UDK 551.583:616.24(571.62)

CLIMATE AND CHILDREN WITH BRONCHIAL ASTHMA: CASE STUDY FOR THE RUSSIAN FAR EAST

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Bronchial asthma (BA) continuously increases during the last century, and to date, has reached 15% of the world's child population. Respiratory system and bronchial asthma morbidity are the first in the list of climate-sensitive diseases, and children compound a climate-high-risk group of the population. In recent years, there has been a steady growth of BA among children and teenagers of the Khabarovsk Krai, Russia; among teenagers, this number has doubled in the last ten years. The aim of the current study is to carry a comprehensive analysis covering climatic factors for bronchial asthma in children and teenagers, at the southern part of the Russian Far East (FE). The study area is located in monsoon climate of temperate latitudes characterized by extreme annual air temperature amplitude, with cold Siberian winter and tropically hot and sultry summer. Assessment of weather impact on children with BA in Khabarovsk, administrative center of the FE, for period 2013–2014 shows that the BA visits have a seasonal regime with peaks in spring (March – April) and in autumn – early winter (November – December), when day-to-day changes in temperature are large, and in summer (July) due to a large number of allergens (flowering plant-allergens), when various allergic diseases exacerbate. At the same time, huge peaks in BA visits have been found in November, 2013 and in April, 2014, that can be estimated as consequences of catastrophic flooding at the Amur River in August-September, 2013.

Keywords: *bronchial asthma, children and teenagers, monsoon climate, air temperature, flooding, Khabarovsk.*

Introduction

Respiratory diseases in children and teenagers have the highest rate in the structure of morbidity in Russia as a whole, and at the Far East (FE), being a leading problem in the public health system [9]. Bronchial asthma (BA) is the most common respiratory chronic disease in children, the prevalence of which has increased significantly in recent years. According to official statistics, about 15% of children in Russia suffer from BA, but the real number is much higher, especially at the FE [8]. Undeclared and misdiagnosed cases, inadequate or lost treatment lead to an increase in child disability and fatal outcomes.

The southern part of the Russian Far East is located in the area with monsoon climate of temperate latitudes, characterized by severe cold Siberian winter and hot humid, tropically sultry summer. Severe day-to-day changes in temperature and air pressure, typical to the transitional seasons, lead to changes in the content of oxygen in the air, having negative impact on people with bronchopulmonary disease, especially children [11]. A weak thermoregulatory mechanism of the child's body should undergo seasonal changes, when chronic diseases, including BA, can aggravate, and is particularly vulnerable to seasonal illnesses, primarily respiratory viral infections [13, 16].

The area close to the Amur River is flooded regularly; as a result conditions favorable for uncontrolled spreading of fungal allergens outside and inside, in wet and poorly ventilated houses, are formed. Catastrophic flood during August – September, 2013 was unprecedentedly powerful and protracted with huge economic damage. Another problem in warm season is a large number of allergens (flowering period of allergen plants), triggering exacerbation of various allergic diseases, including asthma.

The aim of the current work is to identify weather factors of bronchial asthma evolution in children and teenagers in Khabarovsk before and after the 2013-year flood on the Amur River.

Materials and Methods

Weather data used was everyday mean air temperature at weather station in Khabarovsk (WMO index 31735) for period from January, 01, 2013, till December, 31, 2014, available from the Russian Research Institute of Hydrometeorological Information – World Data Centre located in Obninsk, Russia (http://meteo.ru/data). The mean daily air temperature was calculated using 3-hours interval temperatures.

Daily hospital visits were acquired from the Clinical Department of the Research Institute of Maternal and Child Health, for the same period. Counts were taken with presence of disease exacerbation, when diagnosis included asthma of different level of disease severity for children (4–14 years) and teenagers (15–17 years) as based on the appropriate code according to the International Classification of Disease, version 9 or 10. Total count of visits over this time period was 310 cases, with 153 cases in 2013 and 157 – in 2014. These daily data were averaged for each month of two years separately and an Index of Seasonality (IS) for visits was derived as:

$$IS = (M_i / M_m)\ 100$$

where M_i is mean number of visits for a given month and M_m is mean number of visits for a month at the current year [4].

Day-to-day changes of mean daily temperatures dT_{mean} were calculated; frequency of days in each month with mean temperature changes more than 95th percentile (F_{mean}) was evaluated. To estimate if asthma visits depend on weather changes, coefficient of correlation (r) between both dT_{mean} and F_{mean}, and IS was examined.

Results and Discussion

Mean daily air temperature for the study period was 2.7°C with both extremes in 2014: minimum value −27.8°C on December, 26, and maximum +27.3°C on June, 3. Day-to-day changes in mean temperature averaged for two years show mean value of 2.1°C with two peaks in transition season: in March and May, and September – October. Additional search for cases with abrupt day-to-day changes (more than 95th percentile for 2-year record) shows the frequency of such days is higher in 2014 with peaks in transition period (April-May, October) and in December (Figure 1). 2013-year changes are less dangerous with maximum frequency (10%) in both March and October. As a whole the weather is more stable in summer without cases of sharp temperature change.

Using the IS metric defined in equation above, monthly BA visits distribution for the study period is shown in Figure 2. The results demonstrate IS for BA visits to be the highest in November-December (262 and 177%, respectively) of 2013, and in spring from March till May, 2014, with more heavily results for April (201%).

To examine possible response of human morbidity on weather, relationship between temperature changes and BA visits was studied. Coefficients of correlation r for mean monthly dT_{mean} and IS are 0.47 and 0.49 in 2013 and 2014, respectively. The results are more interesting when looking at frequency of days with sharp changes of temperature F_{mean}: $r = 0.69$ in 2013, and 0.43 in 2014.

The findings indicate strong enough dependence of BA in children from weather and its changes. The weather in Khabarovsk is characterized by very hot summers and extremely cold winters coupled by the abrupt weather changes that take place in the transitional seasons. The results manifest the high risk of BA exacerbation during both spring and autumn. However, secondary jump in winter (December, 2013) shows low temperature (extremely low in December,

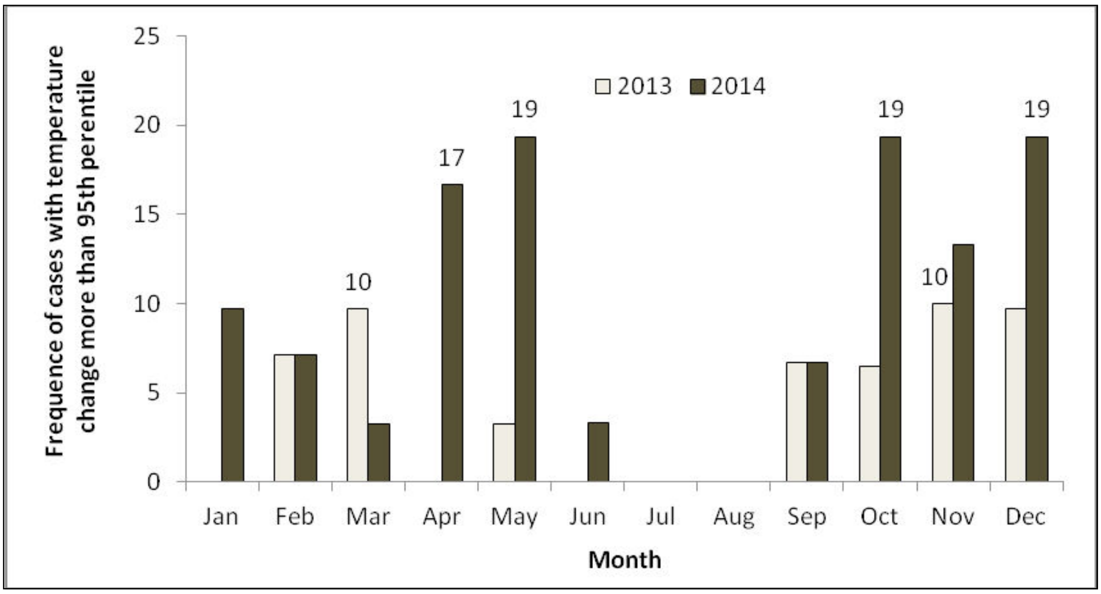

Figure 1. Frequency of cases with day-to-day change in mean temperature more than 95th percentile in Khabarovsk, 2013–2014

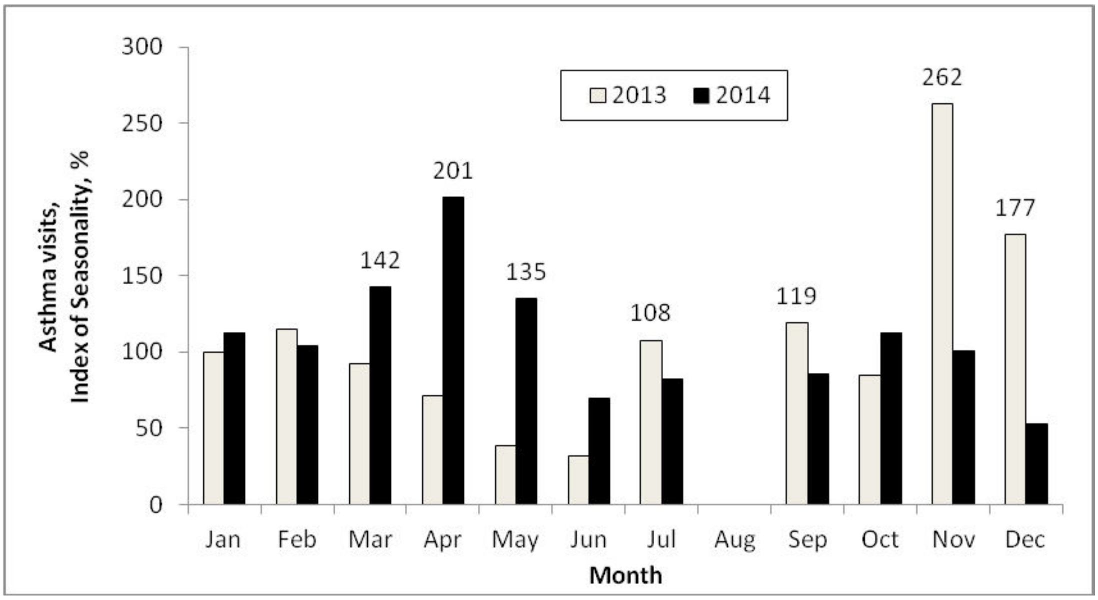

Figure 2. Index of Seasonality for child BA visits, Khabarovsk, 2013–2014

2014) can aggravate seasonal illnesses, primarily respiratory viral infections, causing additional load on children with BA. Earlier Driessen et al. [6] discussed decrease in lung function in cooling airway for asthmatic children. Relatively large and rapid changes in air temperature and air pressure, typical of the transitional seasons, lead to changes in the oxygen content of air that collectively are associated with pulmonary and cardiac insufficiency and bronchopulmonary disease [11].

The Russian Far East, especially its southern part, is an area of monsoon climate with heavy rains and extremely high humidity in warm season, particularly in period from July till mid-September [10], creating damp and moldy situations both inside and outside. It is documented, that tropically wet sultry weather with hot and humid air induces additional BA exacerbation [5].

It is well-known that thermal losses from the human body from respiration in winter are 1.5 times higher than in the transition seasons, and twice higher than in summer. This contrast may be a reason for increased respiratory morbidity during autumn and spring. Generally, the most severe thermal strain occurs with the adjustment shift from hot-to-cold during autumn [4]. Most certainly, this is one more reason for BA admission jumps in spring and autumn with peaks in November and April, that is shown in details in [3].

At the same time, dramatic peak in asthma visits in November, 2013, was definitely caused by consequences of catastrophic flooding on the Amur River in August-September, 2013, when conditions were created for uncontrolled spreading of fungal allergens in the air of damp and poorly ventilated buildings. The main source of mold spores can be spoiled food, organic waste, and air conditioning system. An earlier manifestation of BA with severe runs and frequent exacerbations increases the severity and duration of asthmatic attacks in ecologically dangerous areas [15]. It can be assumed the same reason, coupled with a sharp seasonal rise of temperature, provoked the maximum of BA visits in April, 2014.

It can be additionally marked that warm season is the period of flowering of allergen plants, with exacerbation of various allergic diseases and respiratory infections of the viral type [1, 16], triggering extra cases of BA visits and admissions.

However, natural and climatic environment is complicated by industrial emissions, rising concerns about the influence of ambient air pollution on respiratory illness [2, 12, 14]. In Khabarovsk, living near enterprises of heavy, chemical and engineering industry significantly increases the risk of BA disease. Chaotic planning structure in urban area, with thermal power plants, small boiler plants, highways and other industrial facilities within the residential zone, is typical for many settlements at the FE, aggravating the problem of industrial air pollution.

The important note should be done for a lack of data from Clinical Department in August. The main reason is a vacation period for both medical staff and families with a sick child – their physical absence in the city. A lot of families use holidays for recreation with the purpose of recovery in spa-centers in places with better weather conditions.

Conclusion

The research shows that BA visits are influenced by natural environment: abrupt changes in air temperature cause asthma exacerbation. Other factors, such as after-flooding mold and plant allergens aggravate the problem. Additional research is planned to find how day-to-day changes are connected with level of BA disease severity, to find the shape of this relationship (i.e. linear or non-linear) and whether temperature effect is lagged, using database of asthma admissions for period from 2010 till 2017. Bronchial asthma in children has a high medical and social significance; an adequate assessment of the environment (both social and natural) is necessary to reduce risk of BA morbidity and mortality, which will help to develop programs of preventive medical and social assistance, improving the overall quality of life, guaranteeing social well-being and economic development at the Russian Far East.

REFERENCES:

1. Akhbari M, Kneale D, Harris KM, Pike KC (2018) Interventions for autumn exacerbations of asthma in children: a systematic review. Arch Dis Child 103(Suppl 1): 188. Doi: 10.1136/archdischild-2018-rcpch.448.
2. Byers N, Ritchey M, Vaidyanathan A, Brandt AJ, Yip F (2016) Short-term effects of ambient air pollutants on asthma related emergency department visits in Indianapolis, Indiana, 2007–2011. J Asthma 53(3): 245–252.
3. Davis RE, Enfield KB (2018) Respiratory hospital admissions and weather changes: a retrospective study in Charlottesville, Virginia, USA. Int J Biometeorol 62(6): 1015–1025. https://doi.org/10.1007/s00484-018-1503-9.
4. de Freitas CR, Grigorieva EA (2015) Role of acclimatization in weather related human mortality during the transition seasons of autumn and spring in a thermally extreme mid-latitude continental climate. Int J Environ Res Public Health 12(12): 14974–14987. https://doi.org/10.3390/ijerph121214962.
5. Don Hayes J, Collins PB, Khosravi M, Lin R-L, Lee L-Y (2012) Bronchoconstriction triggered by breathing hot humid air in patients with asthma. Am J Respir Crit Care Med 185(11): 1190–1196. https://doi.org/10.1164/rccm.201201-0088OC.
6. Driessen JM, van der Palen J, van Aalderen WM, de Jongh FH, Thio BJ (2012) Inspiratory airflow limitation after exercise challenge in cold air in asthmatic children. Respir Med 106: 1362–1368. Doi: 10.1016/j.rmed.2012.06.017.
7. Emo B, Hu L-W, Yang B-Y, et al. (2018) Housing characteristics, home environmental factors, and pulmonary function deficit in Chinese children: Results from the Seven Northeast Cities (SNEC) Study. FACETS 3: 242–259. Doi:10.1139/facets-2017-0036.
8. Evseeva GP, Holodok GN, Morozova NV, Suprun EN, et al. (2016) Epidemiology of bronchopulmonary diseases in children and teenagers of Khabarovsk Kray. Bull Physiol Pathol Respirat 61: 31–35 (in Russian).
9. Grigorieva EA (2017) Climatic conditions of the Far East as a factor in the development of respiratory diseases. Reg Problems 20(4): 79–85 (in Russian).
10. Grigorieva EA, de Freitas CR (2014) Temporal dynamics of precipitation in an extreme mid-latitude monsoonal climate. Theor Appl Climatol 116(1): 1–9. Doi: 10.1007/s00704-013-0925-x.
11. Grigorieva EA, Kityantseva LP (2016) Cardiorespiratory morbidity caused by seasonal weather changes and measures for its prevention. Health Nation Life Environ 2(275): 7–10 (in Russian).
12. Hasunuma H, Yamazaki S, Tamura K, et al. (2018) Association between daily ambient air pollution and respiratory symptoms in children with asthma and healthy children in western Japan. J Asthma 55(7): 712–719. Doi: 10.1080/02770903.2017.1369988.
13. Liu Y, Guo Y, Wang C, et al. (2015) Association between Temperature Change and Outpatient Visits for Respiratory Tract Infections among Children in Guangzhou, China. Int J Environ Res Public Health 12: 439–454.
14. Norbäck D, Lu C, Wang J, Zhang Y, et al. (2018) Asthma and rhinitis among Chinese children – Indoor and outdoor air pollution and indicators of socioeconomic status (SES). Environment Int 115: 1–8. Doi: 10.1016/j.envint.2018.02.023.
15. Suprun EN, Efimenko MV, Pivkina TV, Azovtseva YuG, Evstigneeva AV (2016) The influence of flooding in 2013 on frequency of mold allergen sensibilisation in children with bronchial asthma at the Russian Far East Russian J Perinatol Pediatrics 4: 176–147 (in Russian).
16. Xu Z, Crooks JL, Davies JM, et al. (2018) The association between ambient temperature and childhood asthma: a systematic review. Int J Biometeorol 62: 471–481. Doi: 10.1007/s00484-017-1455-5.