

RISK COMMUNICATION. RISK MANAGEMENT

UDC 613.954.4

DOI: 10.21668/health.risk/2016.3.11

JUSTIFYING THE OPTIMAL NUMBER OF CHILDREN IN A GROUP: TAKING SANITARY-HYGIENIC STATE OF CHILDREN PRE-SCHOOL FACILITIES AND HEALTH RISKS FOR CHILDREN INTO ACCOUNT

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*When a number of children attending one group in a pre-school children facility becomes higher than 22, sanitary and hygienic conditions in this group playrooms and restrooms deteriorate as per chemical, biological and physical parameters. When children groups are overcrowded, the air in playrooms and restrooms contains phenol and formaldehyde in concentrations equal to 2.2-4.6 maximum permissible concentrations; air contamination with opportunistic-pathogenic flora (*St. aureus*) increases by 30%; noise exposure level during playtime reaches 80 dB. We detected direct correlation between a number of children in a group and increased children morbidity for such nosologic forms as allergic respiratory organs and skin diseases, functional gastrointestinal disorders, acute virus and bacterial diseases and urinary tract infections ($R^2=0.32-0.89$; $p\leq 0.035-0.0001$). Risk of children's physical and biological development retardation becomes 1.2-2.0 times higher ($OR=1.51-2.17$; $DI=1.1-3.01$; $p=0.01-0.03$); adaptive reserves of cardiovascular, respiratory and involuntary nervous system decrease, and risk of functional disorders, including cognitive ones, increases 1.2-10.0 times ($OR=1.2-10.11$; $DI=1.11-18.81$; $p=0.01-0.04$). Long-term joint combined exposure to chemical, biological and physical factors determines chronic physiological distress-syndrome evolution in children; it becomes apparent through changes in metabolism and hemopoiesis, and in cellular and humoral component of immune reaction being less active, in disorders of antioxidant protection intracellular mechanisms ($p=0.0001-0.017$). Results of sanitary-hygienic, clinical and laboratory and mathematic research helped us to determine the optimal number of children any group of a standard pre-school children facility for overall development should include. This number amounts to 14-16 children; standard area per 1 child in playrooms and restrooms should be not less than 4 square meters. If a group in a pre-school children facility is attended by 14-16 children and playroom and restroom area conforms to standards, parameters of physical and cognitive development as well as children's functional state are only to a minimal extent determined by sanitary and hygienic conditions of a pre-school facility internal environment.*

Keywords: pre-school children facilities, optimal number of children in a group, sanitary and hygienic welfare, children's health.

There has been a substantial growth in birth rate in the RF since 2000; it has led to a positive trend in number of children attending pre-school children facilities while the number of such facilities remains stable [10]. Number of children aged 3-7 attending pre-school children facilities in-

creased by 22.8% from 2012 to 2015 [6]. Although a lot of programs aimed at modernization of regional pre-school education systems have been implemented, the problem of overcrowded groups in pre-school children facilities still exists. The highest number of children in a group (more than

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23) is detected in independent pre-school children facilities which are attended by 85.9% of children aged 3-7; groups made for overall development which are attended by 88.5% of preschoolers, can include 24 and even more children [7]. We should also remember that number of children in a group varies in different regions of the RF; some groups can be attended by 30 and even more children [3, 8]. When a group is overcrowded it results in violation of sanitary and hygienic standards for children time-spending and education in a pre-school facility. Abramats et al. prove that when a child living environment becomes worse it may result in adaptive processes disorders and premorbid conditions evolution [1]. Kuchma (2013), Mirskaya (2013), Semenova (2015), and a number of foreign researchers detected correlations between educational process parameters in pre-school facilities and functional state of nervous, muscular, and respiratory systems; they also described risk factors causing chronic distress-syndrome evolution, slower and less harmonic physical development, higher morbidity rate etc. [1, 2, 4, 5, 9, 11-16]. According to valid Sanitary and Epidemiologic Requirements 2.4.1.3049-13 "Sanitary and epidemiologic requirements to arrangement, contents and organization of pre-school children facilities functioning" area per 1 child still remains the basic criterion defining a number of children in a group; there are no existing medical recommendations based on complex scientific sanitary-hygienic and clinical research which can set a limit for a number of children in a group of a pre-school children facility.

Research goal: to work out and to scientifically justify a standard for an optimal number of a children in a pre-school facility group basing on the complex hygienic assessment of chemical, physical and biological parameters of a pre-school facility sanitary and hygienic welfare and analysis of their correlation to health disorders in children attending pre-school facilities for overall development.

Data and methods. We carried out a comparative assessment of two typical pre-school children facilities (typical project No. 214-2-22 and No. 212-2-64) with different number of children in groups concentrating on the conformity of arrangement, contents and organization of their functioning to Sanitary and Epidemiologic Requirements 2.4.1.3049-13 of May 15, 2013. To accomplish the assessment we analyzed the data taken from scheduled field checks certifications issued by Rospotrebnadzor Regional Office in Perm over

2012-2014. The internal environment quality inside group playrooms and restrooms was assessed as per field observations results, with chemical and microbiological air contamination, noise level and microclimate being basic assessment parameters. To obtain an objective assessment of influence exerted by sanitary and hygienic situation in a pre-school facility on children's health we accomplished in-depth clinical and laboratory examination of 332 children aged 3-7 and attending two selected typical pre-school facilities. An average number of children in a group in a focus pre-school facility was equal to 29.6 ± 1.84 children (33 max, 27 min), 193 children were examined; this number was equal to 21.1 ± 1.85 children in a comparative pre-school facility (22 max, 16 min), 139 children were examined. The examined children from junior, middle, senior and preschool preparatory groups attended those pre-school facilities for 1, 2, 3 and 4 years correspondingly. Gender makeup of examined children, both totally ($p=0.87-0.98$), and in separate age groups ($p=0.63-0.99$) didn't have any statistically significant discrepancies. Examined groups also didn't have any significant discrepancies as per social factors able to exert negative influence on children's health ($p=0.15-0.9$). Both pre-school facilities began their functioning in 1998-1999; the latest running maintenance was made 9-10 months prior to our research; both pre-school facilities were equipped with identical furniture.

Clinical and laboratory examination of children was carried out in full conformity with ethical principles stated in Helsinki Declaration, European Union Regulations (8/609EC) And the RF State Standards 52379-2005 «Appropriate Clinical Practice» (ICH E6 GCP). In our research course we used a whole set of various research techniques including sanitary and hygienic ones (assessment of air contamination with technogeneous organic substances in playrooms and on the territory of a pre-school facility, examination of noise exposure intensity, microclimate parameters, bacterial contamination of playrooms air); chemical and analytical ones (defining formaldehyde, phenol, styrene, ethylbenzene and benzene content in atmosphere outside and in playrooms air inside a pre-school facility and in children's blood); epidemiologic ones (back-in-time morbidity analysis of children attending the selected pre-school facilities as per Obligatory Medical Insurance fund data); clinical and functional ones (check-ups made by a pediatrician, allergist, ENT-specialist, gastro-

enterologist, and neurologist; electrocardiography, intranasal pressure measurement, spirometry, heart rate assessment); instrumental ones (ultrasonic scanning of abdominal cavity organs); and finally, laboratory research techniques. We defined cognitive functions maturity basing on the results of perceptive function assessment (“Which objects are hidden?” test), spatial praxis (Head test), kinesthetic organization of movements (“Finger pose praxis” test) and attention (“Put signs” test). A complex of clinical and laboratory research was accomplished as per standard techniques with the use of certified equipment which had been through metrological verification; and we conducted all laboratory research in the accredited laboratories at Federal Scientific Center for Medical and Preventive Health Risk Management Technologies of Rospotrebnadzor.

To scientifically justify our recommendations on an optimal number of children in a pre-school facility group we made up a list of parameters characterizing sanitary and hygienic welfare of environment inside pre-school facilities, level of physical development, adaptive potential of children’s vital body systems and children’s cognitive functions. Our choice of crucial parameters was based on the following requirements: parameter should have a standard; its variations at different number of children in a group should be statistically authentic and pathogenetically grounded; correlation between all sanitary and hygienic parameters and a number of children in a pre-school facility group should be proved and parameterized; the same should be done for the correlation between clinical parameters and changes in chemical, biological and physical parameters of sanitary and hygienic welfare.

To justify an optimal number of children in a pre-school facility group we used the following parameters: average daily concentrations of organic compounds in playrooms air (phenol, formaldehyde), physical development parameters, and functional state of cardiovascular system, upper air passages, involuntary nervous system and cognitive functions.

Calculation of an optimal number of children in a pre-school facility group was accomplished with the use of linear approximation technique as per formula (1):

$$N_0 = \frac{(N_2 - N_1)}{(F_2 - F_1)}(F_0 - F_1) + N_1, \quad (1)$$

where N_0 is an optimal number of children; N_1 is a number of children in comparative pre-school facility group; N_2 is a number of children in focus pre-school facility group; F_1 is parameter value in comparative pre-school facility; F_2 is parameter value in focus pre-school facility; F_0 is standard value.

To compare the groups as per quantitative results we used two-sample Student test. We assessed correlations between parameters using single-factor analysis and correlation-regression analysis. We applied Fischer and Student criteria to assess the obtained results validity. We thought discrepancies in the obtained results to be statistically significant at $p < 0.05$. We determined and assessed correlation between changes in examined parameters and a number of children in a group basing on odds relation calculation (OR) and its confidence interval (DI). $OR \geq 1$ was a criterion proving occurrence of “number of children in a group – effect parameter” correlation.

Results and discussion. In our research we determined that both pre-school facilities were identical as per their functioning arrangement, contents and organization. In general, their functioning parameters corresponded to relevant sanitary legislation requirements (Sanitary and Epidemiologic Requirements 2.4.1.3049-13). Average area per 1 child in playrooms in the focus pre-school facility amounted to $2.02 \pm 0.12 \text{ m}^2$, and to $2.3 \pm 0.29 \text{ m}^2$ in the comparative pre-school facility ($p = 0.08$), and it conformed to sections 1.3., 1.8. of Sanitary and Epidemiologic Requirements 2.4.1.3049-13 in both pre-school facilities. The basic discrepancy between those two pre-school facilities was the number of children in the groups.

As we carried out field observations of air quality in playrooms we determined that styrene, benzene and ethylbenzene content in it in both pre-school facilities didn’t exceed hygienic standards ($p \leq 0.0001$). At the same time, average daily formaldehyde and phenol concentrations in playrooms air in the focus pre-school facility were 1.5-2.0 times higher than in the comparative pre-school facility; their concentrations were also 2.2-4.6 times higher than average daily maximum permissible level ($p = 0.001$) (Table 1).

As we examined the air outside the selected pre-school facilities we found out that formaldehyde concentrations ($0.0030 \pm 0.0006 \text{ mgr/ m}^3$ at the focus pre-school facility; $0.0010 \pm 0.0002 \text{ mgr/ m}^3$ at the comparative pre-school facility) and phenol

(0.0042 ± 0.0011 and 0.0074 ± 0.0018 mgr/m³ correspondingly) didn't exceed hygienic standards (0.01 mgr/m³ and 0.003 mgr/m³ correspondingly). We processed the obtained data mathematically and it helped us to detect that the content of those chemicals inside the pre-school facilities was not caused by any external sources ($R^2=0.12-0.16$; $F=22.81-112.73$; $p=0.72-0.84$). At the same time playrooms in the focus pre-school facility were equipped with furniture, linoleum and other finishing agents in quantities authentically bigger than in the comparative pre-school facility (1.06 ± 0.11 m²/m³ and 0.91 ± 0.06 m²/m³ correspondingly, $p=0.04$).

As we conducted chemical and analytical research we detected that formaldehyde and phenol content in blood of children attending the focus pre-school facility was 1.9-2.9 times higher than the same chemicals content in blood of children attending the comparative pre-school facility: 0.0029 ± 0.0003 mgr/dm³ against 0.0015 ± 0.0002 mgr/dm³ and 0.020 ± 0.003 mgr/dm³ against 0.0069 ± 0.004 mgr/dm³ correspondingly, $p=0.03-0.001$.

We also studied bacterial contamination of playrooms air and the study showed that if a group was overcrowded the overall microbe value was 1.2 times higher in the focus pre-school facility by 11 a.m. already; 30% of samples contained opportunistic-pathogenic flora (*St. aureus*) (Table 1). We revealed the direct correlation between the overall microbe value of bacterial contamination in play-

rooms and opportunistic-pathogenic flora (*St. aureus*) occurrence ($R^2=0.69$; $p=0.001$).

The results of acoustic factor examination proved that equivalent and maximum noise level during playtime in the focus pre-school facility reached intensively abnormal values (78-79 dB) and exceeded the same parameter in the comparative pre-school facility ($p \leq 0.001$); we should also remember that the total noise exposure usually lasts for more than 6 hours (table 1).

Temperature rate and relative air humidity in the compared pre-school facilities were stable during the day and completely conformed to the hygienic standards set forth by Sanitary and Epidemiologic Requirements 2.4.1.3049-13.

The results of retrospective epidemiologic analysis of children's morbidity over 2010-2014 showed that children attending overcrowded groups in pre-school facilities had 1.2-3.5 times higher morbidity figures for such nosologic forms as bronchial asthma, bacterial enteric and quarantine infections (chickenpox, scarlatina), chronic inflammatory diseases of nasopharynx and tonsils, urinary tract infections, enterobiasis ($p=0.0016-0.91$); acute serous otitis was detected even 5.9 times more frequently ($p=0.028$). We detected distinctive growth over the analyzed period in atopic dermatitis morbidity in the focus pre-school facility (from 0.0172 to 0.1552 cases/1 child), bronchitis morbidity (from 0.0172 to 0.0345 cases/1 child), and acute upper

Table 1

Comparative characteristics of sanitary-hygienic parameters related to the quality of the internal environment in pre-school facilities with a different number of children in groups

Parameter		Focus pre-school facility	Comparative pre-school facility	<i>p</i>	Standard
An average number of children in a group (people)		$29,6 \pm 1,84$	$21,1 \pm 1,85$	0,03	none
Average playroom area per 1 child (m ²)		$2,02 \pm 0,12$	$2,3 \pm 0,29$	0,08	2.0 m ² per 1 child
Daily average phenol concentration in playrooms air (mgr/m ³)		$0,0138 \pm 0,0034$	$0,0070 \pm 0,0017$	$\leq 0,001$	0,003
Daily average formaldehyde concentration in playrooms air (mgr/m ³)		$0,0215 \pm 0,0043$	$0,0142 \pm 0,0028$	$\leq 0,001$	0,01
Overall microbe value in playrooms air (CFU/m ³)		$1360,91 \pm 550,49$	$1151,67 \pm 688,76$	0,61	none
St. aureus	Microbe value (CFU/m ³)	4-20	0	0,07	none
	% positive test	30	0	0,04	none
Equivalent noise in playrooms (dB)		$77,77 \pm 2,32$	$70,40 \pm 1,79$	$\leq 0,001$	none
Maximum noise in playrooms (dB)		$78,53 \pm 1,34$	$71,93 \pm 0,72$	$\leq 0,001$	none

p – validity of discrepancy between the pre-school facilities being compared.

air passages infections (from 1.4482 to 1.9283 cases/1 child) ($p=0.003-0.66$). We determined the direct correlation between a number of children in a group in pre-school facilities and higher children

morbidity for such nosologies as allergic respiratory organs and skin diseases, functional gastrointestinal disorders, acute virus and bacterial diseases,

urinary tract infections, and chronic tubulointerstitial nephritis ($R^2=0.32-0.89$; $p\leq 0.035-0.0001$).

Our somatometric and physiometric research enabled us to find out that a number of children with statural-weight value deviations from the physiological standard was 1.3 times higher in overcrowded groups than in the comparative pre-school facility (57.1% against 44% and 35.7% against 27% correspondingly, $p=0.02-0.23$); the number of children with low values of head and chest circumference was 1.4-1.8 times higher (71% against 51.1% and 56.5% against 31.3% correspondingly, $p\leq 0.001-0.011$). As we analyzed prevalence of various children body-build somatotypes, we determined that only 50% of children attending the focus pre-school facility had mesosomatotype (67% in the comparative pre-school facility, $p=0.03$), and a number of children with microsomatotype and macrosomatotype was 1.2-1.8 times higher than in the comparative pre-school facility ($p=0.04-0.56$). Only 2.9% of children attending overcrowded groups in a pre-school facility had carpal dynamometry parameter conforming to the physiological standard (14.3% of children attending the comparative pre-school facility, $p=0.013$). Relative risks of statural-weight and circumference parameters deviating from physiological standards, as well as risks of body developing as per micro- or macrosomatotype were 1.5-2.2 times higher for children attending overcrowded groups in the focus pre-school facility than for children attending the comparative pre-school facility ($OR=1.54-2.17$; $DI=1.1-3.01$; $p=0.02-0.03$). We revealed the authentic direct correlation between a number of children in a group and a number of children having statural-weight disorders, low Erisman index and high Pine index ($R^2=0.25-0.38$; $p=0.04-0.0001$). The results of individual dental formula assessment showed that the number of children with biological development retardation (41%) was 1.3 times higher in the focus pre-school facility than in the comparative one (32%, $p=0.21$), and the relative risk of biological maturity disorders in children attending overcrowded groups was 1.5 times higher in the focus pre-school facility than in the comparative one ($OR=1.51$; $DI=1.11-1.96$; $p=0.01$).

The comparative assessment of cardiovascular system functional state and adaptive reserves showed that children attending overcrowded groups ran 1.4-10.0 times higher risks of episodic arterial hypertension, disorders in vascular tone regulation and functional abilities development, lower heart stroke output and cardiac output, dis-

orders in cardiac muscle irritability process, than children attending the comparative pre-school facility ($OR=1.4-10.11$; $DI=1.11-18.81$; $p=0.01-0.03$). As we applied electrocardiography, we detected that "physiological standard" outcome for excitement and conduction in cardiac muscle was 1.4 times less frequent in children attending the focus pre-school facilities than in children from the comparative one (44.1% against 63.3%, $p=0.02$). We determined the direct correlation between a number of children in a group and higher frequency of tachycardia cases and disorders in cardiac muscle irritability process ($R^2=0.16-0.34$; $p=0.03-0.02$).

Disorders in upper air passages patency detected via intranasal pressure measurement occurred in 43.8% of children attending overcrowded groups and it was 5 times higher than in the comparative pre-school facility (8.7%, $p\leq 0.001$). Relative risk of respiratory muscles being underdeveloped and disorders in nasal breathing function in children attending the focus pre-school facility was 1.6-7.0 times higher than in the comparative one ($OR=1.64-7.77$; $DI=1.21-13.88$; $p=0.02-0.04$). As we applied spirometry to examine functional state of lower air passages we determined that restrictive respiratory disorders in mild form were the dominant type of respiratory disorders in 16.1% of children attending the focus pre-school facility and in 17.1% of children attending the comparative pre-school facility ($p=0.88$).

As we applied heart rate assessment to examine functional state of involuntary nervous system we detected that eutony (the optimal initial vegetative tone for pre-school age children) occurred only in each third child (33.5%) attending the focus pre-school facility against 67% in the comparative pre-school facility ($p\leq 0.001$); vagotonic tone occurred 3 times more frequently (33.5% against 11.5%, $p\leq 0.001$), and 11.5% had hypersympathicotonic type of initial vegetative tone ($p\leq 0.001$ against the comparative pre-school facility). As we conducted wedge-orthostatic test we registered sympathicotonic type of vegetative reactivity 1.7 times less frequently in children attending overcrowded groups (50% against 83%, $p\leq 0.001$), but hypersympathicotonic type was detected 2.9 times more frequently (50% against 17% in the comparative pre-school facility, $p\leq 0.001$), and it coincided with the vegetative reactivity assessment as per calculated Kerdo index. Relative risk of initial vegetative state deviations from eutony in children attending overcrowded groups in pre-school facilities was 4 times higher than in the comparative

pre-school facility; relative risk of hypersympathicotonic vegetative reactions development as a response to graduated physical activity was 5 times higher in the focus pre-school facility (OR=4.0-5.0; DI=2.81-9.11; p=0.03).

Our analysis of average group results for cognitive functions maturity revealed that the examined groups didn't have any authentic discrepancies in terms of perceptive function development, spatial praxis and kinesthetic organization of movements (p=0.21-0.4), although average group estimate of attention function for children attending the focus pre-school facility (4.12±1.22 points) was 1.5 times lower than in the comparative pre-school facility (6.07±0.64 points, p=0.005) and also lower than physiological standard (6-8 points, p=0.012) (table 2); and the number of children with low attention level was 1.5 times higher (56.3% against 36.4%, p=0.02). Relative risk of cognitive functions retardation for children attending overcrowded groups was 1.2 times higher than for children from the comparative pre-school facility (OR=1.2; DI=1.01-4.32; p=0.03).

As we analyzed the results of complex medical examination we detected that children in the focus pre-school facility had chronic respiratory organs diseases 1.7 times more frequently than in the comparative one (28.8% against 17.3%, p=0.07); allergic diseases, 2,2 times more frequently (23.3% against 10.6%, p=0.02); nervous system diseases, 2.1 times more frequently (53.4% against 25%, p≤0.001); chronic urinary system diseases, 5.5 times more frequently (5.5% against 1%, p=0.03). Children from the focus pre-school facility attending overcrowded groups ran 1.5-6 times higher relative risk of allergic respiratory organs and skin diseases, chronic inflammatory-proliferative diseases of upper air passages, functional disorders of nervous system, and urinary system pathologies, than children attending the comparative pre-school facility (OR=1.47-6.03; DI=1.11-8.79; p=0.01-0.04). Ultrasonic examination of abdominal cavity organs helped us to determine that children attending the focus pre-school facility had premorbid morpho-functional deviations in liver and pancreas 1.3-1.5 times more frequently than children attending the comparative pre-school facility (p≤0.001-0.05); dyscholia was

registered 3 times more frequently (86% against 29%, p≤0.001). We should note that number of children having the 3rd health category was 3.3 times higher in overcrowded groups (19.2% against 5.8% in the comparative pre-school facility, p=0.006). Relative risk of systemic multi-organ pathology evolvement was 4 times higher for children attending overcrowded groups than for children attending the comparative pre-school facility (OR=3.85; DI=2.17-6.11; p=0.04).

Clinical and laboratory data examination revealed that children attending overcrowded groups had authentically higher activity of erythrocytic and neutrophilic hemopoiesis germ (15-30% higher, p=0.007-0.008) combined with lower lympho- and monocytopoiesis (20-35% lower, p=0.0001-0.0002). As we conducted comparative analysis of homeostasis integral parameters we detected authentically lower activity of protein, carbohydrate, and mineral metabolism processes and synthetic processes (10-30% lower, p=0.0002-0.049), in children attending the focus pre-school facility; antioxidant protection, energetic metabolism and A, D, and E vitamins content in blood was also lower (1.3-2.3 times, p=0.0001-0.017); crude cholesterol and low-density lyposaccharides were higher (17-30%, p=0.005-0.02). Immunogram revealed that cellular and humoral component of immune reaction tended to be less active in children attending overcrowded groups; it was combined with activation of immediate allergic reactions. Children attending the focus pre-school facility ran 1.2-2.3 times higher risk of lower G immunoglobulin level, lower active immunocytes quantity (CD3+CD25+-lymphocytes and CD3+CD95+-lymphocytes) and higher E immunoglobulin content, than children attending the comparative pre-school facility (DI=1.06-5.78; p=0.01-0.04).

Average group hormonal profile parameters for all examined children corresponded to the physiological age standard; however, children attending overcrowded groups had 1.1-1.3 times higher content of stress-hormones (noradrenalin and hydrocortisone) in blood (p=0.0004-0.02), and serotonin concentration was authentically 1.3 times lower (p=0.022) (table 3).

Table 2
The results of cognitive functions assessment for children from the compared pre-school facilities (points)

Functions	The focus pre-school facility	The comparative pre-school facility	p^1	Physiological standard	p^2
Perception assessment	9,06 ± 1,02	8,36 ± 0,96	0,3	6–8	0,9
Spatial praxis assessment	2,56 ± 0,39	2,68 ± 0,21	0,4	0–1	≤0,001
Kinesthetic organization of movements, assessment	2,25 ± 0,36	1,86 ± 0,52	0,21	0–1	0,038–0,001
Attention assessment	4,12 ± 1,22	6,07 ± 0,64	0,005	6–8	0,4–0,012

p^1 – validity of discrepancy between the pre-school facilities being compared;

p^2 – validity of discrepancy between the compared pre-school facilities and physiological standard.

Table 3

Comparative analysis of average group hormonal profile parameters
in children attending the compared pre-school facilities

Parameter	Physiological standard	The focus pre-school facility	The comparative pre-school facility	p
Adrenaline, pgr/cm ³	0–100	32,56 ± 3,16	35,46 ± 2,79	0,187
Dopamine, pgr/cm ³	0–100	31,84 ± 5,85	34,81 ± 2,46	0,364
Hydrocortisone, nmol/cm ³	140–600	350,01 ± 50,89	269,62 ± 45,05	0,020
Noradrenalin, pgr/cm ³	0–600	309,13 ± 8,32	282,70 ± 12,05	0,0004
Serotonin, ngr/cm ³	80–450	231,83 ± 34,41	295,96 ± 43,04	0,022
T-3, ngr/cm ³	0,6–2,1	2,18 ± 0,16	2,36 ± 0,14	0,103
T4 crude, nmol/dm ³	83–170	131,44 ± 7,80	136,70 ± 6,28	0,298
T4 free, pmol/dm ³	10–25	14,18 ± 0,75	14,06 ± 0,56	0,790
thyrothopin, mcME/cm ³	0,3–4,0	2,44 ± 0,50	1,89 ± 0,31	0,067

p – validity of discrepancy between the pre-school facilities being compared.

During the following stage of our research we determined cause-and-effect relations between hormonal homeostasis disorder and unsatisfactory sanitary and hygienic parameters of the environment inside pre-school facilities. We detected the correlation between higher hydrocortisone content in blood of children attending overcrowded groups and increase in playrooms air contamination with bacteria, high level of phenol and formaldehyde concentrations in playrooms air, and noise exposure

($R^2=0.24-0.44$; $39.09 \leq F \leq 118.15$; $p=0.01-0.0001$) (Table 4). We defined the correlation between noradrenalin concentration in blood and noise exposure, its contribution being 31% ($p=0.03$).

The following analysis of probability models enabled us to prove stress-hormones contribution into metabolic processes disorders and decode some components of pathogenetic changes in health of children attending pre-school facilities with low quality of the internal environment caused by too many children in one group. We detected authentic correlation between higher hydrocortisone content in blood and decrease in relative lymphocytes and monocytes content, crude protein level, dextrose,

glutathione peroxidase and superoxide dismutase, E vitamin, CD19+/- и CD3+CD4+/- lymphocytes absolute content, G category immunoglobulin, phagocytic number, and increase in stab neutrophils and reticulocytes in blood ($R^2=0.20-0.53$; $24.63 \leq F \leq 156.85$; $p=0.04-0,0001$). We proved that 21%-25% decrease in magnesium and crude protein content in blood was caused by noradrenalin ($p=0.001$); and 24%-29% decrease in dextrose and cyclic guanosine monophosphate was caused by lower serotonin content in blood ($p=0.02-0.003$).

So, long-term joint combined exposure to chemical, biological and physical factor determine chronic physiological distress-syndrome evolvement in children; the syndrome signs are changes in metabolism and hemopoiesis, lower activity of cellular and humoral component of immune reaction, disorders in intracellular mechanisms of antioxidant protection. Shift in redox-homeostasis and unbalanced metabolic processes can cause physical development disorders (in 47.1%-71%), cognitive development disorders (in 31.3%-56.3%), and adaptive processes inefficiency in children (8.2%-56.3%); such disorders are determined by a high number of children in groups ($R^2=0.16-0.38$;

Table 4

Correlation models parameters «stress-factors – hormones content in blood»
in children attending focus pre-school facility

Stressor	Impact mark	Trend in parameter change	Model parameters		Determination coefficient	Fischer criterion	Model validity
			b0	b1	R^2	F	p
Formaldehyde	Hydrocortisone	Increase	$2,78 \pm 0,001$	$310,98 \pm 35,25$	0,44	118,15	0,0001
Phenol	Hydrocortisone	Increase	$-1,21 \pm 0,03$	$142,03 \pm 0,024$	0,37	43,61	0,0001
Noise	Hydrocortisone	Increase	$2,13 \pm 0,18$	$109,93 \pm 11,13$	0,41	89,39	0,001
	Noradrenalin	Increase	$2,28 \pm 0,57$	$57,88 \pm 16,09$	0,31	50,93	0,03
Air contamination	Hydrocortisone	Increase	$2,05 \pm 0,78$	$39,17 \pm 6,75$	0,24	39,09	0,01

Table 5

Parameters list required for justifying the optimal number of children in a group in a pre-school facility where children spend 12 hours every day

Parameter		Focus pre-school facility	Comparative pre-school facility	p	Standard
<i>Criteria of sanitary and hygienic conditions inside a pre-school facility</i>					
Average daily concentrations of organic compounds in playrooms air (mgr/m ³)	Phenol	$0,0138 \pm 0,0034$	$0,0070 \pm 0,0017$	$\leq 0,001$	0,003
	Formaldehyde	$0,0215 \pm 0,0043$	$0,0142 \pm 0,0028$	$\leq 0,001$	0,01
<i>Clinical criteria</i>					
Physical development parameters	Number of children with chest circumference lower than physical standard (%)	56,5	31,3	$\leq 0,001$	Less than 20
	Mesosomatic type of body-build (%)	50,0	67	0,03	80,0
Parameters of cardiovascular system	Physiological parameters of electrocardiogram (%)	44,1	63,3	0,02	80 and more
Parameters of nasal breathing	Number of children with nasal patency disorders (%)	43,8	8,7	$\leq 0,001$	0
Parameters of involuntary nervous system	Hypersympathicotonic type of vegetative reactivity (%)	50	17	$\leq 0,001$	0
	Ultrasounds signs of dysholia	86	29	$\leq 0,001$	20
Cognitive functions state	Attention assessment (b)	$4,12 \pm 1,22$	$6,07 \pm 0,64$	0,005	6-8

p – validity of discrepancy between pre-school facilities being compared.

$p=0.04-0.0001$). Physical development retardation, lower adaptive abilities and lower immune resistance lead to 1.7-2.2 times higher children morbidity for such nosologic forms as chronic proliferative diseases of upper air passages and ears, acute respiratory virus and bacterial infections, allergic pathologies; overcrowded groups contribution into such diseases involvement can reach 32-89% ($p \leq 0.035-0.0001$).

To calculate an optimal number of children in one group in a pre-school facility we used a complete set of sanitary and hygienic (chemical) and clinical and functional parameters (table 5). Our calculation results (1) showed that as per sanitary and hygienic criteria the optimal number of children in a group should not exceed 16; as per physi-

cal and cognitive development criteria, 15-21; as per functional state of cardiovascular, respiratory and involuntary nervous systems, 14-20. Basing on the obtained results and taking “limiting factor rule” into account, we determined that the optimal number of children in a group in a typical pre-school facility aimed at overall development should not exceed 14-16, and minimum acceptable square of playrooms and restrooms per 1 child cannot be less than 4 m². If one group is attended by 14-16 children, and playrooms and restrooms areas meet the required square standard, all the parameters of children’s physical and cognitive development, as well as functional state of their vital organs and systems are only to a minimal ex-

tent determined by sanitary and hygienic parameters of the environment inside a pre-school facility.

Conclusions.

1. We detected unsatisfactory sanitary and hygienic conditions in overcrowded pre-school facilities where playrooms and restrooms area per 1 child amounts to 2 square meters; such conditions are caused by higher concentrations of technogenic chemicals (phenol and formaldehyde, up to 4.6 maximum permissible concentrations) in playrooms and restrooms air; by 1.2 times increase of air bacterial contamination with 30% samples containing opportunistic-pathogenic flora; by higher intensity of equivalent and maximum noise reaching abnormal level (up to 80 dB).

2. Unsatisfactory sanitary and hygienic conditions in overcrowded pre-school facilities lead to 2.2 times higher risk of physical and biological development retardation, up to 10.0 times higher risk of cardiovascular, respiratory and involuntary nervous systems having lower adaptive reserves, and 1.6 times higher risk of slower cognitive functions development.

3. Long-term joint combined exposure to chemical, biological and physical factors determines chronic physiological distress-syndrome

evolution in children together with 1.3 times higher sympathoadrenal system activity (noradrenalin, hydrocortisone); it results in 1.3 times lower intensity of basic metabolic processes and 2.3 times lower level of antioxidant protection and immune resistance.

4. 2.3-3.5 times higher morbidity of children attending overcrowded pre-school facilities for such nosologies as acute virus and bacterial infections, chronic inflammatory and proliferative diseases of upper air passages, respiratory organs diseases and skin diseases of allergic genesis, functional disorders of nervous system, is caused by chronic joint combined exposure to chemical (phenol and formaldehyde contamination of playrooms air), biological (higher contents of opportunistic-pathogenic flora in pre-school facilities air) and physical (noise up to 80 dB) risk factors.

5. When a number of children in a pre-school facility group amounts to 14-16, and play- and restrooms area per 1 child is equal to 4m², satisfactory sanitary and hygienic conditions are provided; such number of children in a group and area per 1 child are optimal for preserving children's health and their development.

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