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The impact of vehicle emissions on child morbidity of Lviv urban system

Wpływ spalin transportu samochodowego na choroby wśród dzieci w systemie miejskim Lwowa

Słowa kluczowe: zdrowie, choroby, spaliny transportu samochodowego, analiza korelacyjna i regresyjna

Key words: health, morbidity, vehicle emissions, correlative and regression analysis

INTRODUCTION

The processes of urbanization, economic development and the growth of technology are strongly associated with motorization. The number of vehicles worldwide increases by 36 million every year (Даценко et al. 1997). At the present time auto transport has become the main source of air pollution in the cities. It produces a great amount of pollutants that exceeds the emissions of power sector, industry and other branches of economics combined.

Adverse effect of environmental factors causes the increase of population morbidity, birth defects and physical developmental disturbances, as well as mortality rate (Бердник 2005). As a whole ecopathogenic factors of man-made environment have a negative influence on population health. It is seen in the chronic pathology development of different organs and systems, such as respiratory, digestive and urogenital systems most of all, in a great number of allergic diseases, increase of birth defects and genetic diseases, as well as oncopathology. Disorders of cytogenetic homeostasis are caused by adverse environmental factors and toxic effect on the human body (Сердюк 2011).

One of the most dangerous effects of toxic substances on human body is aerogenic effect because of the anatomico-physiological properties of respiratory system and the fact that a human body is not able to control the quality of the air that is consumed (Білецька 2010).

Therefore, the problem of the effects of vehicle emissions on population health is one of the most significant problems nowadays, especially in the big urban systems where the growing of traffic load is constant.

Environmental state of Lviv urban ecosystem is affected by a very specific and closely related complex of natural, city-building, engineering, socioeconomic and other conditions. In spite of a decline in industrial production, ecological situation in Lviv, as well as in Ukraine, remains tense which creates a number of problems both for city and region citizens. Lviv urban ecosystem is characterized by an increasing effect of transport and it is its main atmosphere pollutant. In 2011, 89% of all pollutants were vehicle emissions in Lviv urban system (Статистичний щорічник Львова за 2010 рік). The circumstances that were mentioned above make Lviv urban system a perfect testing ground for researches in Applied Medical Geography.

The studies of the effect of air pollution on population health of urban systems were made by Hutsuliak V. M. and Nakonechna K. P., 2010; Shevchuk L. T., 1997; Voloshin I. M. et al., 2011; Konitsula T. J., 2008; Litvinova O. N., 2003; Prokopenko N. O., 2009; Zahorodnij V. V., 2011; Turos O. I., 2008.

To investigate the effect of vehicle emissions in Lviv urban system on morbidity indicators we selected child population in the age group 0–14 because primarily this category is the most attached to its residence place, and secondly, it is the least protected and most affected by negative impact on the environment. Concerning adverse effects of the environment on the health of the body, child population is the most vulnerable group because of the imperfect development of all functional systems. Cells of a younger body have more genetic errors because they adsorb more chemical toxins per weight unit (Віштак 2011).

The object of research is the health of child population of Lviv urban system. The subject of research is the impact of vehicle emissions on population health. The aim of research is to study the impact of vehicle emissions on population health of urban system, to identify patterns of its influence in space and time (for example Lviv urban system). We set the following objectives in the paper:

– to describe the prevalence of diseases among children in Lviv during 2000–2011;

– to conduct correlation and regression analysis between vehicle emissions and child morbidity of Lviv urban system.

While studying this subject we used a specially selected system of methods. We applied the general principles of scientific reasoning: induction, deduction,

analysis and synthesis, analogy. In addition, we applied such methods: literature, comparison, narrative, descriptive statistics, a number of statistical and mathematical methods. An important part of the study of the effects of vehicle emissions on child population health was epidemiological method, including its methods – ecological (or correlation) studies, retrospective epidemiological analysis of statistical observation (monitoring).

An important role is given to the basic methods of geography – geo-method that reveals the connection between things in space and time; modeling, mapping and systematic approach.

This study was conducted in the following stages: stock data collection of healthcare department and environmental mobile laboratory of Lviv city council, city sanitary-epidemiological station; primary data processing was made by applying emission factors of the mobile laboratory and zoning structures of Lviv healthcare; the primary statistical data processing was made by compiling a database of emission factors and child morbidity in Lviv; analytical and integrative stages were made by statistical correlation analysis that determined the relation between emission factors and child morbidity of Lviv urban system according to the main classes of diseases. To study the statistics and their visualization we used such software as STATISTICA, Excel, ArcGIS 10.

PRESENTATION OF THEORETICAL MATERIAL

An important part of the study of population health belongs to morbidity and disease prevalence rate among the population. The methods for studying the overall morbidity according to its applications were proposed by sanitary doctors E. A. Osypov, P. I. Kurkin, S. M. Bohoslovskyj et al. The priority of health statistics of studying general morbidity according to the materials was convincingly confirmed by the International hygiene exhibition in Dresden in 1911 (Соціальна медицина 2007). The statistics of morbidity are considered one of the most important aspects of population health characteristics. There are several definitions of it based on the approaches to the study of the concept of health.

Human health as an individual (biological and social concepts) is a state of complete physical, mental and social well-being and not only the absence of disease and physical defects.

Human health (statistical concept) is characterized by a set of demographic factors, demographic processes, primarily fertility, mortality, physical development, morbidity and disability.

Human health (practical concept) is a functional state of body which provides duration of life, physical and mental capacity, health and recreation function.

Public health is understood as population health that is caused by the complex effect of social and biological factors of environment which is assessed by demo-

graphics, characteristics of physical development, morbidity and disability. It has a special meaning of socio-political and economic order and factors depending on the terms of a collective life (work, life, rest, nutrition, literacy rate, education, culture, health, etc.).

Disease is a disorder of body viability, its relation with the environment, resulting in temporary or permanent reduction or disability (activity).

Premorbid state is a state of body that precedes and contributes to the development of the disease.

Morbidity is a level and frequency of prevalence of diseases all together and each individually among the population as a whole and its individual age, sex, social, professional and other groups (*Соціальна медицина* 2007).

A concept of disease in medical geography is considered as a specific disease in a certain population group, and it is a function of area (Шевченко 1994).

While studying the concept of disease, we distinguish three groups: the actual morbidity (primary disease), disease prevalence (morbidity, the overall morbidity) and pathological affection.

Actual morbidity (primary disease) is the first diagnosed disease within a year. This indicator is the most responsive to changes in the environment during the year for which it is studied.

Primary morbidity rate is the ratio of the number of newly registered diseases and injuries for a certain period of time (usually a year) to the number of people for such time; it is defined for a different number of people (100, 1000, etc., in accordance %, ‰). By analyzing this indicator for years we can get the most correct idea of the occurrence and dynamics of morbidity, also we can learn about the question that is the most important in our study – the impact of environmental conditions on the morbidity rate.

By morbidity prevalence is understood all diseases among the population that were identified and registered regardless of the time of their origin and primary diagnosis for a certain period (year). This factor is more resistant to various environmental effects, and its growth does not mean negative changes in health state of the population, but rather shows the achievements of medical science and practice in the treatment of patients and continuation of their lives, which leads to the "accumulation" of contingents standing on the records.

By pathological vulnerability are meant diseases which were recorded among the population at a certain time during the medical examination. This indicator is used to determine the frequency of pathology among the population, which is set during the medical examinations (*Соціальна медицина* 2007).

Health statistics serve as the sources for the research on morbidity. In Ukraine there has been established the International Statistical Classification of Diseases, Injuries and Causes of Death of X view, according to which they are divided

according to etiology, pathogenesis and localization of the relevant classes, groups and sections.

By pollution we understand the presence of chemicals in natural ingredients and their origin must be connected to anthropogenic activity (Шевченко 1994).

RESULTS AND DISCUSSION

The data of mobile environmental laboratory in 2010–2011 were analyzed by author to characterize the atmospheric component of Lviv urban system. On its basis we can clearly see the relation between the growing number of vehicles and the overall rate of air pollution. Large transport interchanges and narrow main streets with lots of traffic are the most polluted. Even a small amount of green space considerably reduces the overall rate of pollution by vehicle emissions. Pollution indicators are more less in places with no traffic movement and park areas than on the main streets.

Having analyzed the data of healthcare department of Lviv City Council regarding child morbidity in Lviv urban system, we calculated the prevalence of diseases (morbidity) for each pediatric unit and Lviv as a whole. The structure of disease prevalence by classes of diseases in Lviv in 2011 is as follows: first place – respiratory diseases – 62.7%, second place - endocrine, nutritional and metabolic diseases – 5%, third place – eye diseases – 4.6%. Such factors of disease prevalence by classes of diseases have increased over the last 11 years in Lviv urban system: neoplasms +1.7%; diseases of the nervous system +22.9%; cardiovascular diseases +7.7%; diseases of skin and subcutaneous tissue +20, 6%; congenital anomalies (malformations, deformations and chromosomal abnormalities) +22.8%.

There are slightly different factors in the structure of primary morbidity. The highest rate of primary morbidity in Lviv urban system in 2011 belongs to respiratory diseases – 74%; second place belongs to ear and mastoid diseases – 5%; and third place belongs to diseases of skin and subcutaneous tissue – 4%. The growth of morbidity rate is observed in tumors +54.3% comparing with 2000 year, in diseases of skin and subcutaneous tissue +24.2%; congenital anomalies (malformations, deformations and chromosomal abnormalities) +17.9%; nervous system diseases +15.7%.

Physician scientists have proven the negative impact of air on the occurrence of diseases of respiratory system, circulatory system, congenital anomalies, diseases of eye, nervous system, etc. (Даценко et al. 2000).

To analyze the effect of vehicle emissions on population health of Lviv urban system we collected healthcare department data about child morbidity in Lviv in 2011, as well as data from Lviv City Council mobile environmental laboratory “Administrative and technical management” about air pollution

by vehicle emissions in 2010 and 2011. Collected indicators of morbidity and vehicle emissions were placed on the map of pediatric stations, therefore grouped geographically. The next step was their processing using statistical software. Correlation analysis conducted in the package STATISTICA 6.1 showed the presence of statistically significant relations (r – correlation coefficient, p – level of significance):

– between emissions of CO in 2010 and the overall morbidity: diseases of the nervous system (r = 0,81, p = 0.008); eye diseases (r = 0.774, p = 0.014); diseases of the circulatory system (r = 0.729, p = 0.026);

– between emissions of CO in 2010 and the primary child morbidity: bronchial asthma (r = 0,717, p = 0,030, Figure 1); diseases of the nervous system (r = 0.773, p = 0.015, Figure 2); eye diseases (r = 0.814, p = 0.008, Figure 3), diseases of the circulatory system (r = 0,706, p = 0.033, Figure 4);

– between NO emissions in 2011 and primary diseases of the digestive system (r = 0.778, p = 0.014);

– between NO_2 emissions in 2011 and primary diseases of the digestive system (r = 0.763, p = 0.017).

The results of the package STATISTICA 6.1 of regression analysis of the depending of certain diseases and emissions are shown in Tables 1–3, where b0 – free term, b1– dependency ratio, R2 – coefficient of determination, F – value of Fisher's exact test, p – level of significance.

Thus, the increase of the concentration of carbon monoxide at 1 mg/m^3 causes an increase of nervous system diseases in child morbidity of Lviv urban system – by 222 persons, eye diseases – by 310 people, diseases of the circulatory system – by 144 persons (Table 1).

Tab. 1. Results of regression analysis of relations between indicators of child morbidity in 2011 and vehicle emissions in 2012 of Lviv urban system

Type of disease	Emission	b0	b1	R2	F	p
Nervous system diseases	CO	–1642.57	222.66	0.654	13.24	0.008
Eye diseases	CO	–2152.91	310.82	0.599	10.48	0.014
Circulatory system diseases	CO	–1192.45	144.71	0.532	7.943	0.026

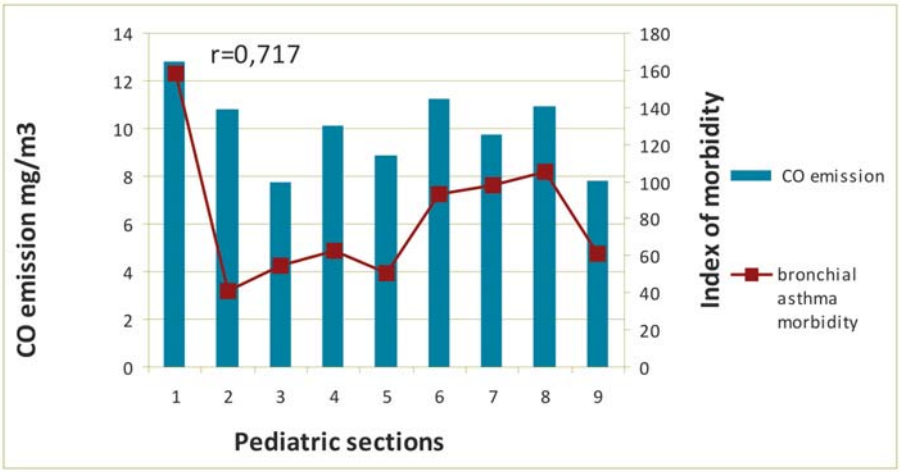

Fig. 1. Correlation between primary asthma morbidity among child population of Lviv urban system and CO emissions with a one-year delay

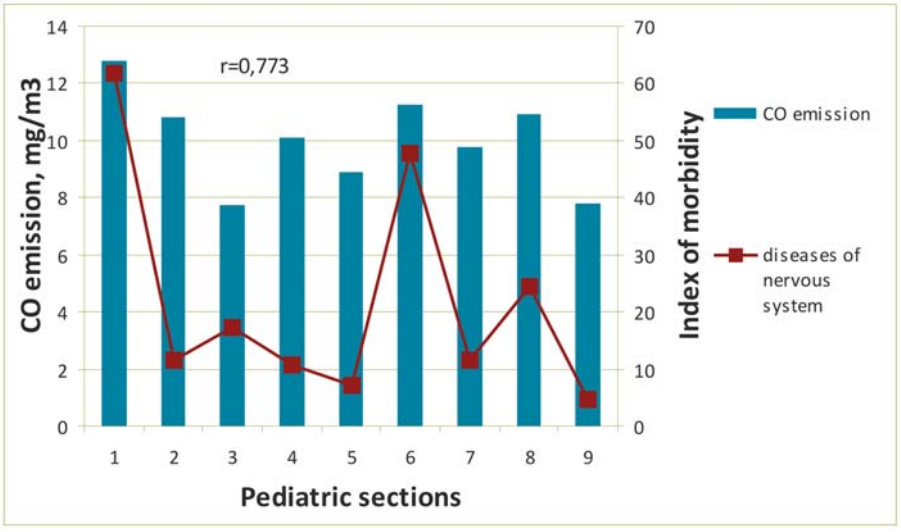

Fig. 2. The correlation between primary nervous system morbidity among child population of Lviv urban system and CO emissions with a one-year delay

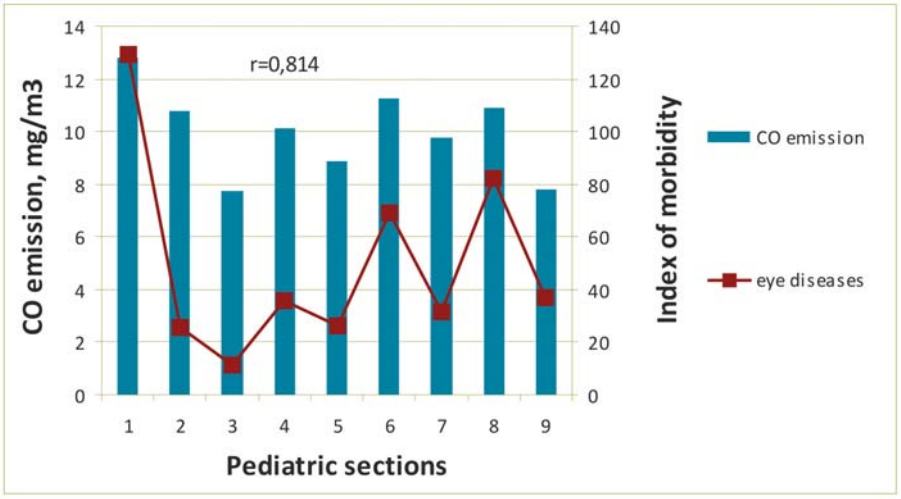

Fig. 3. Correlation between primary eye disease among child population of Lviv urban system and CO emissions with a one-year delay

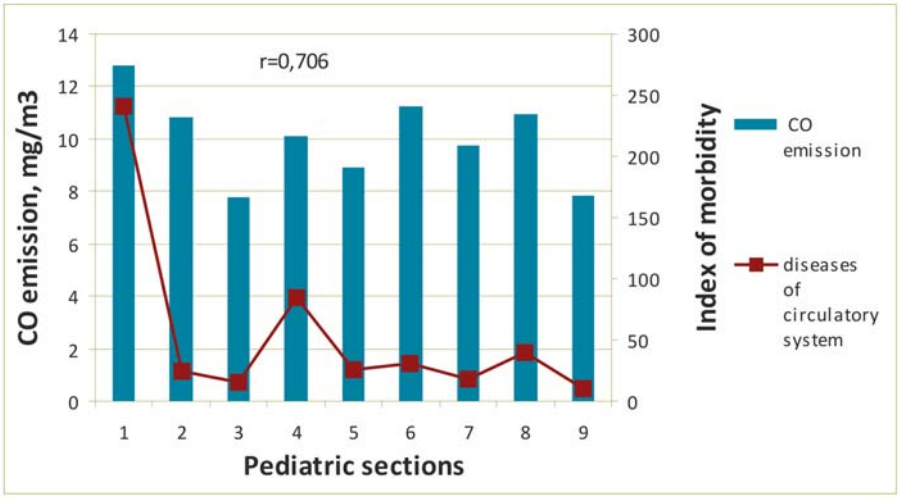

Fig. 4. Correlation between primary circulatory system morbidity among child population of Lviv urban system and CO emissions with a one-year delay

Tab. 2. Results of regression analysis of relations between primary child morbidity in 2011 and vehicle emissions in 2010 of Lviv urban system

Type of disease	Emission	h0	h1	R2	F	p
Bronchial asthma	CO	-78.966	15.931	0.515	7.425	0.029
Nervous system diseases	CO	-70.606	9.236	0.597	10.378	0.015
Eye diseases	CO	-132.616	18.214	0.662	13.739	0.008
Circulatory system diseases	CO	-258.367	31.251	0.499	6.966	0.033

Based on the research (Table 2), the increase of the concentration of carbon monoxide at 1 mg/m^3 causes an increase in primary child morbidity of Lviv urban system of asthma – by 16 people, of nervous system diseases – by 9 people, eye diseases – by 18 people, circulatory system diseases – by 31 people.

The increase of the concentration of nitrogen monoxide at 1 mg/m^3 causes an increase of primary child morbidity of Lviv urban system of digestive diseases by 3093 people (Table 3). The increase in the concentration of nitrogen dioxide at 1 mg/m^3 causes an increase of primary child morbidity in Lviv urban system of digestive diseases by 5275 people (Table 3).

Tab. 3. Results of regression analysis of relations between primary child morbidity in 2011 and vehicle emissions in 2011 in Lviv urban system

Type of disease	Emission	h_0	h_1	R2	F	p
Digestive diseases	NO	-691.623	3093.176	0.606	10.750	0.014
Digestive diseases	NO2	-929.762	5275.029	0.583	9.773	0.017

CONCLUSIONS

On the author's schematic map of air pollution in Lviv urban system we can clearly see the relations of the growing number of vehicles and the overall rate of air pollution. Large transport interchanges and narrow main streets are the most polluted.

The first place of the highest rate of the primary morbidity in the structure of the primary child morbidity in Lviv urban system in 2011 belongs to respiratory diseases – 74%, the second place belongs to ear and mastoid diseases – 5%, and the third place belongs to diseases of skin and subcutaneous tissue – 4%. Growth rate of morbidity is observed in tumors +54.3% comparing with 2000 year, in diseases

of skin and subcutaneous tissue +24.2%; congenital anomalies (malformations, deformations and chromosomal abnormalities) +17.9%; nervous system diseases +15.7%.

The analysis of processed literature clearly identifies the negative impact of air pollution on population health. This is confirmed by our study of children health. Based on our calculation, the admixture of carbon monoxide of vehicle emissions is especially dangerous, and can trigger the increase of indicator of primary child morbidity with asthma – by 16 people, nervous system diseases - by 9 people, eye diseases – by 18 people, circulatory system diseases – by 31 people.

To prevent the negative impact of environmental factors on human health we need to adhere to the following actions:

– optimization of pollution sources by regulating traffic flow, especially on the narrow streets;

– introduction of new automotive technologies to reduce the toxicity of exhaust gases;

– ensuring optimum state of air by blocking highways by creating a protective green stripes;

– implementation of new environmental legislation according to European requirements for vehicle emissions of exhaust gases;

– formation of the corresponding body and lifestyle of the individual which is resistance (or minimizing adverse effects) to adverse environmental factors.

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STRESZCZENIE

W artykule określono aktualność tematyki oraz zaproponowano odpowiednią metodę badania. Scharakteryzowano rozpowszechnienie chorób wśród dzieci w mieście w latach 2000-2011, przeprowadzono analizę korelacyjną i regresyjną między spalinami transportu samochodowego a chorobami wśród dzieci w lwowskim urbosystemie.