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The impact of air pollution on the development of asthma in the population of the city of Kazan, Republic of Tatarstan.

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ABSTRACT

Analysis of the incidence of asthma in all adult and child population of the city of Kazan showed that the incidence rates in Kazan significantly exceed the national level, and there has been a reliable increase in the incidence of bronchial asthma in Kazan population over the past five years. According to the results of factor analysis of the causes of increasing incidence of asthma, air pollution takes one of the first rank places. We have analyzed the concentration of major pollutants contained in the atmosphere and affecting the incidence of respiratory diseases: suspended solids (total, and fractions PM10 and PM2.5), nitrogen dioxide, soot, formaldehyde, and ammonia. We have calculated hazard ratios (HR) for these substances, showing the presence of the risk of morbidity based on the concentration of the pollutant. Concentrations of PM10 and PM2.5 in the atmosphere of the city of Kazan significantly exceed the WHO-recommended concentration (3.9 times in 2010 to 2.9 times in 2015 for PM10, and 4.3 times in 2010 to 3.2 times in 2015 for PM2.5). That is, the hazard ratios (HR) ranged from 4.3 to 3.2. Hazard ratios for nitrogen dioxide, soot, and particulate matters significantly exceed unity, i.e., they pose the risk of incidence of the respiratory diseases.

Keywords: bronchial asthma, particulate matters, nitrogen dioxide, morbidity, sources of air pollution.

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INTRODUCTION

Many epidemiological studies of the prevalence of bronchial asthma (BA) have shown that there was a doubling of cases of the disease over the past 30 years. It is now known that 4 to 8% of the population suffers from this disease. In the child population, this percentage is higher - 5-10%, and in adults - about 5%. The true reasons for the increased prevalence of bronchial asthma remain unclear. Many authors consider BA an environmentally related disease, referring it to sensitive markers of environmental pollution, especially of atmospheric air. A set of works by different authors can serve as a proof of the above. Currently, there is lot of studies, which establish a clear relation between the specific air pollutants and bronchial asthma. The study by Brauer M. et al. (2007), conducted on the children of first four years of life, shows an increasing incidence of bronchial asthma during increase in the concentration of nitrogen dioxide, dust and soot. Another study conducted by Sun H.L. et al. (2006) shows the relation between bronchial asthma and the increased concentrations of pollutants such as nitrogen dioxide and particulate matters less than 10 microns in size. Moreover, it was shown that air contamination plays a greater role in the pathogenesis of bronchial asthma in children than in adults. The study by Govalov S.M. et al. (1997) reports of more severe attacks and an increasing number of patients requiring hospitalization in areas with high concentrations of formaldehyde (average annual concentration - 6 MPC), ammonia (average annual concentration exceeded the daily average MPC), nitrogen dioxide (2.3 MPC), benzene (4.7 MPC) and soot, as compared with areas with lower concentration of these substances.

MATERIALS AND METHODS

We have conducted a literature search in the scientific libraries, Pubmed data bases, Medline literature on bronchial asthma and its relation to air pollution. A systematic review of the published literature on the subject under study has been conducted. Initial data for the incidence calculation were taken from the reporting form No.12, "Information on the reported cases of disease in patients residing in the service area of a medical institution", and demographics data from the Statistical Yearbook of the Ministry of Health of the Republic of Tatarstan. The analysis of pollution of atmospheric air has been conducted with the use of database of air pollution research protocols, FBHCI "Center for Hygiene and Epidemiology in the Republic of Tatarstan (Tatarstan)" and "Data on the atmospheric air state" of the Federal State Organization "Department of Hydrometeorology and Environmental Monitoring of the Republic of Tatarstan". Data processing was carried out using the descriptive statistics methods (percentages), and the main trend analysis. Data processing and calculations were performed on a PC using Microsoft Excel 2010 and STATISTICA 6.0 software package.

RESULTS

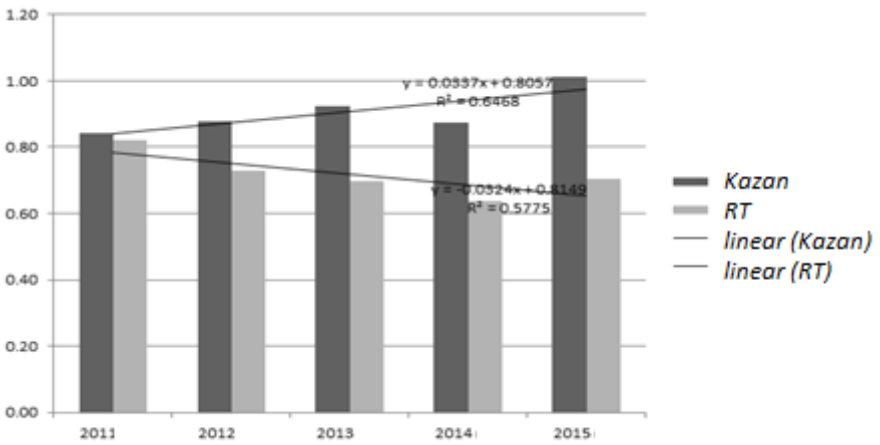

Fig. 1. Incidence of bronchial asthma in the entire population of the city of Kazan and the Republic of Tatarstan during 2011-2015 (per 1,000 population).

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The dynamics of the incidence of bronchial asthma in the entire population of the city of Kazan and the Republic of Tatarstan during 2011-2015 (per 1,000 population) is shown in Fig. 1.

The figure shows that the incidence of bronchial asthma in the entire population of the city of Kazan significantly exceeds the national level. Average annual incidence rate per 1,000 population in the city of Kazan was 0.91 against 0.72 in the Republic of Tatarstan (1.3 times higher). There has been a significant increase in the incidence of bronchial asthma among the population of the city of Kazan over the past five years (approximation equation of the trend line y = 0.0337x + 0.8057, R^2 = 0.6468). While the Republic of Tatarstan, on the contrary, shows a significant decrease in the incidence of bronchial asthma (approximation equation of the trend line y = 0.0324x + 0.8149, R^2 = 0.5775).

The dynamics of the incidence of bronchial asthma in the child population (under 14 years) of the city of Kazan and the Republic of Tatarstan during 2011-2015 (per 1,000 children) is shown in Fig. 2.

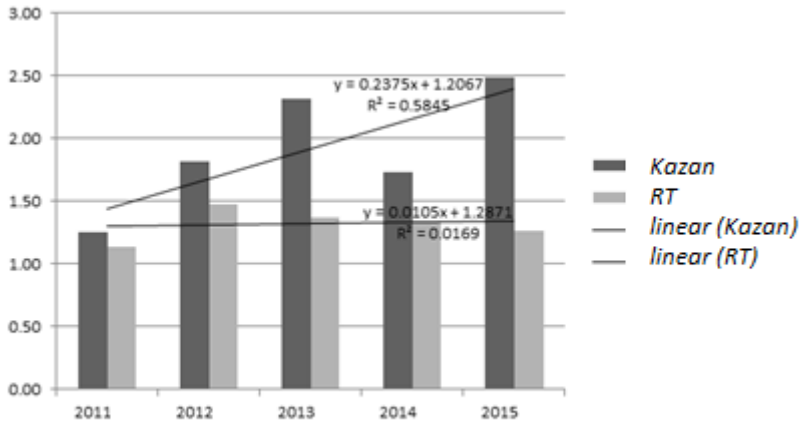

Fig. 2. Incidence of bronchial asthma in the child population (under 14 years) of the city of Kazan and the Republic of Tatarstan during 2011-2015 (per 1,000 children).

The figure shows that the incidence of bronchial asthma in the child population (under 14 years) of the city of Kazan significantly exceeds the national level. Average annual incidence rate per 1,000 children in the city of Kazan was 1.91 against 1.32 in the Republic of Tatarstan (1.4 times higher). There has been a significant increase in the incidence of bronchial asthma among the children of the city of Kazan over the past five years (approximation equation of the trend line y = 0.2375x + 1.2067, R^2 = 0.5845). While in the Republic of Tatarstan the incidence of bronchial asthma remains stable (approximation equation of the trend line y = 0.0105x + 1.2871, R^2 = 0.0169).

According to the results of factor analysis of the causes of increasing incidence of asthma, air pollution takes one of the first rank places.

We have analyzed the concentration of major pollutants contained in the atmosphere and affecting the incidence of respiratory diseases: suspended solids (total, and fractions PM10 and PM2.5), nitrogen dioxide, soot, formaldehyde, and ammonia. We have calculated hazard ratios (HR) for these substances, showing the presence of the risk of morbidity based on the concentration of the pollutant.

The particulate matters (PM) are a widespread air pollutant, comprising a mixture of solid and liquid particles present in the air in a suspended state. The indicators commonly used to characterize the PM and significant for health include the mass concentration of particles with a diameter less than 10 microns (PM10) and particles with a diameter less than 2.5 microns (PM2.5). According to WHO atmospheric air quality guidelines (AQG), the recommended concentration of PM10 is below 20 mg/m^3 (0.02 mg/m^3), and PM2.5 - below 10 mg/m^3 (0.01 mg/m^3).

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Figure 3 shows the dynamics of PM10 concentrations in the atmospheric air of the city of Kazan.

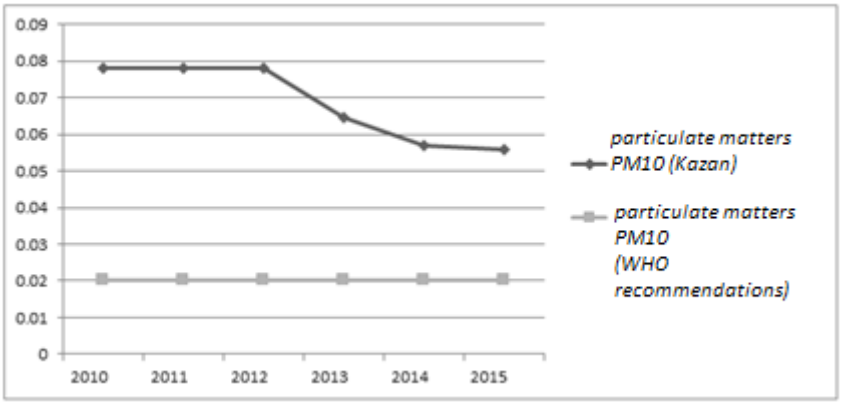

Fig. 3. Dynamics of PM10 concentrations in the atmospheric air of the city of Kazan during 2010-2015.

The figure shows that the concentrations of PM10 in the atmospheric air of the city of Kazan significantly exceed the WHO-recommended concentration (3.9 times in 2010 to 2.9 times in 2015). That is, the hazard ratios (HR) ranged from 3.9 to 2.9.

Figure 4 shows the dynamics of PM2.5 concentrations in the atmospheric air of the city of Kazan.

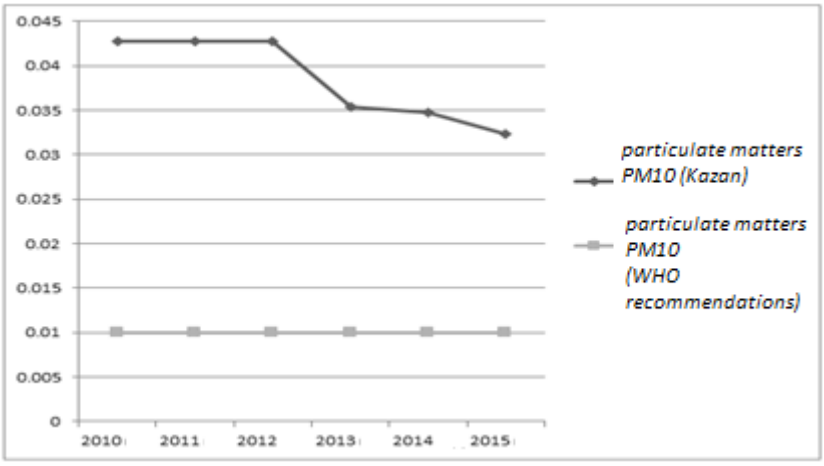

Fig. 4. Dynamics of PM2.5 concentrations in the atmospheric air of the city of Kazan during 2010-2015.

The figure shows that the concentrations of PM2.5 in the atmospheric air of the city of Kazan significantly exceed the WHO-recommended concentration (4.3 times in 2010 to 3.2 times in 2015). That is, the hazard ratios (HR) ranged from 4.3 to 3.2.

The resulted HR values indicate an increased risk of pathologic development.

Particulate matters can be either directly discharged in the atmosphere (primary matters) or formed in the atmosphere from other substances and compounds, such as sulfur dioxide, nitrogen oxides, ammonia and volatile organic compounds (secondary matters). The sources of pollution can be both natural and anthropogenic sources of air pollution. PM10 and PM2.5 contain the respirable particles, able to easily penetrate into the thoracic part of the respiratory system. The impact of respirable PM on health is well-documented. This impact is caused by both short-term (hours or days) and long-term (months or years) exposure and includes: respiratory and cardiovascular diseases, such as exacerbation of bronchial asthma and respiratory symptoms and increase in the number of hospitalizations; mortality from cardiovascular and

respiratory diseases and lung cancer. There is sufficient evidence of the impact of short-term exposure to PM10 on the respiratory system. Children are particularly vulnerable thereto. For example, exposure to PM negatively affects the lung development in children, resulting in, in particular, reversible pulmonary function disorders, as well as chronic lung growth retardation and long-term respiratory failure. Chronic exposure to particulate matters leads to increased incidence of bronchitis in children. It was found that the increase in the concentration of PM10 per of 10 $\mu m/m^3$ leads to increase in the number of hospitalizations to the pulmonary department by 0.8%, and the ambulance visits by 1.0%, and in patients with bronchial asthma - by 1.9 and 3.4%, respectively.

HRs for the substances contained in the atmospheric air and affecting the respiratory system were calculated for the period of 2007-2015. The results are shown in Table 1 below.

Table 1: Hazard ratios (HR) for the main pollutants contained in the atmospheric air and affecting the respiratory system, calculated for the period of 2007-2015.

	2007	2008	2009	2010	2011	2012	2013	2014	2015
HR (Ammonia)	0.1	0.4	0.1	0.3	0.7	0.3	0.2	0.1	0.1
HR (Nitrogen dioxide)	2.0	1.9	2.5	2.5	2.3	2.5	2.0	2.0	2.0
HR (Soot)	12.4	9.1	12.1	15.7	11.7	10.6	6.7	6.8	6.6
HR (particulate matters)	6.8	5.1	4.0	4.0	3.3	3.2	2.7	2.4	2.5
HR (Formaldehyde)	0.7	2.2	0.9	0.3	0.9	0.3	0.1	0.1	0.1
HI	22.0	18.6	19.5	22.7	18.8	16.9	11.7	11.4	11.2

The table shows that the hazard ratios for nitrogen dioxide, soot, and particulate matters significantly exceed the unity, i.e., they pose the risk of respiratory diseases. Hazard index of the combined effect of pollutants on the respiratory system in dynamics ranged from 22.0 in 2007 to 11.2 in 2015.

The highest HR and HI were in 2010-2011.

The role of nitrogen dioxide in the pathogenesis of bronchial asthma is of particular importance.

The ecological and epidemiological studies have shown that the 10 g/m^3 concentration of nitrogen dioxide increases average risk of allergic diseases by 1.4%, including bronchial asthma.

It is particularly noteworthy that patients with bronchial asthma are characterized by high sensitivity to nitrogen dioxide, therefore, the transformation of mild disease in more severe form is possible in highly contaminated conditions. Furthermore, the substances produced by combustion of liquid gasoline fuel may directly damage the airway epithelium and facilitate the release of inflammatory mediators and, perhaps, the development of bronchial hyperreactivity.

SUMMARY

Our study has shown that the incidence of bronchial asthma in the adult and child population of the city of Kazan is above the national average level, and tends to growth. The pollutants contained in the air contribute to the formation of this disease. The concentrations of the particulate matters PM10 and PM2.5 in the atmospheric air of Kazan are significantly higher than the WHO-recommended concentrations. Hazard ratios (HR) for pollutants (nitrogen dioxide, soot, particulate matters) significantly exceed the unity, that is, they pose the risk of respiratory diseases.

CONCLUSION

Thus, the obtained results indicate the possible impact of air pollution on the incidence of bronchial asthma in child and adult population of the city of Kazan. The issue, however, remains open. Further research should be conducted in this area.

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