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BRONCHIAL ASTHMA IN CHILDREN OF UKRAINE: MEDICAL AND ENVIRONMENTAL PARALLELS OF MORBIDITY AND PREVALENCE

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Ключевые слова: *дети, заболеваемость, распространенность, бронхиальная астма, окружающая среда, поллютанты*

Abstract. Bronchial asthma in children of Ukraine: medical and environmental parallels of morbidity and prevalence. Volosovets O.P., Bolbot Y.K., Kryvopustov S.P., Mozyrska O.V., Kryvopustova M.V., Prokhorova M.P., Kupkina A.V. *Bronchial asthma is one of the most common non-infectious diseases of children worldwide. More than half of such clinical cases may lead to functional disability and significantly affects the quality of life of a sick child. The aim of the study was to research trends in the incidence and prevalence of bronchial asthma among children in different regions of Ukraine over the past 25 years and assess the effect of air pollutant emissions from stationary sources in the region of children residence on the incidence and prevalence of bronchial asthma among them. According to the Center for Medical Statistics of the Ministry of Health of Ukraine, the incidence of bronchial asthma among children aged 0-17 years was 4513 0.59 of new cases per 1000 population in 2017. Prevalence of this disease was 37246 cases (4.91 per 1000 population). The majority of newly diagnosed bronchial asthma cases was observed in children aged 7-14 years – 2439 or 54.0% of the total, which is in line with global trends. The highest incidence and prevalence in all three age groups was observed among children of Kyiv and Kharkiv, Zaporizhia, Vinnitsa, Dnipropetrovsk, Donetsk regions. We have discovered a direct and close connection (ρ=0.741) between the reduction of air pollutant emissions from stationary sources and decreasing of the prevalence of bronchial asthma among children in recent years. Over the past 25 years in Ukraine there has been 69.3% increase in prevalence and 22.9% increase in incidence of bronchial asthma among children. Predominance of detecting this pathology was in the group of children from large industrial and agro-industrial regions of the country with significant volumes of atmospheric pollutants from stationary sources of pollution.*

Реферат. Бронхиальная астма у детей Украины: медико-экологические параллели заболеваемости и распространенности. Волосовец А.П., Больбот Ю.К., Кривопустов С.П., Мозырская Е.В., Кривопустова М.В., Прохорова М.П., Купкина А.В. *Бронхиальная астма (далее – БА) остается одной из самых распространенных неинфекционных болезней у детей во всем мире, которая более чем в половине случаев приводит к инвалидизации и существенно влияет на качество жизни больного ребенка. Целью исследования было определение трендов заболеваемости и распространенности бронхиальной астмы у детей Украины в динамике за последние 25 лет в областях Украины и оценка влияния объемов выбросов загрязняющих веществ в атмосферный воздух от стационарных источников загрязнения в регионе проживания на уровни заболеваемости БА у детей и ее распространенность. По данным Центра медицинской статистики МЗ Украины заболеваемость детей в возрасте 0-17 лет бронхиальной астмой в 2017 году составляла 4513 новых случаев БА или 0,59 на 1 тыс. населения, а распространенность составляла 37246, или 4,91 на 1000 населения. Больше всего впервые выявленных случаев БА наблюдалось у детей в возрасте 7-14 лет – 2439, или 54,0% от общего количества, что соответствует мировым тенденциям. Наибольший уровень заболеваемости и распространенности наблюдался у детей Харьковской, Запорожской, Винницкой, Днепропетровской, Донецкой областей и г. Киеве. Нами установлена прямая и тесная связь (ρ=0,741) между уменьшением объемов выбросов загрязнителей от стационарных источников в атмосферный воздух и уменьшением распространенности БА у детей в последние годы. Таким образом, за последние 25 лет в Украине наблюдается рост на 69,3% распространенности бронхиальной астмы у детей и на 22,9% уровня заболеваемости бронхиальной астмой с преобладанием выявления этой патологии у детей из крупных промышленных и агропромышленных областей страны со значительными объемами выбросов загрязняющих веществ в атмосферный воздух от стационарных источников загрязнения.*

Today, the global asthma epidemic continues worldwide and there is a large geographical difference in the prevalence, severity and mortality of asthma [9, 10, 14]. Bronchial asthma (hereinafter –asthma) remains one of the most common non-communicable childhood diseases worldwide, which in more than half of cases leads to disability, significantly affects the quality of life of a sick child and the moral and psychological state of his family [7, 12 , 15]. Among children, the incidence of asthma varies between 5-10% and depends on the level of development of the country and the state of health of the population [9, 10].

According to the Center for Medical Statistics of the Ministry of Health of Ukraine, in recent years the incidence of asthma in children ranges from 0.6 to 0.5%, which, in particular, indicates the problem of underdiagnosis of the disease [1]. According to a number of experts, the actual number of cases of asthma in children from Eastern Europe may be 5-6 times higher than official statistics, which should be taken into account in the final assessment of the health system needs for this group of patients [5]. Thus, in Ukraine, according to Antipkin YG, according to the results of unified studies (ISAAC), the prevalence of asthma in children can range from 5% to 22% [1].

Although the possible triggers for the development of asthma have been sufficiently studied, the study of possible heredity-environmental interactions may help to better reveal the determinants of asthma [9]. There is ample proof that air pollutants, such as vehicle emissions, industrial emissions, and tobacco smoke reduce lung function in children, exacerbate asthma and increase hospitalizations [4, 13, 17, 18].

In our opinion, such regularities fully apply to Ukraine, which is a country with ecological crises. Thus, in 2017 alone, the country's atmosphere was polluted with 2.58 million tons of pollutants, which together with other factors, including radiation, certainly affects the health of children in Ukraine in the post-Chernobyl era [3, 11, 19].

Despite the progress in the treatment of asthma in recent decades, it is necessary to improve its diagnosis in order to identify all predictors of the disease [10, 12, 15]. The role of environmental factors in the etiology of asthma remains largely uncertain until the end [9, 10].

Therefore, the aim of the study was to determine the trends in the incidence and prevalence of asthma in children in the dynamics over the past 25 years in the regions of Ukraine and to assess the impact of pollutant emissions from stationary sources in the region of residence on the incidence of asthma in children. and its prevalence.

MATERIALS AND METHODS OF RESEARCH

A study of a 25-year trends in the incidence and prevalence of asthma in children aged 0-17 years living in regions of Ukraine with different levels of ecotoxic pressure on the body was carried out.

Methods of statistical assessment and epidemiological analysis of relevant data of the Center for Medical Statistics of the Ministry of Health of Ukraine from 1993 to 2018 were used.

Statistical evaluation methods were used, in particular the U-criterion of signed ranks (Wilcoxon-Mann – Whitney test) to compare the incidence of asthma in children from the same regions of Ukraine at different times [6]. Cluster assessment of regions

of Ukraine according to the levels of asthma morbidity in children was carried out by the method of K-means due to the ratio of levels of asthma morbidity in children to the national level and in accordance with the emissions of pollutants into the atmosphere [6]. Volumes of pollutant emissions into the atmosphere in 2017 were established in accordance with the data of the annual statistical collection of the State Statistics Service of Ukraine for 2017 [11].

To establish a linear relationship and determine the correlation and possible relationship between the volume of pollutant emissions into the atmosphere from stationary sources of pollution (hereinafter – the volume of pollutant emissions) and the incidence and prevalence of asthma in children from different regions, Spearman's rank correlation coefficient was used (Spearman`s rank correlation coefficient) [16]. Statistical processing of research results was conducted using the software product STATISTICA 6.1 (StatSoftInc., serial № AGAR909E415822FA) and Excel-2010.

The study was conducted in accordance with the main provisions of the ICH GCP and the Helsinki Declaration on the Ethical Principles of Medical Research Relating to Human Subjects and its Revisions (Seoul, 2008), the Council of Europe Convention on Human Rights and Biomedicine (2007), recommendations of the Committee on Bioethics under the Presidium of the National Academy of Medical Sciences of Ukraine (2002) and the provisions of the Ethics Committee of O.O. Bogomolets National Medical University [2, 8, 20].

RESULTS AND DISCUSSION

According to the Center for Medical Statistics of the Ministry of Health of Ukraine, the incidence of bronchial asthma in children aged 0-17 years in 2017 was 4513 new cases of asthma, or 0.59 per 1 thousand of children, and the prevalence was 37246, or 4.91 per 1000 of children. In 2019, 2,073 children with disabilities due to asthma were under dispensary observation. Among them, the disability of severe asthma in 226 children was established for the first time, which significantly impaired their functional capabilities and quality of life. The most of such cases was among school-age children (1265 people), prevalently from the western regions of the country.

For comparison, in 1993, 5,256 cases of asthma were detected for the first time, or 0.48 per 1,000 of children. The prevalence of bronchial asthma was then 31,305, or 2.9 per 1,000 of children aged 0 to 14 years. The share of asthma among all registered diseases of the pediatric population in Ukraine is – 0.32, which does not reduce the socio-medical significance of this complex disease.

As illustrated in Figure 1, over 25 years the prevalence of asthma in children of the country increased by 69.3% ($p>0.05$), and the incidence – by 22.9% ($p>0.05$). The Mann-Whitney U-rank criterion reached 76.5 and 169, respectively, but these critical values were outside the zone of significance for a certain number of comparable groups of indicators. These data correspond to the global trend of increasing asthma incidence in most countries of the world, especially among the developing ones. The first wave of asthma incidence increased by 79.2% from 1993 to 2001, then the incidence of asthma began to decrease, reaching a relative minimum in 2015 (0.50 per 1,000 children). In 2017 there was a moderate increase (+ 18%) in this indicator to 0.59 per 1,000 of children.

It is worth noting that after 2018, the collection of statistical information on the incidence and prevalence of childhood diseases, including asthma, with the exception of socially significant diseases stopped for the reasons unknown to the medical community.

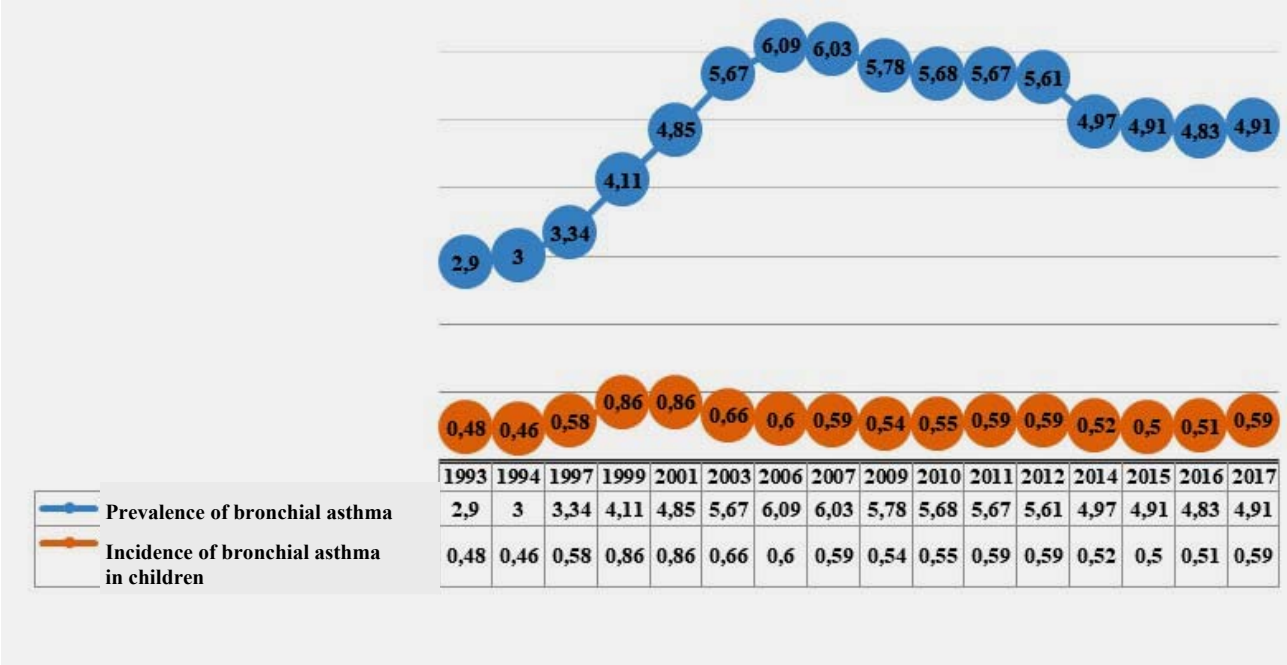
The maximum prevalence of asthma in children was observed in 2006 (6.09 per 1000 of population) with a significant decrease by 15.05% at this time, which also occurred against the background of decreasing incidence in recent years (Fig. 1).

Such fluctuations in the values of the prevalence and incidence of asthma in children can be explained by the appropriate trend of the system of medical care delivery to children as for the registration of patients' encounters, not due to their active detection. The reduction in the number of pediatricians and pediatric allergists in the country, the lack of sanitary and educational work with the population and the reduction of the corresponding vigilance among primary care physicians also play a role in these processes.

In our opinion, one of the possible factors of decreasing the prevalence of asthma in children can be considered a by 20.2% reduction of pollutant emissions from stationary sources into the atmosphere from 3928 thousand tons in 2009 to 2585 thousand tons in 2017 due to the reduction of industrial capacity, primarily in Donetsk and Luhansk regions due to ongoing hostilities in these regions [11].

We have established a direct and close relationship between the reduction of pollutant emissions from stationary sources into the atmosphere and the decrease in the prevalence of asthma in children. The determined critical value of the Spearman correlation coefficient (ρ), which reached the

level of 0.741 indicates a close and strong relationship between these groups of indicators by the Chaddock scale with the number of degrees of freedom (f) – 5.



	1993	1994	1997	1999	2001	2003	2006	2007	2009	2010	2011	2012	2014	2015	2016	2017
Prevalence of bronchial asthma	2,9	3	3,34	4,11	4,85	5,67	6,09	6,03	5,78	5,68	5,67	5,61	4,97	4,91	4,83	4,91
Incidence of bronchial asthma in children	0,48	0,46	0,58	0,86	0,86	0,66	0,6	0,59	0,54	0,55	0,59	0,59	0,52	0,5	0,51	0,59

Fig. 1. Comparative dynamics of prevalence and incidence of bronchial asthma in children of Ukraine (1993-2017)

It should be noted that for 25 years the rate of increase in asthma incidence in disease children in the country corresponded to the increase in the overall incidence of children in Ukraine. In general, the growth rate of asthma in children in Ukraine for 25 years exceeded the growth rate of the overall prevalence of diseases in children of Ukraine by 1.5 times [19].

In terms of age, most cases of asthma detected for the first time in children aged 7-14 years was 2439, or 54.0% of the total number, which corresponds to global trends [9, 10]. In children aged 0 to 6 years, 35.7% (1615 people) of the total number of cases of bronchial asthma were detected for the first time. The lowest incidence of asthma was between the age of 15 and 17 – 10.2% of the total. The highest level of morbidity and prevalence in all three age groups was observed in children of Kharkiv, Zaporizhzhia, Vinnytsia, Dnipropetrovsk and Donetsk regions.

The incidence rates of children with asthma aged 0 to 6 years were twice as high as the national average (0.51 per 1,000 of population) in Kharkiv and Vinnytsia regions – 1.2 and 1.11 per 1,000 of population, respectively. The incidence of asthma in children aged 7 to 14 in Kherson and Zaporizhzhia regions was almost twice as high as the national average (0.72 per 1,000 of population) – 1.48 and 1.41 per 1,000 of population, respectively. The highest incidence of children with asthma (1.8 times higher than the national rate) was observed in adolescents in Kyiv and Kharkiv region – 7.6 and 7.5 per 1000 population, respectively.

The highest incidence of asthma in children aged 0 to 6 years was in Vinnytsia region – 3.7 per 1,000 of population, those of aged 7 to 14 years – in Kharkiv region – 11.4 per 1,000 of population. The highest prevalence of asthma was observed in adolescents in Kyiv – 20.4 per 1,000 of population.

The lowest number of asthma cases was detected in adolescents aged 15 to 17, only 459, which was 10.3% of the total number of newly diagnosed patients with asthma among children in the country. However, it was in adolescence that the highest prevalence of asthma was observed – up to 87.0 per 10,000 children against 67.9 in children aged 7 to 14 years and 16.2 at the age of 0-6 years.

In the dynamics of the last 6 years there were moderate changes in the age structure of the incidence of asthma: it increased by 2.8% in children aged 7-14 years, increased by 5% in adolescents, and in children 0-6 years the incidence of asthma decreased by 8.5%.

Apparently, this is partly due to the increase in the ecotoxic load on the child's body, which may be due not only to the factors of the polluted

environment, but also to the spread of smoking in school-age children.

The prevalence of asthma in relation to the age structure of patients decreased in all age groups: by 12.5% in school-age children, by 19% in children aged 0 to 6 years and by 5.6% in adolescents.

As illustrated in Figure 2, the highest number of cases of asthma detected for the first time in 2017 in children aged 0 to 17 years was in Kharkiv (1.21 per 1000 of children), Kherson (1.5), Zaporizhzhia (1.04), Vinnytsia (0.95), Dnipropetrovsk (0.81), Donetsk (0.8) regions, which, according to the State Statistics Service of Ukraine, are characterized as one of the highest emissions of pollutants into the atmosphere from stationary sources of pollution due to excessive developed infrastructure and agricultural production [11].

Fig. 2. Map of bronchial asthma incidence in children in Ukraine in the year 2017

It should be noted that according to the current legislation, Vinnytsia region is included in the list of regions with areas of in-depth radiological control after the accident at the Chernobyl nuclear power plant in 1986.

The lowest number of cases of asthma detected for the first time in children was in Odesa (0.30 cases per 1000 of children), Rivne (0.32), Sumy (0.37) and Khmelnytsky (0.39) regions.

In 1993, among the leaders in the incidence of asthma in children were also areas with a difficult environmental situation: Zaporizhzhia (6.69 per 1000 of children), Dnipropetrovsk (4.78) regions, Kyiv (4.63), Cherkasy 4.11), Vinnytsia (3.97), Lviv (3.6) and Kherson (3.56) regions. At present, the leadership in the incidence of asthma in children has changed: Kharkiv and Kherson regions have become the leaders. Obviously, this can be explained, in particular, by the dynamic development of industry and the agricultural sector in these regions, this has increased the ecotoxic pressure on the child's body.

High prevalence of asthma in 2017 was registered in Kharkiv region (8.09 per 1000 children), Kyiv (7.59 per 1000 children), Vinnytsia (7.3), Zaporizhzhia (6.93), Dnipropetrovsk (6.8,), Ivano-Frankivsk (6.85), Donetsk (5.95) regions.

The lowest prevalence of asthma was observed in Kirovohrad (2.95 per 1000 of children), Khmel-

nytsky (3.03), Rivne (3.08), Luhansk (3.33), Sumy (3.5), Mykolaiv (3) , 56) and Odessa (3.62) regions.

It should be noted that 25 years ago, the leaders in the prevalence of asthma in children were dominated by regions and cities with significant emissions of pollutants into the atmosphere, namely: Zaporizhzhia (6.69 per 1,000 population), Dnipropetrovsk (4.78) region, Kyiv (4.63), Cherkasy (4.11), Lviv (3.6), Kherson (3.56) and Luhansk (3.29) regions.

The lowest prevalence of asthma was observed in Zakarpattia (0.97 per 1000 population), Volyn (1.0), Rivne (1.11), Kirovohrad (1.12), Zhytomyr (1.64), Chernihiv (1.69), Khmelnytsky (1.75), Poltava (1.87) regions.

A comparative analysis of the prevalence of asthma in children of Ukraine made 25 years ago in terms of areas with areas of radiological control (hereinafter – TRC) and other areas, revealed that in 8 out of 9 regions with TRC it was much lower than the national average.

It should be noted that during 25 years of observation in Kharkiv, Chernivtsi, Volyn, Zhytomyr, Chernihiv regions there was the largest increase in children incidence in asthma, respectively +290.3%, +208.0%, 192.8%, +128% and +96.5% compared with the incidence of asthma in 1993. While among other regions the increase in morbidity ranged from +8.6% to +90.0%. A negative increase in the incidence of asthma was observed in children of Dnipropetrovsk (-18.2%), Cherkasy (-17.5%), Lviv (-2.1%) regions and the city of Kyiv (-16.25%).

The clustering of regions of Ukraine depending on the incidence rates of asthma and the distribution of regions depending on the volumes of pollutant emissions into the atmosphere per 1 person are presented in the Table. The national emission indicator was 60.8 kg of emissions per person per year.

We found a direct effect of moderate force (ρ=0.391) on the relationship between the volume of pollutant emissions from stationary sources into the atmosphere per person and the incidence of asthma in children. The determined critical value of the Spearman correlation coefficient with the number of degrees of freedom (f) – 23 indicates that the dependence of the traits was statistically insignificant ($p>0.05$).

Clustering of regions of Ukraine by levels of asthma incidence and emissions of pollutants into the atmosphere per capita

The incidence of children with asthma	Regions of Ukraine	Volumes of pollutant emissions into the atmosphere per capita	Regions of Ukraine
Very high incidence of asthma in children	Kharkiv Kherson	Very high emissions	Dnipropetrovsk Donetsk
High incidence of asthma in children	Zaporizhzhia, Vinnytsia Dnipropetrovsk Donetsk	High emissions	
Incidence of asthma in children is close to the national indicator	Chernivtsi City of. Kyiv Luhansk Ivano-Frankivsk Transcarpathian Ternopil Cherkasy Zhytomyr Chernihiv Lviv	Emissions at the level of the national indicator	Ivano-Frankivsk Zaporizhzhia
Low incidence of asthma in children	Volyn Poltava Mykolaiv Khmelnytsky Kirovohrad Sumy Rivne Odessa	Emissions below the national average	Poltava Cherkasy Luhansk Chernihiv, Kyiv Sumy Kharkiv, Khmelnytsky City of Kyiv Kirovograd Mykolaiv, Odessa Ternopil, Kherson, Zhytomyr, Volyn, Rivne Chernivtsi Transcarpathian

CONCLUSIONS

Over the past 25 years in Ukraine there has been 69.3% increase in the prevalence of bronchial asthma in children and 22.9% – incidence of bronchial asthma with a predominance of detection of this pathology in children from large industrial and agricultural-industrial regions of the country with significant emissions of pollutants from stationary sources of pollution into the atmospheric air, this has a direct effect of moderate force on both increasing and decreasing detection of the number of cases of bronchial asthma in children at different time intervals.

Conflict of interest. The authors declare no conflict of interest.

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