EPIDEMIOLOGY OF SELECTED CHILDHOOD CANCERS IN THE CONTEXT OF AIR POLLUTION IN GDAŃSK

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A b s t r a c t

The long-term effects of ambient air pollution are of concern, as many pollutants are carcinogenic, potentially causing various types of cancer, including childhood cancers. The aim of this article is to discuss the incidence of selected cancers in children and adolescents in Gdańsk in the context of air pollution. The research material consists of data on the incidence of selected cancers in children and adolescents aged 0-18 years and data on average annual air pollution concentrations in Gdańsk. Spearman's rank correlation coefficient was used. The incidence of individual cancers varied. The highest average annual concentration of benzo(a)pyrene was recorded in 2014-2015, and the lowest (0.5 ng/m³) in 2023. Due to the small sample size (n = 10) and the exploratory nature of the analysis, there is no basis for drawing firm conclusions. Low correlation coefficients may indicate a lack of a direct, linear, or monotonic relationship between the variables studied. Another important factor influencing the clear conclusions drawn from the study results is the relatively short analysis period. The presented results do not lead to the conclusion of a cause-and-effect relationship.

Keywords: childhood cancers, air pollution, particulate matter, bone cancer, leukemia

1. INTODUCTION

Childhood cancer accounts for approximately 1-2% of all cancer cases, and despite significant progress in treatment and prevention in recent decades, it remains a serious public health problem in Poland and some European Union countries [1]. It is characterized by significant variation in both histology and location. In most European countries, between 120 and 170 new cases are reported annually per million

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children aged 0 to 14. In Europe, nearly 15 000 new cases of cancer are reported each year among children under 14, and nearly 20 000 among young people aged 15-24.

Carcinogenic factors include lifestyle (excessive alcohol consumption, smoking, poor diet), chemical factors (benzo[a]pyrene, benzene, asbestos, particulate matter), and biological factors (HPV, HBV, HCV). Approximately 9 million people worldwide die unintentionally each year due to air pollution. Air pollution also has carcinogenic properties, potentially causing childhood cancers [5-9]. Leukemia is the most common malignancy among pediatric patients worldwide, accounting for approximately 30% of all malignancies among children aged 0-14 years, and 0.10% among children aged 15-19 years. Acute lymphoblastic leukemia (ALL) is a type of malignancy that affects 80% of the pediatric population, with 20% of cases occurring in adults (1-1.5 cases/100/000 per year).The incidence of both ALL and LBL (lymphoblastic lymphoma) in Polish children is between 220-250 cases per year [10,11]. Certain chemicals (e.g., benzo[a]pyrene and nitrogen dioxide) contained in air pollution may also contribute to the development of leukemia [12]. Acute myeloid leukemia (AML) is a hematological malignancy in which morphologically and functionally immature blast cells accumulate. Approximately 5% of children with leukemia are diagnosed with chronic myeloid leukemia [13].

Between the ages of 5 and 14, non-Hodgkin lymphoma (NHL) accounts for approximately 5–7% of all childhood cancers [14].

Hodgkin lymphoma (HL) accounts for approximately 5-7% of childhood cancers and 30% of all lymphomas. It occurs with a frequency of 8-12 cases per 100/000 people under 15 years of age. It is relatively rare in children under 4 years of age. The cause of the disease is also associated with air pollution [15-16].

Malignant bone and cartilage tumors (MNBAC) occur primarily in adolescents and young adults between the ages of 14 and 18. The peak incidence occurs in the second and third decades of life. One of the main risk factors is prenatal exposure to toxic environmental factors, such as benzo(a)pyrene and particulate matter in polluted air [17-18].

The aim of this study is to present the correlation between the incidence of selected cancers in children and adolescents in Gdańsk in the context of air pollution.

2. MATERIALS AND METHODS

The material used in this article consisted of data from the National Health Fund - Pomeranian Voivodeship Branch in Gdańsk on the incidence (per 100,000) of malignant bone and joint cartilage cancer (C40), Hodgkin's disease (C81), nodular and diffuse non-Hodgkin's lymphoma (C82-83), lymphocytic leukemia (C91), and myeloid leukemia (C92) among children and adolescents aged 0 to 18 years who are residents of Gdańsk, from 2014 to 2023. Data on average annual air pollution concentrations (PM2.5 and PM10 particulate matter, nitrogen dioxide, and benzo[a]pyrene) were obtained from the Provincial Inspectorate for Environmental Protection in Gdańsk. In order to determine the relationship between the level of air pollution concentrations and the incidence of selected cancers in Gdańsk, the Spearman rank correlation coefficient was used.

3. RESULTS

The incidence of individual cancers varied. For lymphocytic leukemia, the highest incidence rate was recorded in 2014 (5.28/100 000) and the lowest in 2019 (1.18/100 000). The highest incidence rate for myeloid leukemia was recorded in 2015 (0.78/100 000), and from 2019 to 2023, this incidence rate decreased to 0.59/100,000 and 0.02/100 000 respectively. The highest incidence rate for non-Hodgkin's

lymphoma was recorded in 2018 (1.13/100 000) and the lowest in 2021 (0.17/100 000). In the case of Hodgkin's disease, the highest (2.21/100 000) incidence rate was recorded in 2022 and the lowest (0.36/100 000) in 2021. In the case of bone and joint cartilage cancer of the limbs, the highest (0.55/100 000) incidence rate was recorded in 2021 and the lowest (0.14/100 000) in 2014 (Fig.1).

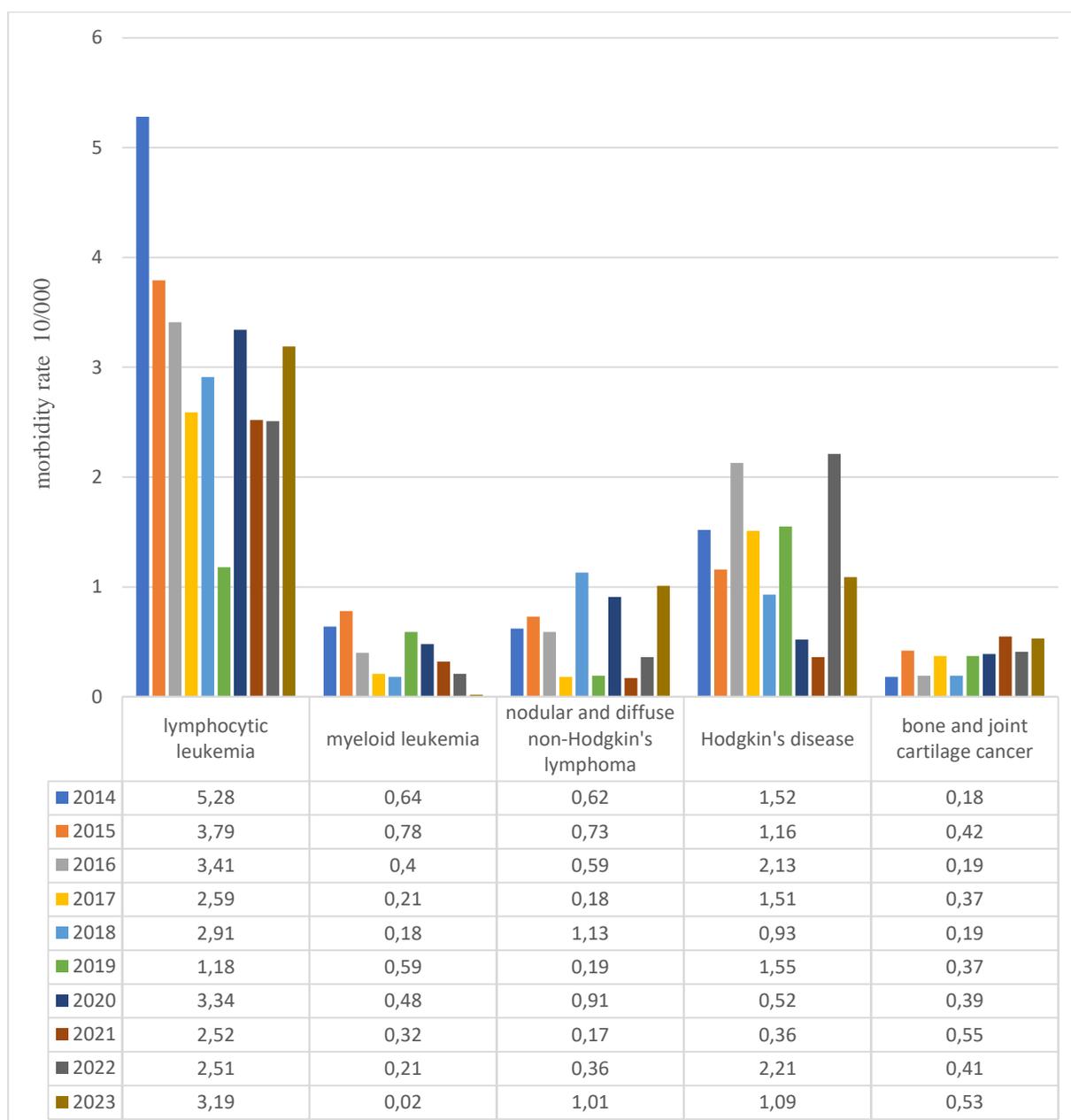|	lymphocytic leukemia	myeloid leukemia	nodular and diffuse non-Hodgkin's lymphoma	Hodgkin's disease	bone and joint cartilage cancer
2014	5,28	0,64	0,62	1,52	0,18
2015	3,79	0,78	0,73	1,16	0,42
2016	3,41	0,4	0,59	2,13	0,19
2017	2,59	0,21	0,18	1,51	0,37
2018	2,91	0,18	1,13	0,93	0,19
2019	1,18	0,59	0,19	1,55	0,37
2020	3,34	0,48	0,91	0,52	0,39
2021	2,52	0,32	0,17	0,36	0,55
2022	2,51	0,21	0,36	2,21	0,41
2023	3,19	0,02	1,01	1,09	0,53

Fig. 1. Incidence of selected malignant tumors in children and adolescents aged 0-18 years in Gdańsk in 2014-2023

Source: prepared based on data from the National Health Fund - Pomeranian Voivodeship Branch in Gdańsk.

The highest average annual concentration of the analyzed air pollutants occurred in 2018 and amounted to 17.8 µg/m³ for nitrogen dioxide, 15.5 µg/m³ for PM2.5 particulate matter and 24.7 µg/m³ for PM10 particulate matter. The lowest average annual concentrations of nitrogen dioxide (12.3 µg/m³) were recorded in 2020, PM2.5 particulate matter (11.4 µg/m³) in 2016 and PM10 particulate matter (15.7 µg/m³) in 2023 (Fig.2).

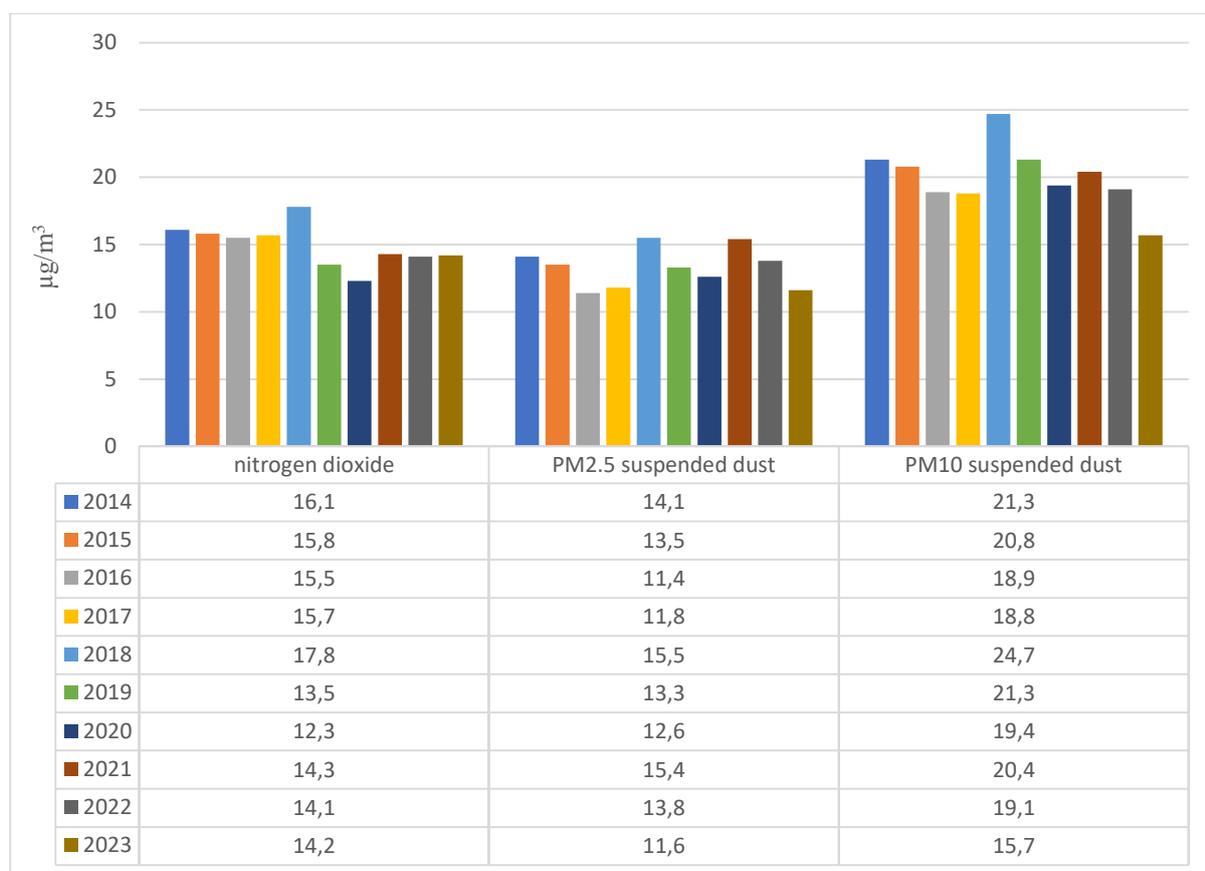|	nitrogen dioxide	PM2.5 suspended dust	PM10 suspended dust
2014	16,1	14,1	21,3
2015	15,8	13,5	20,8
2016	15,5	11,4	18,9
2017	15,7	11,8	18,8
2018	17,8	15,5	24,7
2019	13,5	13,3	21,3
2020	12,3	12,6	19,4
2021	14,3	15,4	20,4
2022	14,1	13,8	19,1
2023	14,2	11,6	15,7

Fig. 2. Average annual concentrations of selected air pollutants in Gdańsk from 2014 to 2023.
Source: Based on data from the Provincial Inspectorate for Environmental Protection in Gdańsk

The highest average annual concentration of benzo(a)pyrene was recorded in 2014 (2.3 ng/m³), 2015 and 2019 (2.2 ng/m³) and the lowest (0.5 ng/m³) in 2023 (Fig. 3).
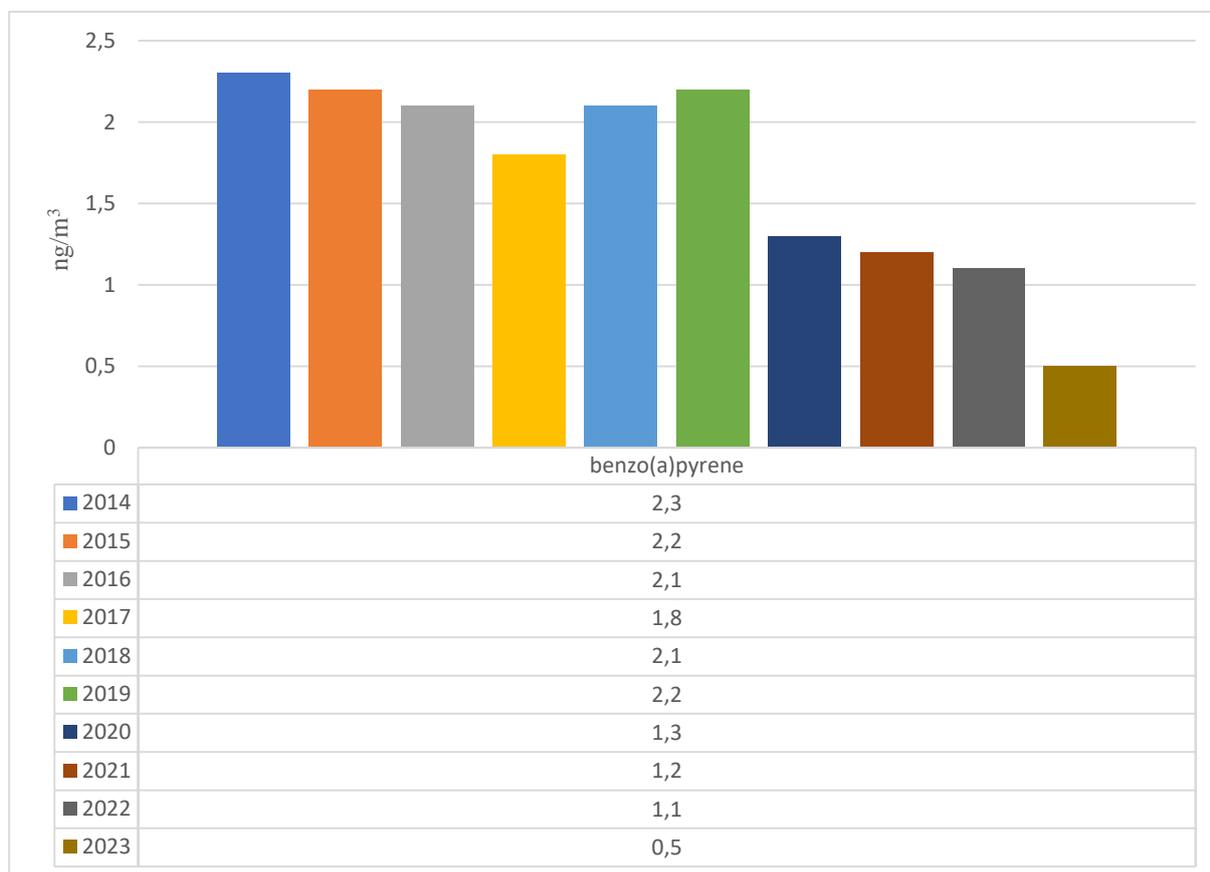
Fig. 3. Average annual concentrations of benzo(a)pyrene in Gdańsk from 2014 to 2023.
Source: Based on data from the Provincial Inspectorate for Environmental Protection in Gdańsk

Spearman's rank correlation coefficient was used to determine the relationship between the concentration levels of selected air pollutants and the incidence of the analyzed cancers. The choice of this test was justified by the small sample size (n = 10). This correlation does not require the assumption of normality of the distribution of variables and is recommended for analyses with small samples. A statistical significance level of $p < 0.05$ was adopted for all analyses.

Table1. Spearman's rank correlations between air pollutants and the incidence of lymphocytic leukemia in Gdańsk

Pollution	N	R Spearmana	p
Nitrogen dioxide	10	0,479	0,162
PM2.5	10	−0,152	0,676
PM10	10	0,036	0,920
Benzo(a)pyrene	10	0,415	0,233

In the case of lymphocytic leukemia, moderately positive Spearman rank correlation coefficients were obtained for nitrogen dioxide and benzo(a)pyrene. However, these correlations did not reach statistical significance. This may indicate a co-occurrence trend between the levels of these pollutants and the incidence of lymphocytic leukemia (Tab.1).

Table 2. Spearman rank correlations between air pollution and the incidence of myeloid leukemia in Gdańsk

Pollution	N	R Spearmana	p
Nitrogen dioxide	10	0,018	0,960
PM2.5	10	0,067	0,854
PM10	10	0,451	0,191
Benzo(a)pyrene	10	0,746	0,013

In the case of myeloid leukemia, a statistically significant, strong positive correlation was found between benzo(a)pyrene levels and the incidence of disease. This result may indicate that higher benzo(a)pyrene concentrations are associated with a higher incidence of disease. The lack of significant correlations for the remaining pollutants suggests that their impact may be weaker, indirect, or masked by other environmental and individual factors (Tab. 2).

Table 3. Spearman's rank correlations between air pollution and the incidence of non-Hodgkin's lymphoma in Gdańsk

Pollution	N	R Spearmana	p
Nitrogen dioxide	10	0,224	0,533
PM2.5	10	0,006	0,987
PM10	10	0,158	0,663
Benzo(a)pyrene	10	0,024	0,947

No statistically significant correlations were observed between the levels of analyzed air pollutants and the incidence of non-Hodgkin's lymphoma. Low correlation coefficients may indicate a lack of a direct linear or monotonic relationship between these variables (Tab. 3).

Table 4. Spearman's rank correlations between air pollutants and the incidence of Hodgkin's disease in Gdańsk

Pollution	N	R Spearmana	p
Nitrogen dioxide	10	−0,055	0,881
PM2.5	10	−0,297	0,405
PM10	10	−0,134	0,713
Benzo(a)pyrene	10	0,256	0,475

In the case of Hodgkin's disease, no statistically significant correlations were found with any of the analyzed pollutants (Tab. 4).

Table 5. Spearman's rank correlations between air pollution and the incidence of bone and joint cartilage cancers in Gdańsk

Pollution	N	R Spearmana	p
Nitrogen dioxide	10	−0,439	0,204
PM2.5	10	−0,024	0,947
PM10	10	−0,382	0,276
Benzo(a)pyrene	10	−0,666	0,036

For the group of bone and articular cartilage cancers of the extremities, a statistically significant, moderately strong negative correlation was found between benzo(a)pyrene levels and incidence. This means that in the analyzed dataset, higher benzo(a)pyrene concentrations were associated with higher incidence.This relationship should not be interpreted as evidence of a causal relationship. The negative correlation may be due to the small sample size, random fluctuations in time-varying values, and the influence of confounding factors. The remaining pollutants did not demonstrate significant associations (Tab.5).

4. DISCUSSION

Over the past few decades, scientific studies have described the potential incidence of childhood cancers associated with air pollution[19-24].

Exposure to air pollution can cause the development of various cancers in childhood, as demonstrated in this article, particularly in relation to leukemia and bone cancer. A study conducted in Denmark examined 1,989 children diagnosed with leukemia, bone cancer, and malignant lymphoma between 1968 and 1991, as well as 15,506 children and adolescents aged 2 to 18 years living in both rural and industrial areas. The children's residential histories were tracked from the age of 9 months until the diagnosis of each cancer. For each of the 17,495 identified addresses, information on the place of residence (rural area, urban area, traffic density, urban development, presence of industrial plants) was collected. Average annual concentrations of particulate matter, benzo[a]pyrene, nitrogen dioxide, and sulfur oxides were then calculated for the study period. The study included periods of pregnancy, childhood, and adolescence. The risk of leukemia and bone cancer was associated with exposure to specific air pollutants, particularly benzo[a]pyrene and nitrogen dioxide. The risk of lymphoma increased by 25% (when benzene concentrations doubled) and 51% (when nitrogen dioxide concentrations doubled) during pregnancy. Later in life (between 2 and 7 years of age), 12% of the study population developed myeloid leukemia and 8% developed Hodgkin's lymphoma [25].

Another study in Brazil examined a total of 2.3 million children between 2002 and 2016, of whom 30.4% were aged 0–4 years, 32.5% were aged 5–9 years, and 37.1% were aged 10–14 years. During this period, 1,145 cases of lymphoid malignancies meeting ICD criteria were recorded. The most common malignancy was lymphocytic leukemia (48.7%), followed by myeloid leukemia (16.3%) and Hodgkin's lymphoma (10.5%). This study found that traffic congestion and high concentrations of nitrogen dioxide and benzo[a]pyrene in the air are associated with increased incidence of Hodgkin's lymphoma and lymphocytic leukemia in children under 14 years of age [26]. Typical exposure measures in other studies have included modeled or measured levels of nitrogen dioxide, particulate matter, benzo(a)pyrene, and sulfur oxides in the immediate vicinity of major roads. Relatively high exposures to myeloid leukemia have been found, especially with high levels of benzene and nitrogen oxides [27-28].

5. CONCLUSIONS

In the pediatric population, air pollution, combined with cancer incidence, is a serious environmental health problem. This article demonstrates that the risk of certain cancers in children and adolescents may be linked to exposure to air pollution. Long-term and short-term exposure to toxic substances suspended in the air induces not only respiratory and cardiovascular diseases, neuropsychiatric and dermatological complications, but also cancer. One of the many ways to counteract air pollution is to prevent its formation by implementing modern industrial technologies that ensure reduced emissions of gases and particulate matter into the atmosphere. Sources of air pollution are clearly linked to human economic activity, therefore, strategies should be developed to increase cooperation between developed and developing countries to counteract the health effects of air pollution. Environmental education, conducted from the earliest years of childhood, can also play a crucial role. Furthermore, to further highlight the correlation between air pollution levels and childhood cancers, further research is needed to assess the potential impact of air pollution on childhood cancers. This requires advanced methodology and statistics, as well as a larger sample of children

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