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Research article

TYPOLOGIZATION OF RUSSIAN REGIONS AS PER ENVIRONMENTAL FACTORS, FACTORS RELATED TO EDUCATIONAL PROCESS AND SCHOOLCHILDREN'S HEALTH

S.V. Kleyn[1,2], D.A. Eisfeld[2], N.V. Nikiforova[2]

[1]Perm State Medical University named after Academician E.A. Wagner, 26 Petropavlovskaya Str., Perm, 614000, Russian Federation
[2]Federal Scientific Center for Medical and Preventive Health Risk Management Technologies, 82 Monastyrskaya Str., Perm, 614045, Russian Federation

The structure of children population determined as per health groups is an integral characteristic of population health in this age group; it can be used as a criterion in creating medical and preventive programs aimed at managing demographic processes and assessing their efficiency. Health disorders among children occur due to many reasons including influence by socioeconomic and sanitary-epidemiological factors, peculiarities of the educational process, eating habits, lifestyle, etc. Our research aim was to determine types of regions in Russia as per environmental factors, the educational process and schoolchildren's health. Determining different types of regions was considered to be an information basis for developing common strategies and mechanisms for improving schoolchildren's health. Typologization of regions as per health groups revealed that the most favorable situation was in 31 regions; the last favorable, only in 2. The most favorable situation as per the educational process was in 55 regions where schools operated in one shift; the least favorable situation was observed in two RF regions where schools had to operate in two or even three shifts. Relative sanitary-epidemiological welfare was found in 20 regions and the situation in 21 regions was the least favorable as per several markers that characterized quality of drinking water, ambient air, and soils. Socioeconomic situations in the regions were analyzed to reveal that only 3 regions could be considered the most favorable and 28 regions were the least favorable; the latter were combined into one cluster with the lower values of the relevant markers including gross regional products per capita, living standard, provision with qualified medical personnel and in-patient hospital beds.

A situation in each particular region is a reflection of regularities related to influence exerted by a set of aforementioned factors on children's health; this proves the necessity to create a road map for each region in the RF with feasible mechanisms aimed at improving the existing situation as per specific aspects.

Keywords: *children's population, health groups, factors related to the educational process, sanitary and epidemiological state, socio-economic state, nutrition, cluster analysis.*

To provide sanitary-epidemiological well-being of the population in the Russian Federation and to preserve citizens' health is among priority activities performed by the RF Government. This was fixed in the Order by the RF President[1] and the Program of priority activities to be performed by the RF Government for a period up to 2024[2].

Svetlana V. Kleyn – Doctor of Medical Sciences, Associate Professor, Head of the Department for Systemic Procedures of Sanitary-Hygienic Analysis and Monitoring (e-mail: kleyn@fcrisk.ru; tel.: +7 (342) 237-18-04; ORCID: https://orcid.org/0000-0002-2534-5713).

Darja A. Eisfeld – Candidate of Biological Sciences, Deputy Director responsible for general issues (e-mail: eisfeld@fcrisk.ru; tel.: +7 (342) 236-77-06; ORCID: https://orcid.org/0000-0002-0442-9010).

Nadezhda V. Nikiforova – Candidate of Medical Sciences, Head of the Laboratory for Procedures of Sanitary-Hygienic Monitoring (e-mail: kriulina@fcrisk.ru; tel.: +7 (342) 237-18-04; ORCID: https://orcid.org/0000-0001-8060-109X).

[1] O natsional'nykh tselyakh i strategicheskikh zadachakh razvitiya Rossiiskoi Federatsii na period do 2024 goda: Ukaz Prezidenta Rossiiskoi Federatsii ot 7 maya 2018 g. № 204 [On national goals and strategic tasks in the development of the Russian Federation for a period up to 2024: The Order by the RF President issued on May 7, 2018 No. 204]. *The official web portal for legal information*. Available at: http://publication.pravo.gov.ru/Document/View/0001201805070038 (September 13, 2021) (in Russian).

[2] Osnovnye napravleniya deyatel'nosti Pravitel'stva Rossiiskoi Federatsii na period do 2024 goda (utv. Predsedatelem Pravitel'stva Rossiiskoi Federatsii D. Medvedevym 29 sentyabrya 2018 g.) [Priority activities to be performed by the Government of the Russian Federation for a period up to 2024 (approved by Dmitry Medvedev, the Head of the RF Government on September 29, 2018)]. *The RF Government*. Available at: http://static.government.ru/media/files/ne0vGNJUk9SQjlGNNsXlX2d2CpCho9qS.pdf (September 13, 2021) (in Russian).

All the activities concerning children are given special attention. Thus, in order to improve the state policy in the sphere of childhood protection, the RF President issued an order declaring the decade 2018–2027 to be The Childhood Decade.

In this respect it seems vital and well-timed to reveal a set of factors that influence children's health and to develop relevant activities aimed at minimizing their adverse impacts. A pilot project by the RF Public Healthcare Ministry which is called "Contemporary model of children's health protection in secondary educational establishments ("School medicine")" is a vital component in the Childhood Decade; the project involves transforming a typical intra-school environment into a powerful resource for improving health of each schoolchild [1–3].

Given overall deterioration of population health over the last years, the situation with children's health is also becoming worse; it is especially true for schoolchildren [4]. Some authors mention substantial increase in exertion of students' functional capacities and high physiological costs of studying due to considerable growth in educational loads created by the more intensified educational process in the contemporary school [5, 6]. The Federal Law "On sanitary-epidemiological well-being of the population" (Clause 40) (last edited by the Federal Law issued on January 10, 2003 No. 15-FZ) ranks education among activities that are potentially hazardous for people[3]. Many authors state in their works that conditions existing inside an educational establishment are comparable as per their influence on children's health to such powerful factors as environmental ones [7][4]. International community considers physical environment in educational establishments to be critically important for optimal education [8]. According to data provided by the WHO experts and Russian scientists, a contribution made by social-hygienic factors into children's health varies from 25 to 40 % [9, 10]. Multiple research works indicate that there is a correlation between a sanitary-epidemiological situation in an educational establishment, a territory where a given educational establishment is located, and health disorders among schoolchildren [11, 12]. Impacts exerted by combined factors, for example, a set of chemical factors and factors related to the educational process, are especially tangible in occurrence of various pathologies [13–15].

Nutrition is another most significant factor that influences children's health; influence is exerted by both meals provided by school and taken at home, the latter being determined by a socioeconomic status of a child's family and eating habits in general. Long-term deviations from so-called balanced nutrition result in violated anthropometric parameters, improper body composition, and overall functional disorders in the body [16, 17]. Some authors insist that health disorders caused by improper nutrition can develop not only in childhood but also at later stages in ontogenesis [18–20].

Therefore, children's health is influenced by a complex set of various factors; at present it is vital to reveal these factors and manage them successfully.

Our research aim was to determine types of regions in Russia as per a set of environmental factors, factors related to the educational process, and those related to children's health. Determining types of RF regions was considered as an information basis for developing common strategies and mechanisms aimed at improving schoolchildren's health.

Materials and methods. We applied methodical approaches based on cluster analysis to determine types of RF regions; the typolo-

[3] O sanitarno-epidemiologicheskom blagopoluchii naseleniya: Federal'nyi zakon ot 30.03.1999 N 52-FZ (red. ot 02.07.2021) [On sanitary-epidemiological well-being of the population: The Federal Law issued on March 30, 1999 No. 52-FZ (last edited on July 02, 2021)]. *KonsultantPlus*. Available at: https://demo.consultant.ru/cgi/online.cgi?req=doc&cacheid=07D4283DE8ED09967ECA937492134B2B&SORTTYPE=0&BASENODE=32913&ts=1598164464062323 18219454958&base=RZR&n=389728&rnd=01A083387EAF08BBF2BDE77748AB9DBB#2w8tu5xmcgm (September 19, 2021) (in Russian).

[4] O sostoyanii sanitarno-epidemiologicheskogo blagopoluchiya naseleniya v Rossiiskoi Federatsii v 2020 godu: Gosudarstvennyi doklad [On sanitary-epidemiological well-being of the population in the Russian Federation in 2020: The State Report]. Moscow, The Federal Service for Surveillance over Consumer Rights and Human Well-being, 2021, 256 p.

gization was accomplished in the present research to examine trends in influence exerted by environmental factors on distribution of children into different health groups.

The basic idea of this methodology was to develop several systems for classification of regions; these systems reflected differences between the regions in the RF as per several sets of indicators that characterized various socioeconomic and sanitary-epidemiological aspects and factors related to lifestyle influencing children's health. The next stage involved analyzing regularities in determining what type a given region belonged to.

Our initial data were taken from statistical departmental reports issued by the Federal Service for Surveillance over Consumer Rights Protection and Human Well-being (Form No. 18 "Data on the sanitary situation in a RF region"; Form No. 9 "Data on the sanitary-epidemiological situation in facilities for children and adolescents"); we also took data provided by the Federal State Statistics Service and data from collections issued by the RF Public Healthcare Ministry "Resources and activities of medical organizations".

The following sets of indicators were selected to be examined within the present research:

– indicators that described distribution of children as per different health groups (5 indicators overall: a share of children in the health group I; a share of children in the health group II; a share of children in the health group III; a share of children in the health group IV; a share of children in the health group V);

– indicators that described educational loads on children (4 indicators overall: a number of schools operating in one shift (in %); a number of schools operating in two shifts (in %); a number of schools operating in three shifts (in %); a share of children attending sport clubs or other establishments for children and adolescents);

– indicators that described socioeconomic conditions in a region (7 indicators overall: gross regional product per capita (rubles); living standard per capita and as per basic sociodemographic groups (children); a number of experts in children and adolescent hygiene (per 10,000 people); a number of in-bed hospital beds for children (per 10,000 children); a number of beds in pediatric hospitals (per 10,000 children of respective age); etc.);

– indicators that described sanitary-epidemiological situations in regions and living and educational environment (29 indicators overall: a share of drinking water samples taken in educational organizations that deviated from hygienic standards as per sanitary-chemical indicators; a share of urban population provided with conditionally qualitative water; a share of urban population provided with low quality water; a share of drinking water samples taken in educational organizations that deviated from hygienic standards as per microbiological indicators, etc.);

– indicators that described children's nutrition (11 indicators overall: a share of cooked meals that deviated from hygienic standards as per caloric content and chemical structure; a share of cooked meals deviating from hygienic standards as per microbiological indicators; a share of cooked meals that deviated from hygienic standards as per vitamin C contents; a share of sample cooked meals deviating from hygienic standards as per sanitary-chemical indicators; a share of schools with a canteen or a buffet (% of the overall number of schools) etc.).

The present research required creating an electronic database with values of 56 indicators as per 5 sets of factors over a period from 2010 to 2019. Preliminary analysis and data preparation involved calculating relative values and determining average long-term values for each indicator.

All the RF regions were distributed into different clusters as per each set of indicators using k-means clustering; it was done with STATISTICA 10 software package for statistical data analysis. Standardized indicators attributed to the examined sets were used as variables in clustering procedures. Standardization of indicators allowed excluding any influence on clusterization results by measuring scale and was performed as per the following ratio (1):

$$\tilde{x}_i = \frac{x_i - \overline{x}_i}{\sigma_i}, \qquad (1)$$

where x_i is a value of the i-th indicator; $\overline{x}_i$, σ_i are mean value and standard deviation of the i-th indicator accordingly.

Having repeated the procedure for each set of indicators, we managed to distribute RF regions into four clusters (4 types).

We created a system of weight coefficients to comparatively assess different types of territories for specific sets of indicators; these coefficients described adverse influence exerted by given indicators on children's health. Weight coefficients were set by an expert opinion and their values varied from 0 to 1. Values close to 0 indicated that adverse influence on children's health was insignificant; values close to 1 indicated that influence was high. Thus, weight coefficients for indicators that described how children were distributed as per health groups varied from 0 to 0.8; indicators that described educational loads on children, from 0.1 to 0.3; indicators describing socioeconomic conditions, within 0.3–0.6; indicators describing the sanitary-epidemiological situation on a given territory and conditions at home and at school, within 0.3–0.6; indicators that described meals provided for children, within 0.2–0.7.

A weight of a cluster for each set of indicators was determined as weighted average of all values of the weight coefficients relative to the cluster averages (2):

$$W_k = \frac{\sum_i \overline{x}_{ki} w_i}{\sum_i \overline{x}_{ki}}, \qquad (2)$$

where W_k is a weight coefficient for the k-th cluster; $\overline{x}_{ki}$ is a mean value of the i-th indicator for the k-th cluster; w_i is a weight coefficient for the i-th indicator.

Calculated cluster weights were used as an integral characteristic of the situation in regions in different clusters in regard to children's health which was assigned into different health groups and they were also used as a criterion in determining rank estimates.

Calculations allowed creating a system of rank properties as per five sets of indicators that gave an opportunity to assess probable adverse influence exerted by them on children's health.

Results and discussion. Typologization of RF regions ***as per children's health groups*** gave an opportunity to distribute RF regions into four clusters. The 1st cluster included 19 regions; the 2nd one, 33; the 3rd one, 31; the 4th cluster included only 2 regions (Figure 1).

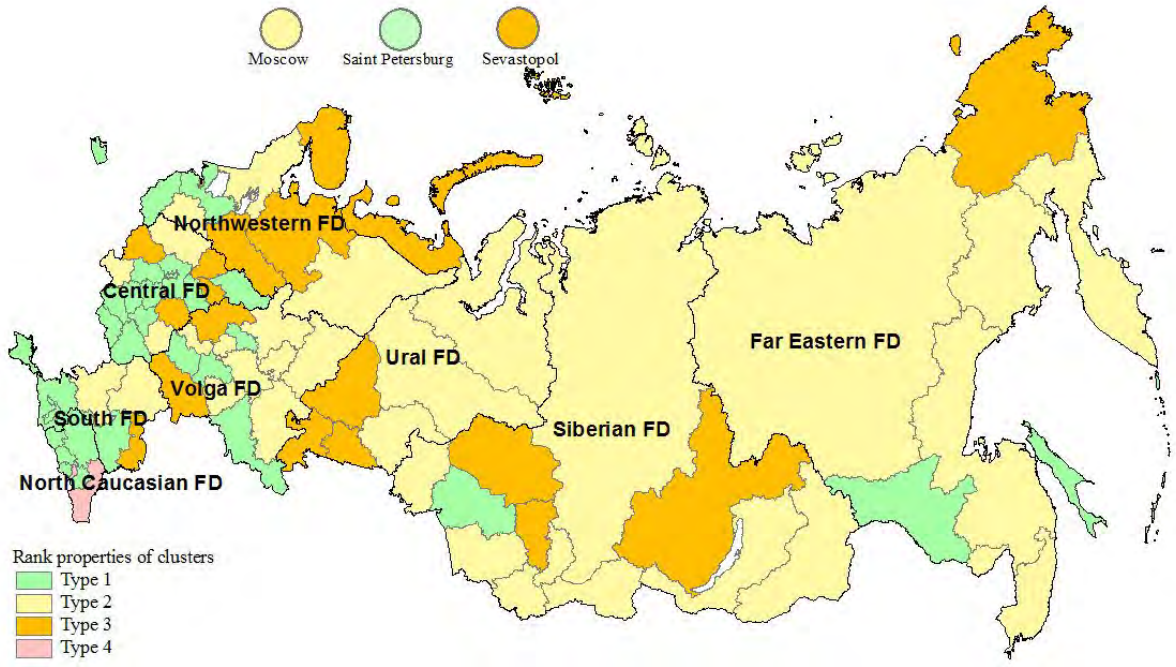

Figure 1. RF regions distributed into clusters as per children's health groups

The most favorable situation is in the 3rd cluster (1 type) where the average cluster share of children in the health group I is the highest and amounts to 29 %. It is by 1.2 times higher than on average in the country. The 3rd cluster includes such regions as Belgorod, Vladimir, Moscow, Novosibirsk, and Leningrad regions; city of Moscow; Adygei, Crimea, Chechnya, Krasnodar region, Stavropol region, Sevastopol, and some other RF regions. Average cluster shares of children in the health groups III, IV and V correspond to those detected for the country as a whole: 16 %, 1 %, 1 % accordingly (Table 1).

The most unfavorable situation is in the 4th cluster (Type 4) where average cluster shares of children in the health groups IV and V are the highest, 4.3 % and 2.8 % accordingly. This is by 4.4 and by 2.9 times higher than on average in the country accordingly. This cluster includes Dagestan and Ingushetia.

Typologization of the RF regions ***as per conditions of the educational process*** revealed that 28 RF regions were included into the 1st cluster; 37, the 2nd one; 18, the 3rd one; and 2 RF regions were included into the 4th cluster (Figure 2).

The situation is the most favorable in the 3rd cluster (Type 1) where 88.79 % schools operate in one shift on average in the cluster and there are no schools that operate in three shifts. The 3rd cluster includes such RF regions as Moscow City, Leningrad, Murmansk, Tyumen, Novosibirsk, and Tomsk regions, Kabardino-Balkaria, Karachay-Cherkessia, and Tatarstan.

Table 1

Average cluster values and regions ranked as per children's health groups

Indicator	Cluster				Long-term average value in the RF
	1	2	3	4	
A share of children in the health group I	0.16	0.20	0.29	0.24	0.23
A share of children in the health group II	0.59	0.65	0.53	0.49	0.59
A share of children in the health group III	0.23	0.13	0.16	0.20	0.16
A share of children in the health group IV	0.009	0.009	0.010	0.043	0.010
A share of children in the health group V	0.010	0.008	0.010	0.028	0.010
Rank value for the cluster	0.22	0.20	0.18	0.23	
A number of RF regions in the cluster	19	33	31	2	
Rank of the cluster	3	2	1	4	

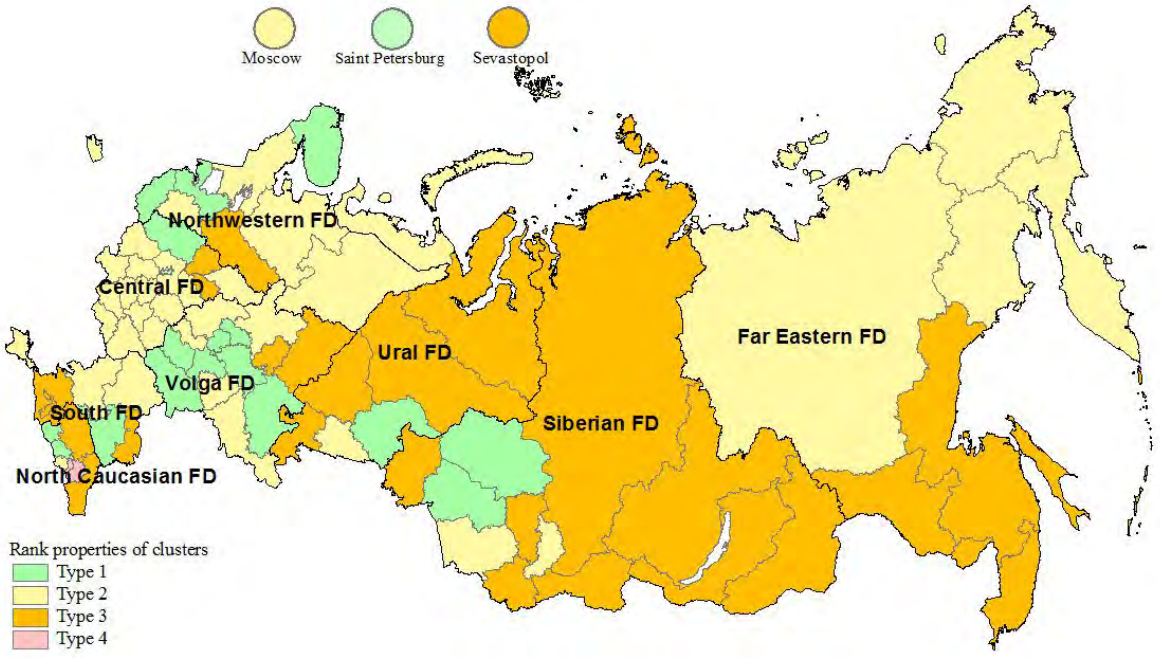

Figure 2. RF regions distributed into clusters as per indicators related to the educational process

Average cluster values in the 2nd cluster (Type 2) are close to those determined for the 3rd cluster. Differences are detected only in the indicator "A share of children attending sport clubs or other establishments for children and adolescents". This indicator has the highest value in the 2nd cluster and amounts to 55 %. The 2nd cluster includes such regions as Belgorod, Vladimir, Voronezh, Moscow, Orel, Ryazan, Arkhangelsk, Kaliningrad, Novgorod, Kurgan, and Magadan regions, Karelia, Crimea, Komi Republic, Yakut Republic, Saint Petersburg, Kamchatka, Chukotka and some others.

The least favorable situation is in the 4th cluster (Type 4) with the highest average cluster shares of schools operating not only in two but also in three shifts, 59.58 % and 6.6 % accordingly. It is by 3.1 and 40.8 times higher than on average in the country. The 4th cluster includes Chechnya and Ingushetia.

Typologization of the RF regions ***as per the sanitary-epidemiologic situation, living and educational environment*** revealed there were 4 clusters as well. The 1st cluster included 38 RF regions; the 2nd one, 6; the 3rd one, 21; and the 4th cluster included 20 regions (Figure 3).

The most favorable situation is in the 4th cluster (Type 1). There are a set of indicators with their average cluster values being the lowest in this cluster including a share of water samples taken from water supply networks that do not conform to hygienic standards as per sanitary-chemical, microbiological, and parasitological indicators; a share of water samples taken from distribution networks that deviate from the standards as per sanitary-chemical, microbiological, and parasitological indicators and total alpha-and-beta activity; a share of water samples taken in educational establishments that don't conform to the standards as per microbiological indicators; a specific weight of population provided with conditionally qualitative water; a share of soil samples taken on territories around children facilities and playgrounds that don't conform to the standards as per sanitary-chemical indicators including contents of heavy metals; a share of ambient air samples with contaminants in concentrations exceeding MPC. This cluster includes such regions as Voronezh, Orel, and Astrakhan regions, Adygei, Crimea, Altai, Krasnodar and Stavropol regions, Kamchatka and some others.

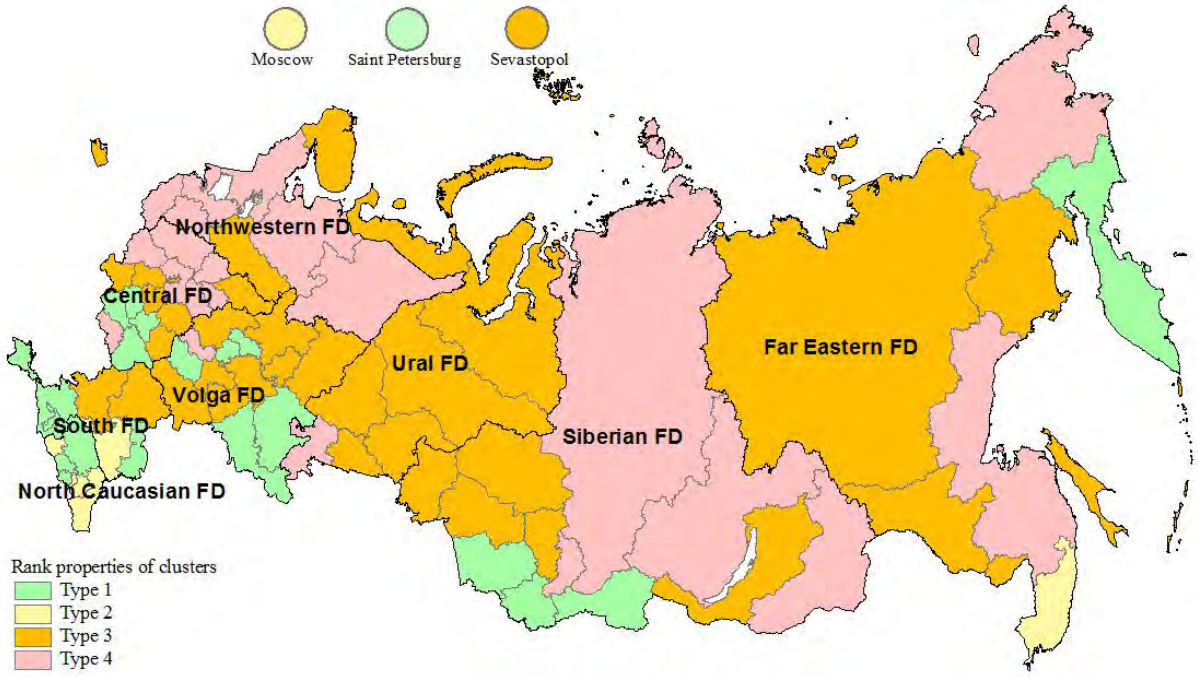

Figure 3. RF regions distributed into clusters as per sanitary-epidemiological well-being, living and educational environment

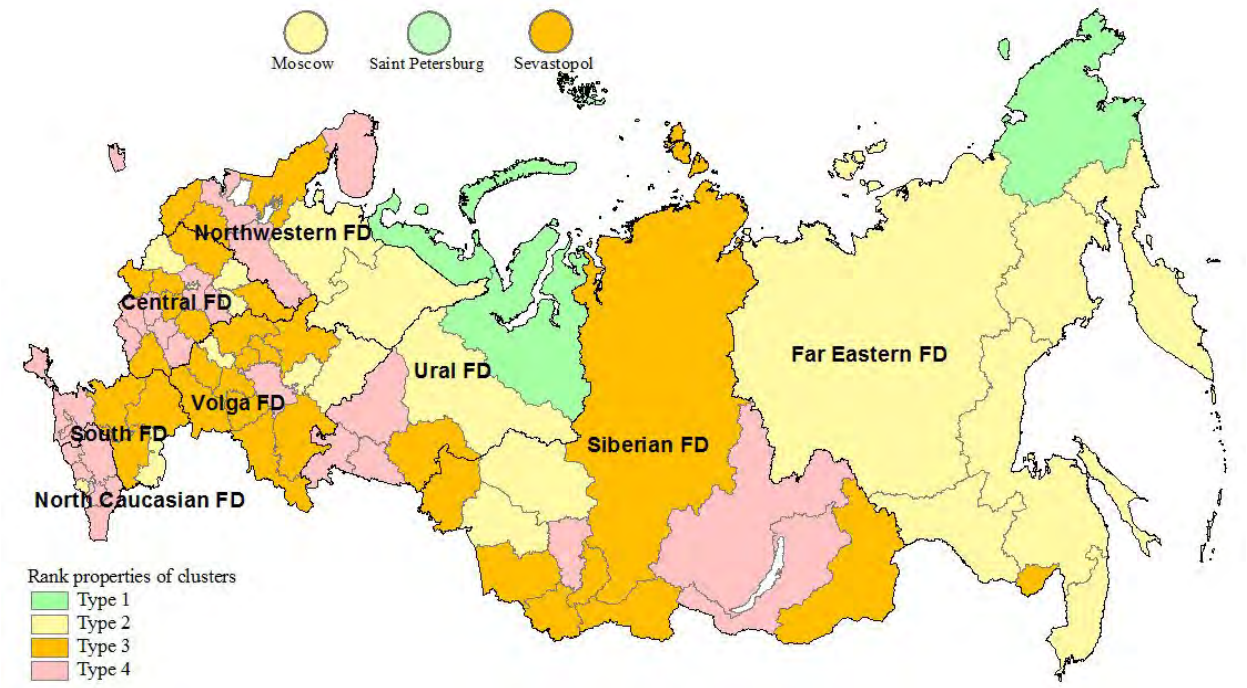

Figure 4. RF regions distributed into clusters as per socioeconomic factors

The complex assessment revealed the least favorable situation in the 3rd cluster (Type 4). There is the highest average cluster specific weight of urban population provided with conditionally qualitative water. There are 21 regions in the cluster including Belgorod, Vladimir, Ivanovo, Moscow, and Smolensk regions, Karelia, Komi Republic, Mordovia, Khakassia, Krasnoyarsk and Khabarovsk regions, Transbaikalia etc..

Typologization of the RF regions ***as per socioeconomic factors*** showed that the 1st cluster included 3 RF regions; the 2nd one, 22; the 3rd one, 32; and the 4th cluster included 28 RF regions (Figure 4).

The most favorable situation is the regions included into the 1st cluster (Type 1). The following indicators were detected in the cluster: living standard amounted to 19,917.4 rubles; gross regional products per capita, 3,823 thousand rubles; a number of experts in children and adolescent hygiene, 0.32 doctors per 10,000 children; a number of in-patient hospital beds, 83.9 beds per 10,000 children; a number of pediatric in-patient beds, 50.5 beds per 10,000 children. The 1st cluster includes only Nenets Autonomous Area, Yamal-Nenets Autonomous Area, and Chukotka.

The least favorable situation is in the 4th cluster (Type 4). The average cluster values tend to be low; thus, gross regional product per capita amounts to only 334.2 thousand rubles; living standard, 10,133.4 rubles, a number of in-patient hospital beds and pediatric beds, 51.74 and 18.03 beds per 10,000 children accordingly; a number of pediatricians and district pediatricians, 14.1 and 8.1 doctors per 10,000 children accordingly. The 4th cluster includes 28 RF regions such as Voronezh, Kursk, Lipetsk, and Orel regions, Adygei, Crimea, North Ossetia, Krasnodar and Altai regions, Kamchatka and some others.

Typologization of RF regions as per indicators ***describing nutrition provided for children*** distributed the regions into 4 clusters, the 1st one including 16 regions; the 2nd one, 36; the 3rd one, 18; and the 4th one, 15 regions (Figure 5).

The most favorable situation as per this set of indicators is in regions included into the 4th cluster (Type 1) as described by the following: the lowest average cluster shares of cooked meals that don't conform to hygienic standards as per caloric content and chemical structure, microbiological and sanitary-chemical indicators, and contents of vitamin C;

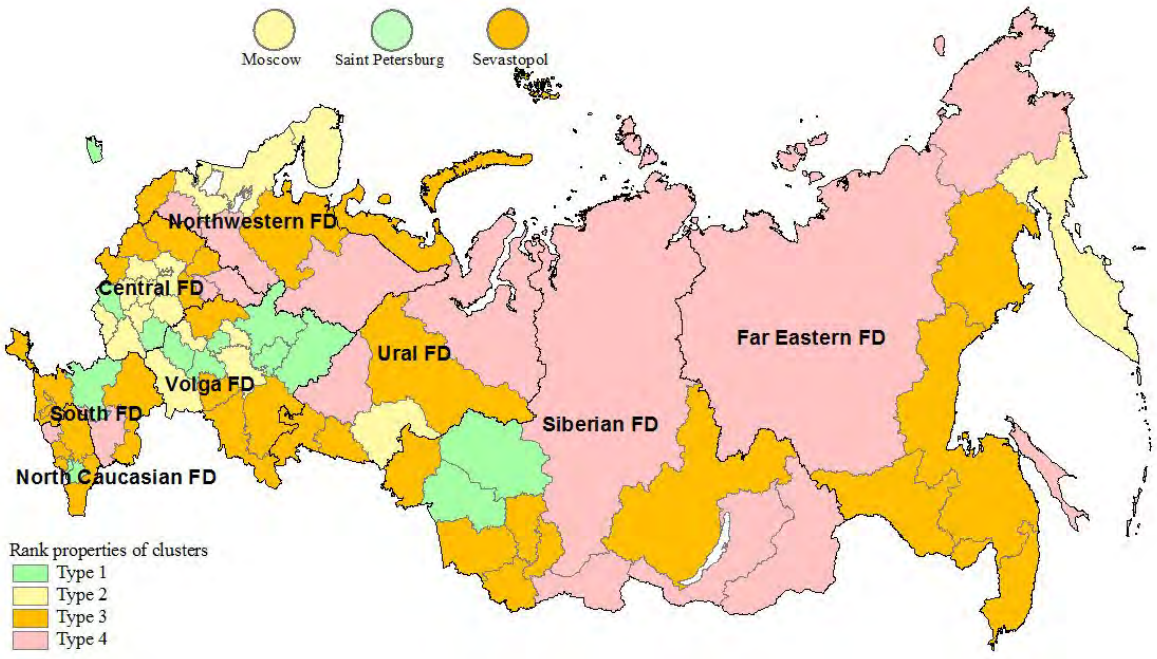

Figure 5. RF regions distributed into clusters as per peculiarities nutrition provided for children

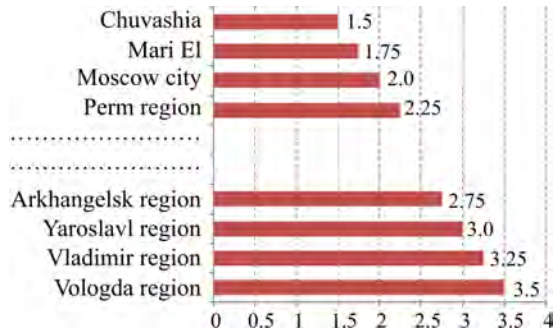

Figure 6. Examples of average rank values for the sets of indicators

the highest average cluster shares of children provided with hot meals, 43.2 %. The cluster includes such regions as Kursk, Tambov, Kaliningrad, and Perm regions, Saint Petersburg, and some others.

The least favorable situation is in the 1st cluster (Type 4). There are the highest values of the following parameters: a share of cooked meals not conforming to the hygienic standards as per caloric contents and chemical structure, 16.2 %; microbiological and sanitary-chemical indicators, 3.8 % and 6.8 % accordingly; contents of vitamin C, 18.2 %; there is also the highest share of educational organizations that don't provide any meals for schoolchildren, 3.3 %.

We calculated all average rank properties for the examined sets of indicators that described their influence on children's health. This calculation revealed that values varied within 1.5–3.5 in various RF regions. The highest values were detected in Vologda, Sverdlovsk, Chelyabinsk, Krasnoyarsk, and Irkutsk regions, Buryatia, and Transbaikalia (Figure 6).

Clusterization accomplished as per the sets of modifying indicators shows that there is an unfavorable situation in 49 RF regions as per a certain set of indicators and this allows us to assign these regions to Type 4.

Weighted values of cluster rank properties vary from Type 1 (the most favorable) to Type 3 (average) in 36 RF regions. This group includes such regions as Bryansk, Voronezh, Kaluga, Ryazan, and Tula regions, Moscow (city), Saint Petersburg, North Ossetia, Bashkortostan, Mari El, Perm region, Altai region, The Jewish Autonomous Region etc. Average ranks values varied from 1.2 to 2.4 in this regions for such modifying set of indicators as educational loads, the sanitary-epidemiological situation in the region, living and educational environment, socioeconomic conditions, and nutrition provided for children.

Profound analysis performed for each region describes the current situation in it and a role played by the analyzed factors in children's health. Thus, Penza region (average rank value is 1.5) that belongs to Type 3 as per socioeconomic conditions, provides the most favorable sanitary-epidemiological situation (Type 1), has the best conditions in regard to educational loads (Type 1) and children are provided with qualitative nutrition at schools in the region (Type 1); consequently, the region is included into the cluster with the highest share of children in the health group I (Type 1, the cluster value is 29 %; the regional value, 24 %).

Chelyabinsk and Irkutsk regions hold the last rank place (Type 4) both as per socioeconomic living conditions and sanitary-epidemiological situation; they belong to Type 3 as per quality of nutrition and educational loads in schools. So it's no wonder that both these regions are in the cluster with the lowest share of children in the health group I (16 %) and high shares of children in health groups III, IV and V (25 %). These regions need a set of activities aimed at improving the socioeconomic and sanitary-epidemiological situation there; educational programs and organization should be adjusted as well. Besides, it is advisable to make changes in school menus to provide children with nutrition that is able to fully satisfy all needs of children's growing and developing bodies. In particular, it is necessary to reach balance between energy requirements of the body, need in basic nutrients and their actual introduction with food rations; menus should include a lot of variable meals so that schoolchildren are able to choose what they like since this ensures an increase in actual food consumption; rations should be added with vegetables, fish and meat. Given the transition to state funding provided for meals in primary schools it is vital to determine necessary volumes of subsidizing sufficient to provide children with meals that can fully satisfy their physiological needs and conform to the standards stipulated by the sanitary legislation. The current standards fixed for nutrition provided in schools need to be revised.

Therefore, the current situation in each region reflects regularities related to influence exerted by a set of factors on children's health. This indicates the necessity to create a road map for each RF region with feasible mechanisms aimed at improving this situation as per specific aspects.

Conclusions:

1. The accomplished assessments and typologization of RF regions allowed revealing certain regularities and trends related to influence exerted by various sets of factors on children's health bearing their regional differentiation in mind.

2. Typologization of the RF regions as per health groups has revealed the most favorable situation in 31 regions where a share of children in the health group I amounts to 29 % being by 1.2 times higher than on average in the country. The least favorable situation is in two regions (Dagestan and Ingushetia), where shares of children in the health groups IV and V amount to 4.3 % and 2.8 % accordingly and this is by 4.4 and 2.9 times higher accordingly than on average in the country.

3. The most favorable situation as per the educational process has been detected in 55 regions (Types 1 and 2) where schools predominantly operate in one shift (87.1 % and 88.8 % accordingly). The least favorable situation is in two regions (Ingushetia and Chechnya) where schools operate in two or three shifts (59.6 % and 6.6 % accordingly).

4. Typologization of the RF regions as per sanitary-epidemiological well-being and living and educational environment also divides the country into 4 clusters where 20 regions are the most favorable (Type 1) as per the indicators describing quality of water, ambient air and soils, and 21 regions are the least favorable (Type 4).

5. Analysis of the socioeconomic situation in the RF regions has revealed that only three regions can be called the most favorable as per the set of the analyzed indicators here (Nenets Autonomous Area, Yamal-Nenets Autonomous Area and Chukotka) where we have detected high average cluster values of gross regional products per capita, 3,823 thousand ru-

bles, and living standard, 19,917 rubles. The least favorable situation is in 28 regions (Type 4), where these two indicators are equal to 334.2 thousand rubles and 10,133 rubles accordingly.

6. All the revealed priority regularities that determine influence exerted by sets of regionally differentiated factors related to living and educational environment on schoolchildren's health call for creating a road map for each RF region with feasible mechanisms aimed at improving the current situation as per specific aspects.

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