of

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any of the 220 and 400 kV power lines in Sweden during the period 1960—1985. The subjects were followed from entry into the area through 1985. All properties at least partly located within the power line corridor were identified, and the population register was used to identify the persons who had lived on the listed properties. The information extracted from the population register was the personal registration number, the name for those with an incomplete or missing personal registration number, and the period the person lived on the property in question. Approximately 127 000 children were identified. The study was designed as a case-referent study nested within the cohort. Cases of cancer were identified through record linkage to the Swedish cancer register, kept by the National Board of Health and Welfare. Altogether 142 cases of childhood cancer were identified, including 39 leukemia cases and 33 cases of central nervous system tumor.

Four referents per case were selected at random among those who were included in the study base during the year of diagnosis of the matched case and who were born in the same year, lived in the same parish during the year of diagnosis, or, if the case had moved before the diagnosis was made, during the last year before the move, and lived near the same power line as the case.

Exposure assessment

An assessment of the exposure to motor vehicle exhaust was made in the homes within the power-line corridor in which the cases and referents lived closest to the date of diagnosis of the case. The nitrogen dioxide (NO_2) content of the outdoor air was used as an indicator of exposure to motor vehicle exhaust, estimated according to 2 methods described by the Swedish Environmental Protection Agency (9, 10). These methods give the 99th percentile of NO_2 content in the outdoor air for 1-h averages over 1 year. The methods are based on information about type of street (7 different types), traffic flow (vehicles/annual average day), speed limit, street width, distance between the house and the street, and other relevant information (intersection, frequent line-ups, other major sources of NO_2 emission, eg, airport). A background level of NO_2, dependent on population density and usual wind force, were also added. The information needed to calculate the NO_2 content was obtained from the public health authorities in the different municipalities for the relevant years. In most instances the information refers to the year of diagnosis of the case, but for some of the subjects information was not available that far back. For these subjects, the oldest information available was used.

Exposure below the median (≤ 39 μg/m^3) was used as the reference category, the third quartile being the intermediate and the upper quartile being the highest exposure category. The NO_2 content of the outdoor air was not evenly distributed according to geographic area. Stockholm is the most densely populated area in Sweden, and, as expected, the level of NO_2 is highest in Stockholm. Place of residence was part of the matching criteria and was therefore controlled in all the analyses. However, when the median was used as the cutpoint for the reference category, a large proportion of the subjects living in the county of Stockholm fell into the exposed categories. Therefore, analyses were also made with the 75th percentile as the cutpoint, placing subjects with ≤ 49 μg/m^3 in the reference category, 50—79 μg/m^3 in the intermediate category, and ≥ 80 μg/m^3 in the highest exposure category.

Analyses were also made with the NO_2 level estimated on a continuous scale. The results were calculated as risk per microgram of nitrogen dioxide per cubic meter. These analyses assume a log-linear relationship between exposure and disease.

Statistical methods

Matched analyses were performed using conditional logistic regression (11). The random variability was assessed by the 95% confidence intervals (95% CI). Adjustment was made for confounding from magnetic fields and socioeconomic status. Analyses were performed for all cancer types combined and for leukemia and central nervous system tumors separately. Stratum-specific analyses were done for age, gender, and geographic area.

Results

Information about the NO_2 content was obtained for all the 142 eligible cases and for 550 referents. The information from the local health authorities was incomplete for 8 referents, for whom NO_2 levels could not be calculated.

Table 1 displays the results relating NO_2 content to childhood cancer incidence. Adjusting for magnetic field exposure and socioeconomic status did not materially change the results, and therefore crude relative risk estimates are presented. The relative risk for total cancer in the highest exposure category was estimated to be 2.7 (95% CI 0.9—8.5). The risk estimates for leukemia and central nervous system tumors were elevated, but imprecise because of the small number of subjects in the specific diagnostic categories.

Table 2 presents stratum-specific analyses for total cancer according to gender, age, and geographic area. Subdividing the material into smaller strata yielded imprecise risk estimates, but the elevated risk was apparent in all the subcategories. The risk estimates were slightly higher for the younger age groups, but with wide confidence intervals.

Table 3 presents results for different exposure levels. For ≥ 80 μg/m^3 the relative risk was estimated to be 3.8 (95% CI 1.2—12.1). The numbers were too small for cancer site-specific analyses to be performed at this exposure level.

Discussion

The results of this study indicate an association between childhood cancer and motor vehicle exhaust, estimated through

Table 1. Relative risk estimates and 95% confidence intervals (95% CI) for childhood cancer in relation to exposure to nitrogen dioxide. (RR = risk ratio)

Diagnosis	Nitrogen dioxide concentration										RR per μg/m³	
	≤39 μg/m³		40—49 μg/m³				≥50 μg/m³				RR	95% CI
	Cases	Referents	Cases	Referents	RR	95%CI	Cases	Referents	RR	95% CI		
All types of cancer	63	246	35	153	1.3	0.4—4.3	44	151	2.7	0.9—8.5	1.02	1.00—1.04
Leukemia	23	91	7	28	1.7	0.2—14.6	9	32	2.7	0.3—20.6	1.02	0.98—1.06
Central nervous system tumors	16	64	6	32	1.0	0.1—12.7	11	32	5.1	0.4—61.2	1.04	1.00—1.08

Table 2. Relative risk estimates and 95% confidence intervals (95% CI) for total cancer for gender, age, and geographic area in relation to exposure to nitrogen dioxide. (RR = risk ratio)

	Nitrogen dioxide concentration				RR	95% CI
	≤39 μg/m³		≥40 μg/m³			
	Cases	Referents	Cases	Referents		
Gender						
Male	28	114	46	178	1.8	0.4—7.6
Female	35	132	33	126	1.9	0.3—11.7
Age						
0—4 years	29	111	25	97	2.9	0.4—21.6
5—9 years	14	61	21	83	2.4	0.3—18.4
10—15 years	20	74	33	124	1.4	0.3—7.2
Geographic area						
Stockholm	8	35	73	287	2.1	0.4—10.0
Rest of Sweden	55	211	6	17	1.8	0.4—8.4

Table 3. Relative risk estimates and 95% condifence intervals (95% CI) for childhood cancer for total cancer in relation to exposure to nitrogen dioxide. (RR = risk ratio)

Nitrogen dioxide concentration	Cases	Referents	RR	95% CI
≤49 μg/m³	98	399	1	
50—79 μg/m³	36	136	1.9	0.8—4.5
≥80 μg/m³	8	15	3.8	1.2—12.1

NO_2 content in outdoor air. A tendency towards an increased risk with increasing exposure was found. Control of potential confounding factors did not change the results. There was a tendency for higher risk estimates for the younger age groups, but all the confidence intervals were wide, and the results are also compatible with no differences between age groups.

The study was population-based, and the identification of cases and the selection of referents were made in such a way that selection bias was minimized. Furthermore, exposure to motor vehicle exhaust was estimated with greater precision than in previous studies, not only the traffic density near the house being taken into account, but also other factors affecting the exhaust level, such as speed limit, type of street, and background level of NO_2. Collection of the information needed to estimate the exposure, and the calculations of NO_2 were made without knowledge of case-referent status.

An obvious limitation of the study is the small number of cases, and random variation must be considered as a possible explanation for the observed associations. On the other hand, the stratum-specific risk estimates were consistent. Another consideration is the possibility that unmeasured confounding factors may have biased the results, but, as little is known about the etiology of childhood cancer, this possibility is difficult to evaluate. Efforts were made to improve the exposure assessment when compared with the methods used in previous studies, but, nevertheless, misclassification of the exposure is likely to have occurred. Motor vehicle exhaust contains several thousand different compounds, and several have been identified as carcinogenic or probably carcinogenic (eg, benzene, formaldehyde, benzo[a]pyrene) (2). We used the NO_2 content of outdoor air as an exposure indicator, and it may not be the relevant etiologic factor. However, the exposure misclassification is probably independent of the case-referent status and would thus bias the risk estimates towards unity.

There are 2 previous epidemiologic studies that have addressed the possible association between childhood cancer and traffic exhaust (4, 5). In one of the studies, the authors studied the association between electromagnetic field exposure and childhood cancer (4), and traffic density was included for confounding control. The authors did not evaluate the association between traffic density and childhood cancer, but provided enough information to enable additional crude analyses. Exposure to heavy traffic was defined as homes within 40 m of streets having a daily traffic count of 5000 vehicles or more. From the original publication (4) the effect of heavy

traffic on total cancer mortality can be calculated (odds ratio 1.6, 95% CI 1.1—2.3). Information for specific cancer sites was not provided.

Savitz & Feingold (5) also used traffic density (vehicles/day) as an indicator of exposure to motor vehicle exhaust. They found an odds ratio of 1.7 (95% CI 1.0—2.8) for cancer among children exposed to more than 500 vehicles per day. The corresponding result for leukemia was 2.1 (95% CI 1.1—4.0), and for brain tumors it was 1.7 (95% CI 0.8—3.9). A dose-response gradient was evident, with a cutoff score of 10 000 vehicles per day, yielding an odds ratio of 3.1 (95% CI 1.2—8.0) for total cancer and of 4.7 (95% CI 1.6—13.5) for leukemia.

The present study confirms the results found in previous studies and represents an advancement in terms of exposure assessment. However, none of the available studies were originally designed to explore the effect of motor vehicle exhaust. The available evidence suggests that further studies of the effect of motor vehicle exhaust on childhood cancer are warranted.

References

1. Greenberg RS, Shuster JI. Epidemiology of cancer in children. Epidemiol Rev 1985;7:22—49.
2. International Agency for Research on Cancer (IARC). Diesel and gasoline engine exhausts and some nitroarenes. Lyon: IARC, 1989. Monographs on the evaluation of carcinogenic risks to humans, vol 46.
3. Lewtas J. Airborne carcinogens. Pharmacol Toxicol 1993;72 suppl 1:55—63.
4. Wertheimer N, Leeper E. Electrical wiring configurations and childhood cancer. Am J Epidemiol 1979;109:273—84.
5. Savitz DA, Feingold L. Association of childhood cancer with residential traffic density. Scand J Work Environ Health 1989;15:360—3.
6. Pershagen G, Norberg S. Health risk evaluation of nitrogen oxides: epidemiologic studies. Scand J Work Environ Health 1993;19 suppl 2:57—69.
7. Hemminki K, Pershagen G. Cancer risk of air pollution: epidemiological evidence. Environ Health Perspect 1994;102 suppl 4:187—92.
8. Feychting M, Ahlbom A. Magnetic fields and cancer in children residing near Swedish high-voltage power lines. Am J Epidemiol 1993;138:467—81.
9. Swedish Environmental Protection Agency. Beräkning av avgashalter vid gator och vägar — manual. Solna (Sweden): Statens Naturvårdsverk, 1984. Naturvärdsverket meddelande 8/1984. In Swedish.
10. Swedish Environmental Protection Agency. Förenklad modell för beräkning av avgashalter vid landsbygdsvägar. Stockholm: Vattenbyggnadsbyrån, 1989. SNV/VBB, 1989. In Swedish.
11. Breslow NE, Day NE. The analysis of case-control studies. Lyon: International Agency for Research on Cancer, 1980. Statistical methods in cancer research, vol1.

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