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A.F. Shypko

Estimation of the Risk of Developing Dysplastic Dependent Pathology of Bronchopulmonary System in Children Considering the Complex of Regional and Environmental as well as Social and Medical Factors

Kharkiv National Medical University, Ministry of Health of Ukraine, Kharkiv, Ukraine

Abstract. Based on the study of the prevalence of potential risk factors the most informative ones were determined. Their prognostic value was used as a criterion for assessing the risk of developing dysplastic dependent pathology of the bronchopulmonary system in children. Pathometric tabular algorithm was developed. An example of its application at the individual level was presented. The given algorithm was verified. The type I error rate was α=3.0%, and the type II error rate was β=7.2%. The algorithm is recommended to use in the system of medical and social monitoring of the population's health.

Keywords: social medicine; children's health; regional features; bronchopulmonary system; prediction.

Problem statement and analysis of the recent research

The term "dysplasia" comes from two Greek words: *dys*- which means "wrong, abnormal" and *plaseo-,* meaning "to form, to create" and refers to an abnormal development of organs or body parts due to abnormal formation of certain body parts or body tissues in the process of embryogenesis and postnatal period [1, 7]. Dysplastic dependent pathology (DDP) of the bronchopulmonary system (BPS) is a group of diseases and pathological conditions including bronchopulmonary dysplasia (BPD), recurrent bronchitis (RB), chronic bronchitis (CB), obliterating bronchiolitis (OB), interstitial lung disease (ILD) [6, 14]. The interrelationship of BPD and other forms of the above-mentioned diseases is direct; they (these forms) are usually the consequences of the course of BPD within the first three years of life. At the same time, BPD is a polyetiologic disease of morphologically immature lungs in preterm children [3, 9, 11]. The formation of risk of developing these diseases and pathological conditions is influenced by the number of factors (practically not investigated) including medical and social factors as well as regional and environmental factors and other influential factors in a child's development [4, 5].

The objective of the research was to provide evidence-based (clinical and statistical) justification of the risk assessment algorithm considering the complex of regional and environmental factors being important for assessing children's health in dysplastic dependent pathology of the bronchopulmonary system.

Materials and methods

Personalized analysis of the existing regional and environmental factors in 252 children with BPD and DDP of the BPS from two administrative regions of Ukraine and 252 healthy children (the comparison group) was made [8, 10, 13]. When studying regional and population-based features of children specially prepared medical reports of expert evidence were used. Being completed for each patient they contained information on the presence of BPD or DDP of the BPS as well as characteristic of specific regional and environmental clusters (REC).

In particular, according to the cartographic information of regional departments of environmental management we have identified four groups of environmental factors. The first group characterized climatic conditions and demographic features: X_{14} – the level of annual precipitation, X_{15} – the level of population density, X_{16} – the population distribution (the proportion of urban and rural population), X_{17} – the level of water use (per 1 inhabitant), X_{28} – the pollution of drinking water, X_{29} – food contamination, X_{30} – the level of general morbidity of the population. The second group included geoecological factors: X_1 – soil loss intensity, X_2 – heavy metal soil contamination, X_3 – the level of soil erosion, X_4 – the level of dust load, X_5 – soil type, X_{21} – waste generation intensity, X_{26} – the contamination level of the bottom soil (caesium, ^{137}Cs), X_{27} – the degree of erosion danger, X_6 – the level of lead, chromium, copper, nickel, zinc in the atmospheric surface layer. The third group included hydrological factors: X_7 – solid runoff intensity and water pollution from diffuse sources, X_8 – industrial wastewater discharge intensity, X_9 – household wastewater discharge intensity, X_{10} – contaminated agricultural drainage wastewater discharge intensity, X_{11} – the existence of landfills for storage of solid household, industrial and agrochemical wastes, X_{12} – salinity levels in groundwater aquifers, X_{13} – flooded areas due to economic activity, X_{18} – the level of pollutants discharge. The fourth group included aeroecological factors: X_{19} – anthropogenic load from stationary sources on the atmospheric air, X_{20} – anthropogenic load from motor transport on the atmospheric air, X_{21} – waste generation intensity, X_{22} – the level of waste accumulation, X_{23} – the existence of domestic wastes landfills, X_{24} – the level of air pollution, X_{25} – the level of radiation background.

When making medical and statistical analysis (the one-way ANOVA) of factors frequency distribution of each factor gradation was used (Table 1). The informative values of factors (I, bit), their effect size (η^2, %) as well as the statistically significant difference in the average indicators were calculated [2].

Results and discussion

According to the results of comparative analysis of 30 regional and environmental factors (Fig. 1 presents their frequency in comparison groups) 10 factors being the most informative were determined using standardized procedure. Their prognostic values were calculated [12]; standardized algorithm for predicting risk of DDP of the BPS in children was processed. The algorithm was based on using prognostic values of the most informative factors and had a table equivalent containing the parameters of the assessment – prognostic coefficients (PC) and the rating scale as an outcome predictor. The algorithm involved independent signs of prediction only. When the strength of the correlation ($\pm r_{xy}$) between two factors was higher than ±0.70 one of the factors was excluded from the list of parameters. The use of tabular algorithm implemented pathometric approach to risk assessment. The principle of arriving at a predictive solution in pathometric algorithm (PA) reduced itself to the addition of prognostic coefficients following the sequence while analyzing the parameters. PA is known to consider the existing parameter as well as to minimize the number of steps which might be taken by prognostic technology due to the use of informative criteria (Table 2).

On the basis of studying pathometric and sanometric values of environmental factors "Method of personalized quality assessment of population health considering the complex of regional and environmental factors" was developed. It relates to the field of medicine, social medicine and sanology in particular, as well as to organizational technologies of the primary health care. It may be used to determine the need for the provision of preventive care as well as to assess the priority and effectiveness of the components of regional prevention programs and to monitor healthy people by environmental risk factors [10, 11].

The goal which forms the basis for our innovative methods is solved by means of measuring and considering personalized parameters of ecological state. Then, a qualitative and quantitative evaluation of the generalized parameter of health quality is carried out and its level is determined using the formula: HQP= (1– (1 – QH/QH$_n$)100, where: HQP is a health quality parameter; HQ – the parameter of entropy of considered regional and environmental measurements; QH$_n$ – the parameter of sanological system entropy in an individual person. The value of this parameter within the range of 100-70% refers to a high level of health quality, 69-31% - moderate level, less than 30% - low level of health quality.

The improvement of accuracy when determining health quality is achieved due to consideration of the impact of environmental factors being personalized for a particular patient (or a homogeneous regional and ontogenetic group of

Table 1. Regional and environmental risk factors for dysplastic dependent pathology of the bronchopulmonary system in children

Code of factor	Regional and environmental factors		Groups				PC, pat	I, bit	η^2, %
			n_I=252 with DDP		n_{I-K}=252 without DDP				
	Parameters	Gradations	abs.	P±m (%)	abs.	P±m (%)			
X_{25}	Level of radiation background	↑	139	55.2±3.1	43	17.1±2.5	+5.1	0.971	21
		↑↓	73	29.0±2.9	68	27.0±2.8	+0.3	0.006	
		↓	40	15.9±2.3	141	56.0±3.1	-5.4	1.093	
	η^2=21 p<0.0001	total	252	100.0	252	100.0	-	2.070	
X_6	Level of lead, chromium, copper, nickel, zinc in the atmospheric surface layer	↑	143	56.7±3.1	44	17.5±2.4	+5.1	1.005	18
		↑↓	62	24.6±2.7	79	31.3±2.9	-1.1	0.035	
		↓	47	18.7±2.5	129	51.2±3.1	-4.4	0.713	
	η^2=18 p<0.0001	total	252	100.0	252	100.0	-	1.754	
X_2	Heavy metal soil contamination	↑	155	61.5±3.1	69	27.4±2.8	+3.5	0.600	12
		↑↓	68	27.0±2.8	107	42.5±3.1	-1.9	0.152	
		↓	29	11.5±2.0	76	30.2±2.9	-4.2	0.390	
	η^2=12 p<0.0001	total	252	100.0	252	100.0	-	1.142	
X_{30}	Level of general morbidity of the population	↑	133	52.8±3.1	49	19.4±2.5	+4.3	0.723	12
		↑↓	61	24.2±2.7	106	42.1±3.1	-2.4	0.214	
		↓	58	23.0±2.7	97	38.5±3.1	-2.2	0.173	
	η^2=12 p<0.0001	total	252	100.0	252	100.0	-	1.110	
X_{19}	Anthropogenic load from stationary sources on the atmospheric air	↑	111	44.0±3.1	52	20.3±2.5	+3.3	0.399	11
		↑↓	92	36.5±3.0	77	30.7±2.9	+0.7	0.022	
		↓	49	19.4±2.5	123	49.0±3.2	-4.0	0.593	
	η^2=11 p<0.0001	total	252	100.0	252	100.0	-	1.014	
X_{21}	Waste generation intensity	↑	108	42.9±3.1	45	17.9±2.4	+3.8	0.475	10
		↑↓	93	36.9±3.0	90	35.7±3.0	+0.1	0.001	
		↓	51	20.2±2.5	117	46.4±3.1	-3.6	0.472	
	η^2=10 p<0.001	total	252	100.0	252	100.0	-	0.948	
X_{22}	Level of waste accumulation	↑	108	42.9±3.1	45	17.9±2.4	+3.8	0.475	10
		↑↓	93	36.9±3.0	90	35.7±3.0	+0.1	0.001	
		↓	51	20.2±2.5	117	46.4±3.1	-3.6	0.472	
	η^2=10 p<0.0001	total	252	100.0	252	100.0	-	0.948	
X_{17}	Level of water use (per 1 inhabitant),	↑	94	37.3±3.0	29	11.5±2.0	+5.1	0.659	9
		↑↓	97	38.5±3.1	113	44.8±3.1	-0.7	0.021	
		↓	61	24.2±2.7	110	43.7±3.1	-2.5	0.249	
	η^2=9 p<0.001	total	252	100.0	252	100.0	-	0.929	

Notes: Table presents informative and statistical characteristics of 10 environmental factors being the most significant; ↑ - above the average regional level; ↑↓ - corresponds to the average regional level; ↓ - below the average reginal level

individuals). The differentiation of health quality parameter into three levels allows us to compare the results of using the method with the results being traditional for the system of providing medical care including the diagnosis, treatment and prophylaxis by regional prevention and treatment facilities. The latter plays an important role in optimizing the system of sanological monitoring and medical and organizational technologies of the prophylaxis at the level of providing primary healthcare. So, the utility model is able to assist social hygienists, pediatricians, general practitioners and sanlogists in determining personalized individual and population-based preventive programs.

The following example shows the application of the algorithm: a 2.5-year-old Olena permanently resides in Nikopol, Dnipropetrovsk region. To predict the risk of developing dysplastic dependent pathology considering the complex of regional and environmental factors as well as the data of the environmental passport of Nikopol and cartographic data of ecological map of Dnipropetrovsk region there has been revealed the following: there was an increased radiation background at place of residence compared to the average radiation background in the region ($^{25}PC_p$=+5.1 pat); the level of lead, chromium, copper, nickel, zinc in the atmospheric surface layer at place of residence was higher than the average level in the region ($^{6}PC_p$=+5.1 pat); the level of heavy metal soil contamination in Nikopol was higher than the average level in the region ($^{2}PC_p$=+3.5 pat); the level of anthropogenic load from stationary sources on the atmospheric air in Nikopol was also higher than the average level in Dnipropetrovsk region ($^{19}PC_p$=+3.3 pat). The procedure of prediction was stopped as a predictive threshold was reached: PT = (+5.1)+(+5.1)+(+3.5)+(+3.3)=+17 pat, i.e. PT=17.03. Since the threshold predictive sum was reached we can predict with adequate reliability (in PC_{max} =+17 error does not exceed 3.0%) that Olena is at a high risk of developing dysplastic dependent pathology of the bronchopulmonary system.

The given algorithm was verified among children of both groups (252 children with DDP and 252 children without DDP). The type I error rate (there was a high risk in the absence of pathology) was α=3.0%, and the type II error rate (there was a low risk in the presence of pathology) was β=7.2%. Thus, the specificity of the algorithm is 92.8% and its sensitivity is 97.0% allowing us to recommend it for using in the system of medical and social monitoring.

Conclusions

1. Based on the study of the prevalence of 30 potential risk factors the most informative ones were determined. Their prognostic value was used as a criterion for assessing the risk of developing DDP of the bronchopulmonary system in children.

2. Standardized pathometric tabular algorithm was developed using the Wald's sequential analysis modified by Hubler EV. An example of its application at the individual level was presented. The application of the given algorithm allows us to document

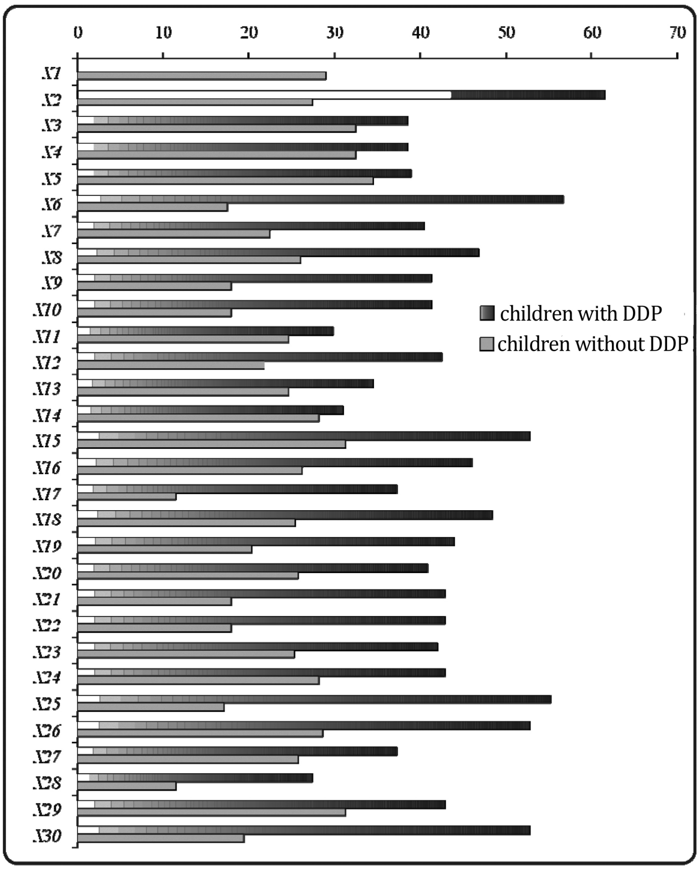

Fig.1. Frequency (%) of elevated levels of individual regional and environmental factors among children of comparison groups

the existent significant risk factors as well as to identify people (or a homogeneous regional and ontogenetic group of individuals) at high risk of DDP of the bronchopulmonary system.

Table 2. Algorithm for predicting dysplastic dependent pathology of the bronchopulmonary system considering the complex of regional and environmental factors

	Regional and environmental factors	Prognostic coefficients	
		Criterion	PC
1.	Level of radiation background at place of residence (X_{25})	↑	+5.1
		↑↓	+0.3
		↓	-5.4
2.	Level of lead, chromium, copper, nickel, zinc in the atmospheric surface layer (total; X_6)	↑	+5.1
		↑↓	-1.1
		↓	-4.4
3.	Level of heavy metal soil contamination (X_2)	↑	+3.5
		↑↓	-1.9
		↓	-4.2
4.	Level of anthropogenic load from stationary sources on the atmospheric air (X_{19})	↑	+3.3
		↑↓	+0.7
		↓	-4.0
5.	Level of waste accumulation (X_{22})	↑	+3.8
		↑↓	+0.1
		↓	-3.6
6.	Level of water use (X_{17})	↑	+5.1
		↑↓	-0.7
		↓	-2.5
7.	Salinity levels in groundwater aquifers (X_{12})	↑	+3.2
		↑↓	+0.1
		↓	-3.8
8.	Contaminated agricultural drainage wastewater discharge intensity (X_{10})	↑	+3.6
		↑↓	-0.5
		↓	-2.8

Note: correspondence is determined for each factor (↑- above the average regional level; ↓ - below the average reginal level; ↑↓ - corresponds to the average regional level); then, pathomeric coefficients are added; when the threshold sum (TS) of coefficients is reached (-17 or +17) the risk level is determined using the scale

3. The given algorithm was verified among children of both groups (252 children with DDP and 252 children without DDP). The type I error rate (there was a high risk in the absence of pathology) was α=3.0%, and the type II error rate (there was a low risk in the presence of pathology) was β=7.2%. Thus, the specificity of the algorithm is 92.8% and its sensitivity is 97.0% allowing us to recommend it for using in the system of medical and social monitoring.

Prospects for further research are determined by the need to develop the algorithms for population-based and individual prediction of DDP of the bronchopulmonary system in the antenatal period as well as at the stages of postnatal ontogenesis considering other informative (medical and organizational, genealogical and anamnestic) factors.

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Rating scale for estimating the risk of dysplastic dependent pathology of the bronchopulmonary system		
$TS_{min} \leq -17.0$		$TS_{max} \geq +17.0$
minimal	uncertain risk	high risk

Fig. 2. Scale of estimating the risk of developing dysplastic dependent pathology of the bronchopulmonary system in children depending on the impact of regional and environmental factors

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Шипко А.Ф.

Популяційна оцінка поширеності диспластикозалежної патології бронхолегеневої системи у дітей та її ризику за комплексом антенальних та генеалогічних факторів

Харківський національний медичний університет

Резюме. За результатами вивчення дійсної поширеності можливих факторів ризику визначені найбільш інформативні з них, прогностичне значення яких використано у якості критеріїв для оцінки ризику диспластикозалежної патології бронхолегеневої системи у дітей. Складено патометричний табличний алгоритм та наведено приклад його застосування. Виконано верифікацію цього алгоритму та з'ясовано, що частота помилок першого роду склала α=3,0%, а помилок другого роду β=7,2%; рекомендовано його використання, як етапу популяційного моніторингу в медико-соціальних дослідженнях здоров'я населення

Ключові слова: соціальна медицина, здоров'я дитячого населення, регіональні особливості, бронхолегенева система, прогнозування.

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