A complex of regional ecological and medico-social factors: evaluation of dysplastic dependent pathology of the bronchopulmonary system

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Respiratory diseases are becoming one of the most widespread threats to the world's population. It is important to focus on new public health management mechanisms for the development and promotion of public health at the national and municipal levels. Dysplastic dependent pathology (DDP) of the bronchopulmonary system (BPS) is a group of diseases or conditions, which includes bronchopulmonary dysplasia (BPD), recurrent bronchitis, chronic bronchitis, obliterating bronchiolitis, interstitial lung disease. The formation of the risk of these diseases and pathological conditions is influenced by several (to date, almost unexplored) factors, among which are medico-social, regional ecological and other influential factors of periods of child development.

The aim *of the study was to substantiate evidence-based (clinically and statistically) algorithm for risk assessment by a set of regional ecological factors relevant for the assessment of the health of children with dysplastic dependent pathology of the bronchopulmonary system.*

Material and methods. *A personalized analysis of the existing factors in 252 children (with BPD and DDP BPS) of two administrative regions of Ukraine and 252 healthy children groups of comparison group was accomplished. While examining the regional-population characteristics of healthy and sick children, specially compiled expert-prognostic chart was used, that was completed for each child and included data on BPD or DDP BPS presence, and characteristics of the regional ecological clusters. Based on the study of the true prevalence of 30 possible risk factors, the most informative ones were identified, the prognostic value of which was used as criteria for the risk assessment of bronchopulmonary system disease in children. Based on the methodology of Wald's sequential analysis in the modification of E.V. Gubler a standardized threatometric (pathometric) tabular algorithm was compiled and an example of its application at the individual level was provided. The application of this algorithm allows to document the available significant risk factors and to identify individuals (and homogeneous territorially ontogenetic groups) with high risk of bronchopulmonary system diseases.*

Results. *The algorithm verification was carried out among children of two groups and was stated, that the error frequency of the first kind amounted to α=3,0%, while errors of the second kind (low risk with pathology was identified) β=7,2%. Thus, the specificity of the prognostic algorithm is 92,8%, and its efficiency is 97,0%, which enables to recommend it as a stage of population monitoring.*

Conclusions. *Prospects for further research on this issue are determined by the need to develop the algorithms for population and individual prognosis of bronchopulmonary system disease in the antenatal period and at the stages of postnatal ontogeny, considering other informative (medical, organizational, genealogical and anamnestic) factors.*

Key words: *public health, regional ecological factors, medico-social factors, dysplastic dependent pathology*

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Kompleks regionalnych czynników ekologicznych i medyczno-społecznych: ocena patologii zależnej od dysplazji układu oskrzelowo-płucnego

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Choroby układu oddechowego stają się jednym z najbardziej rozpowszechnionych zagrożeń dla światowej populacji. Ważne jest skoncentrowanie się na nowych mechanizmach zarządzania zdrowiem publicznym w celu rozwoju i promocji zdrowia publicznego na poziomie krajowym i gminnym. Patologia zależna od dysplazji (DDP) układu oskrzelowo-płucnego (BPS) to grupa chorób lub stanów, w tym dysplazja oskrzelowo-płucna (BPD), nawracające zapalenie oskrzeli, przewlekłe zapalenie oskrzeli, zarostowe zapalenie oskrzelików, śródmiąższowa choroba płuc. Na powstawanie ryzyka tych chorób i stanów patologicznych ma wpływ kilka (jak dotąd prawie niezbadanych) czynników, wśród których są medyczno-społeczne, regionalne ekologiczne i inne wpływowe czynniki okresów rozwoju dziecka.

Celem *badań było uzasadnienie opartego na dowodach (klinicznie i statystycznie) algorytmu oceny ryzyka za pomocą zestawu regionalnych czynników ekologicznych istotnych dla oceny zdrowia dzieci z zależną od dysplastyczności patologią układu oskrzelowo-płucnego.*

Materiał i metody*. Przeprowadzono spersonalizowaną analizę istniejących czynników u 252 dzieci (z BPD i DDP BPS) dwóch regionów administracyjnych Ukrainy i 252 zdrowych dzieci z grupy porównawczej. Podczas badania regionalnych populacji populacji zdrowych i chorych dzieci zastosowano specjalnie opracowaną kartę ekspercką i prognostyczną, która została wypełniona dla każdego dziecka i zawierała dane dotyczące obecności BPD lub DDP BPS oraz cechy regionalnych klastrów ekologicznych. Na podstawie badania prawdziwego rozpowszechnienia 30 możliwych czynników ryzyka zidentyfikowano te najbardziej pouczające, których wartość prognostyczną wykorzystano jako kryteria oceny ryzyka choroby układu oskrzelowo-płucnego u dzieci. W oparciu o metodologię sekwencyjnej analizy Walda w modyfikacji E.V. Gublera został skompilowany znormalizowany algorytm tabelaryczny zagrożenia (patometryczny) i podano przykład jego zastosowania na poziomie indywidualnym. Zastosowanie tego algorytmu pozwala udokumentować dostępne znaczące czynniki ryzyka oraz zidentyfikować osoby (i jednorodne terytorialnie ontogenetyczne grupy) o wysokim ryzyku chorób układu oskrzelowo-płucnego.*

Wyniki*. Weryfikację algorytmu przeprowadzono u dzieci z dwóch grup i stwierdzono, że częstość błędów pierwszego rodzaju wyniosła α = 3,0%, zaś błędy drugiego rodzaju (zidentyfikowano niskie ryzyko z patologią) β = 7,2%. Zatem specyficzność algorytmu prognostycznego wynosi 92,8%, a jego wydajność wynosi 97,0%, co pozwala na zalecenie go jako etapu monitorowania populacji.*

Wnioski. *Perspektywy dalszych badań nad tym zagadnieniem są determinowane potrzebą opracowania algorytmów dla populacji i indywidualnego prognozowania choroby układu oskrzelowo-płucnego w okresie przedporodowym i na etapie ontogenezy poporodowej, biorąc pod uwagę inne czynniki informacyjne (medyczne, organizacyjne, genealogiczne i anamnestyczne).*

Słowa kluczowe*: zdrowie publiczne, regionalne czynniki ekologiczne, czynniki medyczno-społeczne, patologia zależna od dysplazji*

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Respiratory diseases are becoming one of the most widespread threats to the world's population. Governments, corporations, and small businesses annually spent billions to protect their own personnel against these non-communicable respiratory diseases [17]. This problem becomes public and requires new tools to be solved. In addition, national medical diagnostics and monitoring services from leading countries in the world indicate that this problem is growing into a crisis [6]. And it is a crisis not only in the fact of the spread of the disease (it is a consequence), but also in the conditions of its occurrence in specific groups of people (these are the reasons). That is why it is important to focus on new public health management mechanisms for the development and promotion of public health at the national and municipal levels [4,8,10]. Public health studies the causes of morbidity and creates appropriate safety systems. Public health deals with public policy and public administration in the field of disease prevention and healthy lifestyle advocacy.

The term „dysplasia" comes from the Greek "dys" – "disturbance" + "plaseo" – "to form" – incorrect development of an organism or its parts due to improper formation of organs or tissues of the organism during embryogenesis and postnatal period [1,11]. Dysplastic dependent pathology (DDP) of the bronchopulmonary system (BPS) is a group of diseases or conditions, which includes bronchopulmonary dysplasia (BPD), recurrent bronchitis (RB), chronic bronchitis (CB), obliterating bronchiolitis (OB), interstitial lung disease (ILD) [13,14]. Intercorrelation of the BPD with other forms of the listed diseases is direct; these forms are, as usual, the consequences of the course of BPD in the first three years of life. At the same time, BPD is a polyethyological disease of morphologically immature lungs in premature infants [3,18,19]. The formation of the risk of these diseases and pathological conditions is influenced by several (to date, almost unexplored) factors, among which are medico-social, regional ecological and other influential factors of periods of child development [5, 9].

The aim of the study was to substantiate evidence-based (clinically and statistically) algorithm for risk assessment by a set of regional ecological factors relevant for the assessment of the health of children with dysplastic dependent pathology of the bronchopulmonary system.

MATERIALS AND METHODS

A personalized analysis of the existing factors in 252 children (with BPD and DDP BPS) of two administrative regions of Ukraine and 252 healthy children groups of comparison group was accomplished [12,16,18]. While examining the regional-population characteristics of healthy and sick children, specially compiled expert-prognostic chart was used, that was completed for each child and included data on BPD or DDP BPS presence, and characteristics of the regional ecological clusters (ECR). In particular, according to factual cartographic information of regional environmental management departments, we have identified four groups of environmental factors: a group of factors that characterize the climatic conditions of living and demographic characteristics (CDC): X_{14} – annual precipitation, X_{15} – population density, X_{16} – population placement (urban / rural population ratio), X_{17} – the level of use of water (per 1 person) X_{28} – the level of drinking water pollution X_{29} – the level of food pollution, X_{30} – general morbidity; a group of geoecological factors (GeEF): X_1 – the intensity of soil washing, X_2-, X_3 – the level of soil erosion, X_4 – the level of dust loading of the area, X_5 – soil type, X_{21} – the intensity of waste generation, X_{26} – the of level soil contamination (cesium, ^{137}Cs), X_{27} – the degree of erosion hazard, X_6 – the level of lead, chromium, copper, nickel and zinc in the ground layer of the atmosphere; a group of hydroecological factors (HyEF): X_7 – the rate of removal of solid runoff and pollution of water bodies from diffuse sources, X_8 – the intensity of discharge of polluted industrial wastewater, X_9 – the intensity of discharge of contaminated household wastewater, X_{10} – the intensity of discharge of polluted waste water drainage, X_{11} – existence of landfills for storage of solid household, industrial, agrochemical waste, X_{12} – mineralization of the aquifer, X_{13} – areas of flooding caused by economic activity, X_{18} – the level of pollutant discharge; and a group of aeroecological factors (AEF): X_{19} – anthropogenic load of atmospheric air from stationary sources, X_{20} – anthropogenic load from motor transport to atmospheric air, X_{21} – the intensity of waste generation, X_{22} – the level of waste accumulation, X_{23} – the presence of landfills of household waste, X_{24} – the level of air pollution, X_{25} – the level of radiation background.

In medical-statistical analysis (single-factor variance) of factors (tab.1), the frequency distribution of each factor gradation was used, the informativeness of factors (I, bit) and their influence force (η^2,%), as well as the reliability of difference of average indicators were calculated [2].

RESULTS AND DISCUSSION

According to comparative analysis data of 30 regional environmental factors (their frequency in comparison groups – Fig. 1), using standardized procedure, 10 the most informative factors were identified, and their prognostic values were determined [15]. Also, the standardized algorithm of risk prediction of DDP BPS in children was developed.

The algorithm is based on the use of the predictive value of the most informative factors and structurally looks like a table containing the evaluation indicators – predictive coefficients (PCs) and the scale of estimation of the prediction result. Only independent predictive features are included in the algorithm. In cases where the correlation strength ($\pm r_{xy}$) between the factors was greater than ± 0.70, one of the factors was excluded from the list of indicators. The use of a table algorithm implements a pathometric approach to risk assessment. The principle of making a prognostic decision in PA is to add the prognostic coefficients, provided that the sequence of indicators is observed. It is known that PA not only considers the available indicators, but also minimizes the number of steps of prognostic technology by applying informative criteria (tab. 2).

Based on the study of the pathometric and sanometric significance of environmental factors, the "Method of Personalized Assessment of Population Health Quality by the Complex of Regional Ecological Factors" was elaborated, which relates to the field of medicine, in particular to social medicine and sanology, as well as to organizational technologies of primary health care. It can be used to identify the need for preventive care, as well as to assess the priority and effectiveness of constituents of regional prevention programs and for monitoring systems for healthy people with environmental risk factors [7,19].

The aim, underlying innovative techniques, is attained by the measurement and complex account of personalized rate of the ecological environment state, the qualitative and quantitative evaluation of the generalized index of health quality was performed afterwards, and its level was determined using formula: $HQP=(1- (1 -QH/QH_n)100$, where: HQP is the index of health quality; QH -the minimum entropy index of the represented regional-environmental measurements; QHn -index of sanîlogic system entropy of certain individual; and when the value of this index is in the range 100-70%, the high health quality level is determined, 69-31% – average level, less than 30% – low health quality level.

Improving the accuracy of determining the quality of health is achieved by considering the impact of personalized (for each patient or homogeneous regional ontogenetic group of people) environmental factors. Also, the differentiation of the indicator of quality of health at three levels makes it possible to compare the results of the application of the method with the traditional ones used in territorial health care facilities in providing diagnostic, therapeutic and prophylactic services. This plays an important role in optimizing the system of sanitary monitoring and medical organizational prevention technologies at the primary level of health care, which means the utility model is able

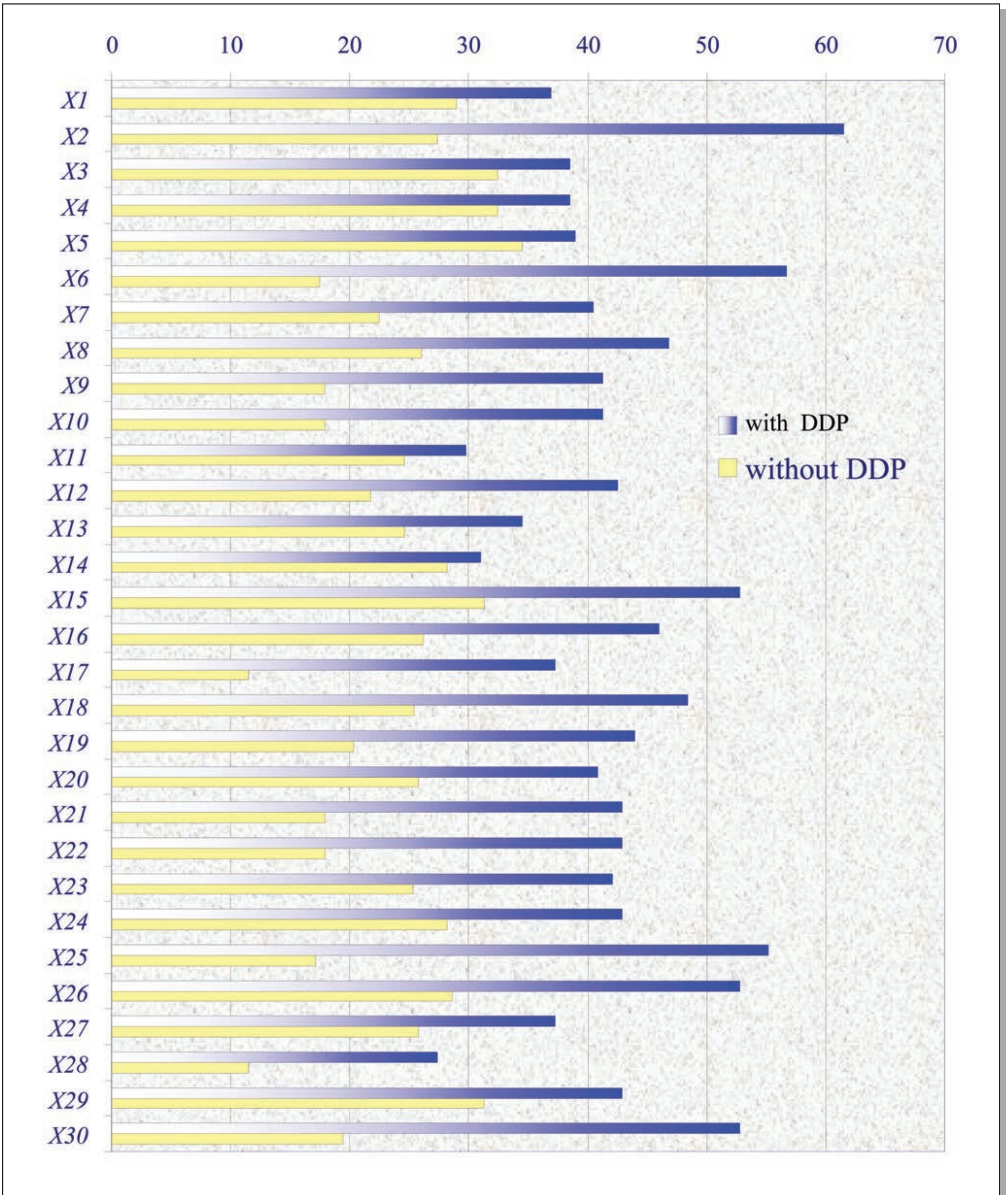

Figure 1. Frequency (%) of elevated levels of individual regional environmental factors among children of comparable population groups (explanations in the text)
Rycina 1. Częstotliwość (%) podwyższonych poziomów indywidualnych regionalnych czynników środowiskowych u dzieci w porównywalnych grupach ludności (wyjaśnienia w tekście)

to assist social hygienists, pediatricians, general practitioners, and health care providers in identifying personalized individual and populational prevention programs.

An example that demonstrates the application of the algorithm: Olena N., 2.5 years old, lives in Nikopol, Dnipropetrovsk region. To predict the risk of developing of the dysplastic-dependent pathology using a set of regional-environmental factors, it was found, that, according to the city ecological passport and factual data of the ecological map of the region, the level of radiation background at the place of residence is higher compared to the average in the region ($^{25}PC_P$ = + 5,1st pat), the level of lead, chromium, copper, nickel, zinc in the surface layer at the place of residence is above the regional average ($^{6}PC_P$ = + 5,1 Pat), soil contamination by heavy metals in Nikopol is

Table 1. Regional and ecological risk factors for dysplastic-dependent pathology of the bronchopulmonary system in children
Tabela 1. Regionalne i ekologiczne czynniki ryzyka dysplastyczności zależnej od patologii układu oskrzelowo-płucnego u dzieci

Factor code	Regional ecological factors			Children groups				Pc, pat	I, bit	η^2, %
				n_1=252 With DDP		$n_{1-\kappa}$=252 Without DDP				
	Indicators		Gradation	abs.	P±m (%)	abs.	P±m (%)			
1	2		3	4	5	6	7	8	9	10
X_{25}	radiation background level		↑	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 and zinc in the ground layer of the atmosphere		↑	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	soil contamination with heavy metals		↑	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}	general morbidity level		↑	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		↑	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}	intensity of waste generation		↑	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 person)		↑	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	

Note: the table shows the information and statistical characteristics of the 10 most significant environmental factors; in this and the following table, ↑ is above the regional average level; ↑↓ – corresponds to the regional average level; ↓ – below the regional average level.

above average within the region (^2PC_P = + 3.5 pat), the level of anthropogenic load of environment with pollutants from stationary sources in Nikopol also exceeds the average values in the Dnipropetrovsk region ($^{19}PC_P$ = + 3.3 pat). The forecasting procedure is stopped because the forecast threshold of PC = (+ 5,1) + (+ 5,1) + (+ 3,5) + (+ 3,3) = + 17 pat is reached, i.e. PP = 17,03. As the Threshold Estimated Amount has been reached, it is possible to ascertain with sufficient confidence for the population level (at PC_{max} = + 17, the error does not exceed 3.0%) that Olena N. is at high risk for the formation of dysplastic-dependent pathology of the bronchopulmonary system (tab.2).

The algorithm verification was carried out among children of two groups (252 children with DDP and 252 without DDP) and was stated, that the error frequency of the first kind (high risk without pathology was identified) amounted to α=3,0%, while errors of the second kind (low risk with pathology was identified) β=7,2%. Thus, the specificity of the prognostic algorithm is 92,8%, and its efficiency is 97,0%, which enables to recommend it as a stage of population monitoring (tab.3).

CONCLUSION

1. Based on the study of the true prevalence of 30 possible risk factors, the most informative ones were identified, the prognostic value of which was used as criteria for the risk assessment of bronchopulmonary system disease in children.
2. Based on the methodology of Wald's sequential analysis in the modification of E.V. Gubler a standardized threatometric (pathometric) tabular algorithm was compiled and an example of its application at the individual level was provided. The application of this algorithm allows to document the available significant risk factors and to identify individuals (and homogeneous territorially ontogenetic groups) with high risk of bronchopulmonary system diseases.
3. The algorithm verification was carried out among children of two groups and was stated, that the error frequency of the first kind amounted to α=3,0%, while errors of the second kind (low risk with pathology was identified) β=7,2%. Thus, the specificity of the prognostic algorithm is 92,8%,

Table 2. Risk assessment algorithm for dysplastic-dependent pathology of the bronchopulmonary system using a set of regional-environmental factors
Tabela 2. Algorytm oceny ryzyka dla zależnej od dysplastyczności patologii układu oskrzelowo-płucnego z wykorzystaniem zestawu regionalnych czynników środowiskowych

Regional ecological factors	Prognostic coeficients	
	criteria	PC
1. The level of radiation background in the place of residence (X25)	↑ ↑↓ ↓	+5,1 +0,3 -5,4
2. The level of lead, chromium, copper, nickel and zinc in the ground layer of the atmosphere (summarized; X6)	↑ ↑↓ ↓	+5,1 -1,1 -4,4
3. Soil contamination with heavy metals (X2)	↑ ↑↓ ↓	+3,5 -1,9 -4,2
4. Anthropogenic load of atmospheric air from stationary sources (X19)	↑ ↑↓ ↓	+3,3 +0,7 -4,0
5. Waste generation (accumulation) intensity (X22)	↑ ↑↓ ↓	+3,8 +0,1 -3,6
6. The level of use of water from stationary sources (X17)	↑ ↑↓ ↓	+5,1 -0,7 -2,5
7. The level of the aquifer mineralization, (X12)	↑ ↑↓ ↓	+3,2 +0,1 -3,8
8. The intensity of discharge of polluted waste water drainage (X10)	↑ ↑↓ ↓	+3,6 -0,5 -2,8

Note: for each of the factors the correspondence is determined (↑ – exceeds, ↓ – less or ↑↓ – within the regional level), and the corresponding pathometric coefficients are added; on reaching the Threshold Amount (TA) of coefficients (-17 or +17), the level of risk is determined using the scale

Table 3. The scale of dysplastic dependent pathology of bronchopulmonary system risk evaluation depending on regional environmental factors' influence
Tabela 3. Skala zależnej od dysplastyczności patologii oceny ryzyka układu oskrzelowo-płucnego w zależności od wpływu regionalnych czynników środowiskowych

The scale of dysplastic dependent pathology of bronchopulmonary system risk evaluation		
$_{TAmin}$ ≤ -17,0		$_{TAmax}$ ≥ +17,0
Minimal risk	indefinite risk	High risk

and its efficiency is 97,0%, which enables to recommend it as a stage of population monitoring.

Prospects for further research on this issue are determined by the need to develop the algorithms for population and individual prognosis of bronchopulmonary system disease in the antenatal period and at the stages of postnatal ontogeny, considering other informative (medical, organizational, genealogical and anamnestic) factors.

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