ANALYTICAL REVIEWS

UDC 613.1; 721.01
DOI: 10.21668/health.risk/2022.1.17.eng

Read online

Review

URBAN PLANNING AND PUBLIC HEALTH: ANALYTICAL REVIEW

B.A. Revich

Institute of Economic Forecasting, 47 Nakhimovsky prospect, Moscow, 117418, Russian Federation

This review focuses on certain challenges related to hygienic assessment of urban planning. Studies by Soviet (and later Russian) hygienists that have been accomplished since 1970ties have brought about optimal solutions for planning urban districts, climatic peculiarities taken into account. Specific hygienic standards have been developed with respect to insolation, building density, minimum safe distances from housing to parking areas, recommendations on creating green spaces along the busiest motorways as well as some other parameters that are now a part of regulatory documents on construction. A comfortable urban environment can hardly be created in Russian cities without adherence to hygienic standards regarding ambient air quality, noise levels, insolation, creating easily available open green spaces. All this should be implemented without any limitations on building density, especially in downtowns areas. Hygienic standards stipulate transition from fossil fuels to more environmentally friendly ones in cities located in Siberia and the Far East. There are also other multiple indicators of urban environment quality that shouldn't be neglected. The review also considers how important insolation is for health of urban citizens, especially bearing in mind the latest data on significance of vitamin D for prevention of osteoporosis. A great attention is paid to positive effects produced by open green spaces on population health including mental health, higher levels of physical activity, better social interactions and mutual trust, and reduced social isolation. All these aspects are becoming truly vital after the COVID-19 pandemic. Green spaces are also important since they help mitigate certain negative consequences of living in an aggressive urban environment.

Key words: *public health, COVID-19, urban planning, building density, ambient air, noise, insolation, green spaces, vitamin D.*

Urbanization has been growing over the last 20 years as has a share of urban population in Russia and it has already reached 74.3 %. It means that a lot of attention should be given to living conditions in cities. In 2020 the share of urban population in Russia was by almost 20 % higher than on average in the world where it amounted to 55 %.

Historical background. In Russia studies on peculiar features of different territories, climate included, started as far back as in the 18th century. They enabled determining population groups with high mortality and morbidity rates. Over a period from 1797 to 1861 provincial boards of health created more than 150 topographies describing wind directions, smells, and other territorial features[1]. F.F. Erismann, a pioneer and founder of scientific hygiene in Russia, stated it was necessary to study health as profoundly as possible bearing in mind associations with sanitary factors. Later the idea was implemented by many doctors working in urban and rural areas. The 20th century brought about rapid industrialization resulting in occurrence of a lot of new cities. Some of them were properly located on the windward side with respect to metallurgic productions (Magnitogorsk as an example) but there were also poor choices on layouts of industrial and residential areas. Some cities were located in hollows between

Boris A. Revich – Doctor of Medical Sciences, Professor, Chief Researcher and Head of Laboratory for Environment Quality Prediction and Population Health (e-mail: brevich@yandex.ru; tel.: +7 (499) 129-18-00; ORCID: https://orcid.org/0000-0002-7528-6643).

[1] Ivanov B.D. Mediko-topograficheskie opisaniya Rossii (do 1861 g.) [Medical and topographical descriptions of Russia (prior to 1861)]. *Sovetskoe zdravookhranenie*, 1960, pp. 46–52 (in Russian).

mountain ranges and their development led to higher ambient air pollution, the city of Chita being a good example here. As scientific hygiene advanced, new data were accumulated and applied to develop relevant standards for territorial layouts. It is very interesting to note that in 1943, during the Great Patriotic War, V.A. Ryazanov, the chief sanitary inspector and deputy public healthcare minister in Perm region, in future an academician and the director of the A.N. Sysin's Chief Hygienic Institute of the Russian Academy of Medical Sciences, defended his doctoral thesis. Its subject was "Urban development with respect to smoke as a major issue"[2]. In his work, he substantiated the necessity to establish maximum permissible concentrations of pollutants in ambient air and to assess ambient air pollution in urban planning. And it was 9 years prior to the infamous London smog that became a worldwide phenomenon and stimulated overall refusal from firewood and coal as fuels. The study by V.A. Ryazanov paved the way for the Soviet hygienic standardization school that established standards for concentrations of pollutants in ambient air. Up to 80ties last century this school occupied the leading place in the world developing this direction together with studies and research in the sphere of urban planning hygiene. Some hygienic recommendations on urban planning became a part of the construction regulations SN 41-58, supplemented in 1967.

After the WWII, hygienists took active part in teams dealing with master plan creation when cities were being developed and reconstructed in the country. Data on various components of an urban environment as well as use of sanitary rules and standards gave grounds for developing science-based requirements to residential areas layouts and their improvement. These tasks were tackled by institutes for hygiene located in Moscow, Leningrad, Saratov, Ufa, Sverdlovsk, Novosibirsk and other cities as well as by experts of hygiene departments at medical institutes. A new trend appeared in practical hygiene, so called preventive sanitary surveillance. It covered a lot of issues starting from hygienic assessment of land allocation for construction and up to commissioning.

When making his report on the meeting devoted to sanitary-hygienic issues of urban development and construction, K.I. Akulov[3, 4] mentioned a growth in designed building density, failure to meet standards for insolation of houses and territories, placing large industrial objects too close to cities, and deteriorating sanitary conditions. Also, it was noted that urban development didn't conform to valid sanitary and construction rules and standards[5]. An issue regarding "smart regulation of city growth" was also very topical at the end of the 60ties last century.

The sanitary service was an influential authority and had a power to veto a project to build an enterprise within city boundaries as it was the case in Krasnoyarsk with the project to build a large lavsan production facility there[4]. Unfortunately, other productions were developed in that city and a dam was built on Yenisei. All this resulted in "black sky" effect, elevated levels of ambient air pollution, and increased population mortality due to respiratory diseases[6] [1]. Reports that were made at the above-mentioned meeting gave examples on

---

[2] Ryazanov V.A. Planirovka gorodov v svyazi s problemoi dyma [Urban planning with respect to smoke as a major issue]: thesis for a degree of a Doctor of Medical Sciences. Molotov, 1943 (in Russian).

[3] RSFSR Chief Sanitary Inspector, deputy RSFSR Public Healthcare Minister (1965–1990).

[4] Akulov K.I. Sostoyanie i zadachi sanitarnoi sluzhby po gigiene planirovki naselennykh mest [The existing situation and tasks to be solved by the sanitary service regarding hygiene of urban planning]. *The proceedings of the organizational and methodical meeting on sanitary-hygienic issues of urban development and construction*. Moscow, RSFSR Public Healthcare Ministry, Erismann's Moscow Scientific Research Institute for Hygiene, 1970, pp. 3–10 (in Russian).

[5] Kovshilo V.E., Zaichenko A.I., Nedogibchenko M.K. Gosudarstvennyi sanitarnyi nadzor za proektirovaniem i stroitel'stvom naselennykh mest v SSSR [The state sanitary surveillance over planning and construction of settlements in the USSR]. *Gigiena planirovki i blagoustroistvo gorodov [Urban development hygiene and improvement in cities]: The proceedings of the first all-Soviet scientific conference*. Moscow, the USSR Public Healthcare Ministry, 1974, pp. 11–14 (in Russian).

[6] O sostoyanii i okhrane okruzhayushchei sredy v Krasnoyarskom krae v 2017 godu: Gosudarstvennyi doklad [On the ecological situation and environmental protection in Krasnoyarsk region in 2017: The State Report]. Krasnoyarsk, The Krasnoyarsk Ministry of Ecology and Regional Use of Natural Resources, 2018. Available at: http://mpr.krskstate.ru/dat/File/3/doklad%202017..pdf (June 08, 2021) (in Russian).

how to develop recommendations for northern territories using uninterrupted ribbon development with high ground floors. Results produced by hygienic expertise of development and construction projects were taken into account when a new edition of construction standards and rules was being prepared in 1967 (SN and P-P-K.2-62). For example, an item 2.7.D was added; according to this item, "when functional division of a territory is taking place, it is necessary to design recreational zones within a settlement". There was also a requirement to provide the least possible building density in residential areas in regions with hot climate (the 4th climatic zone); moderate building density, for regions with moderate climate (the 2nd and 3rd climatic zones); and elevated building density, for cold regions. The document stipulated some other useful provisions, but still, it didn't contain any hygiene-based standards for a minimum green area per 1 person though such standards are truly vital for Moscow and other Russian cities with their population exceeding 1 million people.

It is quite interesting to note that in 1967 the RSFSR Public Healthcare Ministry was made responsible for control over implementation of city master plans by the Order of the RSFSR Council of Ministers and the authority performed it ever since. The sanitary-epidemiological service took active part in developing these master plans working in close cooperation with such project institutes as the Central Scientific and Research Institute for Town Planning, the Ukraine State Institute for Town Planning (Giprograd), institutes responsible for developing master plans of Moscow city and Moscow region, design and town planning institutes in regional centers. Accumulated and generalized experience in town planning hygiene[7] provided an opportunity to develop a scheme how to perform a complex hygienic assessment of residential planning and construction. The assessment involved estimating the environmental conditions and recreation zones, social and demographic characteristics of a given territory, and social surveys among population about living conditions. The latter aimed to determine whether daily rest was efficient enough for people and to analyze children morbidity as well as some other parameters.

We can give a specific example of a hygienic assessment with respect to residential areas planning and development. There was a study performed in Omsk that involved using a wind tunnel and a device reproducing natural lighting. The study revealed that insolation in residential areas wasn't sufficient and there were defects in line building due to free space being too limited. Results produced by aerodynamic filming were especially indicative since they proved hyperventilation to be quite possible due to formation of whirlwinds in small yards not exceeding 0.5 hectare. Drastic fluctuations in wind mode were also possible in areas with line building that wasn't planned properly. An area can cool down more significantly in case of line building (49 % whereas closed-type building results in only 27–31 %). The study also allowed developing a well-grounded recommendation not to use a building system with a complicated configuration when its open angle was northward since it could create unfavorable temperature and humidity conditions in winter that made for drastic cooling of the body and deteriorated insolation[8]. There was also a suggestion to exclude closed building along motorways and to promote more open location of residential buildings with protective green areas between them aiming to prevent polluted air masses from spreading onto residential areas[9]. All the aforementioned are examples of hygi-

[7] Metodicheskie rekomendatsii po gigienicheskomu obosnovaniyu razmeshcheniya i razvitiya proizvoditel'nykh sil na territoriyakh novogo osvoeniya i v promyshlenno razvitykh regionakh [Methodical guidelines on hygienic substantiation of locating and developing production facilities on new territories being developed and in industrially developed regions]. Moscow, USSR Public Healthcare Ministry, A.N. Sysin's Institute for Common and Communal Hygiene, 1983, 69 p. (in Russian).

[8] Sokhoshko I.A. Gigienicheskaya otsenka planirovki i blagoustroistva zhilykh mikroraionov v klimaticheskikh usloviyakh Omska [Hygienic assessment of residential planning and improvement of residential microdistricts in climatic conditions in Omsk]: the abstract of the thesis for a Candidate of Medical Sciences degree. Omsk, 1974, 13 p. (in Russian).

[9] Feldman Yu.G. Gigienicheskaya otsenka avtotransporta kak istochnika zagryazneniya atmosfernogo vozdukha [Hygienic assessment of motor transport as an air pollution source]. Moscow, Meditsina, 1975, 160 p. (in Russian).

enic recommendations on creating the most comfortable living conditions for population. Unfortunately, at present these recommendations are not always followed.

Almost 20 years after the Omsk project another study was accomplished in Nizhniy Novgorod with its focus on assessing the city master plan and several projects on detailed planning and construction, building density, and some other parameters. Many-stories building in the city was accompanied with higher building density, smaller green areas, improper insolation, and elevated noise levels. Microdistricts were planned in such a way that it produced negative effects on incidence among children; incidence rates were by 1.5–2.0 times higher in blocks with closed perimeters and high population density than in semi-open blocks and population density being by 3–4 times lower[10].

The situation in 2021. In 21st century new economic relations stimulated, on one hand, a demand for apartments that could be rented, but on the other hand, a demand for construction of social housing within renovation programs. All this resulted in further sustainable growth of cities with their population exceeding 100 thousand people, and megacities accounted for 33 % in this growth. The highest growth rates (17–20 %) are typical for the southern regions in the country (Bataisk, Krasnodar, or Novorossiysk), in the "oil city" of Surgut, and some others. There have been drastic changes in the situation with town building and reconstruction; developers now determine architectural layouts in a city, infill development has grown in volumes, and microdistricts are developed as unified complexes. The Federal Project "Creating a favorable urban environment" which is a part of the National Project "Housing and urban environment" stipulates a goal to improve quality of the urban environment by 1.5 times by 2030. Efficiency is to be monitored using an index of urban environment quality. Some other indicators are also important and should be monitored to preserve health of urban population. They include a share of population living in dilapidated housing; a share of population with free access to public green spaces; a share of population provided with qualitative drinking water from public water systems; a number of services available in a city that can make life of immobile people more comfortable. However, some important parameters mentioned in the new sanitary-Epidemiologic Rules SanPiN 2.1.3684-21[11] and parameters of sustainable development are neglected, for example, ambient air quality and insolation level.

An index of urban environment quality[12] includes such a parameter as "a share of public green spaces (parks, gardens, etc.) in the total square of all green spaces in a city". This share should be not less than 25 % in a microdistrict (or a block) with apartment buildings; but if we take Moscow, we can see that the requirement is met only in 15 districts of 111 located within the Moscow Automobile Ring Road, the average share in the city amounts to 7 % and it is even lower than 5 % in 37 districts.

---

[10] Baranova T.F. Gigienicheskoe obosnovanie planirovki i zastroiki zhilykh kvartalov krupnogo goroda [Hygienic substantiation of residential planning and construction in a big city]: the abstract of the thesis for a Candidate of Medical Sciences degree. Nizhniy Novgorod, 1992, 29 p. (in Russian).

[11] SanPin 2.1.3684-21. Sanitarno-epidemiologicheskie trebovaniya k soderzhaniyu territorii gorodskikh i sel'skikh poselenii, k vodnym ob"ektam, pit'evoi vode i pit'evomu vodosnabzheniyu, atmosfernomu vozdukhu, pochvam, zhilym pomeshcheniyam, ekspluatatsii proizvodstvennykh, obshchestvennykh pomeshchenii, organizatsii i provedeniyu sanitarno-protivoepidemicheskikh (profilakticheskikh) meropriyatii: utv. postanovleniem Glavnogo gosudarstvennogo sanitarnogo vracha RF ot 28 yanvarya 2021 goda № 3 [SanPiN 2.1.3684-21. Sanitary-epidemiological requirements to maintenance of territories in urban and rural settlements, to water objects, to drinking water and drinking water supply, ambient air, soils, housing, exploitation of production and public facilities, organization and accomplishments of sanitary and anti-epidemic (prevention) activities: approved by the Order of the RF Chief Sanitary Inspector on January 28, 2021 No. 3]. *KODEKS*. Available at: https://docs.cntd.ru/document/573536177 (August 02, 2021) (in Russian).

[12] Ob utverzhdenii Metodiki opredeleniya indeksa kachestva gorodskoi sredy munitsipal'nykh obrazovanii Rossiiskoi Federatsii: Prikaz Minstroya Rossii ot 31 oktyabrya 2017 g. № 1494/pr [On approval of the procedure for determining the index of the urban environment quality in municipal settlements in the Russian Federation: the Order by the RF Ministry of Construction issued on October 31, 2017 No. 1494/pr]. *The RF Ministry of Construction*. Available at: https://minstroyrf.gov.ru/upload/iblock/ddc/prikaz-1494pr.pdf (August 02, 2021) (in Russian).

Another important requirement is that cities with their population exceeding 100 thousand people should have green spaces with their total area being 10 km^2 for public territories and 4 km^2 for residential areas; the figures are 7 and 6 km^2 accordingly for average-sized cities with their population from 50 to 100 thousand. However, this approach doesn't conform to up-to-date recommendations issued by the WHO on green spaces being available to reach on foot. Guided by expert evidence, "Environment and Health" center of the WHO Regional Office for Europe recommends estimating a residential area as per certain quantitative parameters describing availability and square of green spaces. These are the quantitative characteristics of the indicator: a share of people who leave no farther than 300 meters from a green space with its area being not less than 0.5 hectare and therefore can reach this space on foot: a share of people living no farther than 900 meters form a green space with its area being not less than 5 hectares; and a share of people living no farther than 1.5 km from a green space with its area being not less than 10 hectares. These data can be acquired from databases on land-use, satellite photos, OpenStreetMap and some other sources. Therefore, if we want to improve quality of the environment in the close proximity to residential areas, we should include data on green spaces being available to reach on foot in detailed town planning projects. Besides, the WHO Regional office for Europe recommends using some other indicators of urban population health associated with green spaces availability in residential areas. These indicators are mortality rates, mental health, and prevalence of allergic diseases, tuberculosis, and pneumonia. Certainly, these indicators are too general and it is necessary to establish more precise ones for cities in Russia allowing for the available medical statistics and experience in the field. These generalized indicators of urban environment quality established in Russia seem rather insufficient for estimating green spaces in residential areas based only on their availability to reach on foot. Therefore, any decisions on town planning should include recommendations developed by the WHO. Besides availability of green spaces, it is necessary to have data on their condition and morphology. That is why it is important to use a new tool developed by the "Environment and Health" Center of WHO Regional Office for Europe which is called GreenUr. The tool is applied to quantitatively estimate benefits of green spaces in cities for public health. It is a plagin for QGIS which is a free and open-source desktop GIS. GreenUr gives an opportunity to measure presence and availability of green spaces in cities, includes algorithms for calculating potential direct effects produced by green spaces on physical activity, mental health, and some other parameters. This program can be used as educational, communicational and scientific support by various experts and managers dealing with urban economy. The review by the WHO on urban green space interventions and health [2] dwells on how to develop green spaces in cities and estimates their effectiveness for preserving urban population health as per such parameters as physical activity, mental health, and others. Living in a city close to a spatial open green area (especially located near the apartment blocks) makes for reducing levels of stress, anxiety, and depression. Size of green spaces, their availability as well as presence of different kinds of green spaces and ratios between them in a residential area are all statistically significant predictive parameters of stress occurrence [3]. Results produced by an epidemiological study in Denmark are especially interesting since they provide data on more than 940 thousand people born from 1985 to 2003 and estimation of their mental health depending on how close to green spaces they lived in their childhood. Adults who grew up in places with the smallest available green spaces faced elevated risks of mental disorders such as depression, anxiety, and psychoactive drugs abuse in an older age. These risks were by 55 % higher than among people who spent their childhood in areas with large available green spaces [4].

Another wide-scale study in England established that green spaces in cities located near places where people of pre-retirement age live reduce mortality due to all causes [5]. In Canada green spaces in cities made for reduction in

mortality due to respiratory diseases [6], lower risks of mortality due to cardiovascular diseases and greater probability of survival after ischemic stroke [7]. Available green spaces support growing physical activity, make for reduced risks of cardiovascular diseases, type II diabetes, and obesity. Regular walks in a park relieve tachycardia and diastolic blood pressure and can be considered a rehabilitation procedure in case of coronary insufficiency. When residential blocks are located close to green spaces, especially forests, it produces a lot of positive effects including better immune system functioning [8–10], reduced risks of ischemic heart disease [11–14], making for weight loss [15], relieving stress and cognitive fatigue, improving attention and emotional recovery [16], making a society more united [17] though the latter can vary depending on an area covered by a park. Green spaces close to places where pregnant women live make for greater body weight of their newborns which is an important indicator of infant's health [18]. They make a significant contribution to solving vital health issues directly associated with specific features of any megacity: they reduce level of noise and improve sleeping.

According to the WHO estimates, losses caused by anthropogenic noises amount to 1.0–1.6 million of DALY (Disability Adjusted Life Years) in the EU [19]. Properly designed green spaces can considerably mitigate negative effects produced by anthropogenic noises on people living in megacities. The most effective way to get protected from motor transport noises is to take into account landscape peculiarities and to design a motorway bearing in mind how close a residential area is to it and to plan green "shields" between a motorway and residential housing. The necessary width of such shields should be from 1.5 to 10 meters. Positive impacts exerted by green barriers to a great extent occur due to psychological effects since practically all respondents were sure that a green barrier had positive influence but they also tended to overestimate its actual potential of protecting from noise by more than half [20].

Green spaces in a city are not only a necessary recreational resource for health protection but also a way to protect residential areas from polluted ambient air and noise created by motorways. Specific model research performed in 70ties last century showed that trees and bushes planted in several rows (3 or 4 usually) were quite efficient in isolating residential and other buildings from polluted ambient air coming from traffic areas. When trees are planted in one row, they provide protection from gases that amounts to only 3 % in winter growing to 7–10 % in summer. Trees planted in two rows together with bushes reduce introduction of polluted air by 30–40 %[9, 13]. A contribution made by green spaces into reducing motorway noises was also estimated. Trees and bushes planted between a traffic area and a pedestrian area allow a two-fold reduction in noise levels[14]. Earlier these data were actively used by the Moscow Sanitary Service in its practical activities and experts highlighted certain drawbacks when estimating development projects for some microdistricts, in particular, green spaces being distributed unevenly, absence of a compact green area, and others[15].

Results produced by another present-day study that focused on examining five parks in Moscow (Severnoe Medvedkovo, Lefortovo, Golyanovo, Maryino and a park in babushkinskiy district) showed that the greatest noise reduction was achieved when there was horizontal canopy density together with bushes covering spaces below tree crones; elevated noise levels were detected at a 300-meter dis-

---

[13] Sidorenko V.F., Kirillov G.P., Feldman Yu.G. Issledovanie gazozashchitnoi effektivnosti zelenykh nasazhdenii na avtomagistralyakh [A study on efficiency of green spaces in protecting from gases along motorways]. *Gigiena i sanitariya*, 1974, no. 10, pp. 6 (in Russian).

[14] Karagodina I.L., Osipov G.L., Shishkin I.A. Bor'ba s shumom v gorodakh [Fighting against noise in cities]. Moscow, Meditsina, 1972, 160 p. (in Russian).

[15] Zaretskaya G.P., Kushchinskaya L.G., Sinitsyn V.I., Gerashchenko V.V., Faifer F.I. Gigienicheskaya otsenka zastroiki nekotorykh mikroraionov g. Moskvy [Hygienic assessment of development plans for some microdistricts in Moscow]. *Gigiena planirovki i blagoustroistvo gorodov [Hygiene of town planning and improvement]: the proceedings of the I All-Soviet scientific conference*. Moscow, USSR Public Healthcare Ministry, 1974, pp. 119–123 (in Russian).

tance from motorways[16]. Results produced by all these studies stress out the necessity to make changes into the structure of green spaces near motorways with intense traffic, to plant trees and bushes together bearing in mind their capability to protect from gases.

At present it is more obvious that green spaces are greatly required near large office centers as a recreational resource for a lot of office workers. As it was stated by S. Polonskiy, a notorious developer of the Moscow International Business Center (Moscow-City), this office space didn't meet contemporary demands for necessary comfort since "there is no creativity without proper offline".[17] This statement is further proved by foreign researchers who focus on influence exerted by green spaces on urban population health in their works. Apart from effects on health, green spaces in megacities are making a more and more substantial contribution to their socioeconomic development and bring them new competitive advantages on the global "market" of megacities. Ideas related to sustainable development and greater focus on environmental issues, both with respect to economy and society, are becoming more and more popular among people. Therefore, available green spaces that are effectively integrated into the urban environment are becoming a key factor of a megacity investment potential, its prospects in attracting advanced personnel and high-tech productions [21].

In a wider context, green spaces act as a powerful stabilizing factor given the more intensive climatic change and we should remember that people living in megacities are more susceptible to risks associated with it. Experts of the Organization for Economic Cooperation and Development (OECD) spot out three types of the most significant climatic threats to cities, megacities included. These threats have direct influence on living conditions and include heat waves, floods, and increased vulnerability of poor urban population who are the least protected from such phenomena. Heat waves in megacities occur both due to growing weather instability and peculiarities of the urban environment, such as great amounts of concrete and asphalt and elevated heat emissions from variable equipment. As a result, average temperature in cities is by 3.5–4.5 ^{o}C degrees higher than in rural areas and this discrepancy is predicted to grow by 1 ^{o}C over each following decade [22].

Given great deficiency of green spaces in many largest world megacities, all the aforementioned factors lead to occurring "heat islands", or considerable areas in a megacity (up to several km^2) where heat waves produce the greatest effects. Therefore, a role played by parks in a city is becoming more vital since they can cool off air temperature by 1 °C on average and it can be felt on a distance up to 1 km around park boundaries; water reservoirs enhance the effect [23].

Building density and / or population density is another significant parameter applied in assessing how comfortable a residential area is. Average population density in 14 Russian cities with their population exceeding 1 million people amounts to 2.4 thousand people/ square km; it is also close to this value in 24 cities located in the European part of the country with their population being 260–500 thousand people and amounts to 2.3 thousand people per square km. This density corresponds to levels detected in European cities, large capitals excluded. Lower density which is equal to 2.06 thousand people/square km is typical only for 11 cities (Nizhnekamsk, Engels, Stariy Oskol, and some other cities in the central European part of the country) with their population varying from 100 to 250 thousand people. We should note that Nizhnekamsk was developed according to one of the

[16] Luk'yanets A.G. Vliyanie razmeshcheniya tipov parkovykh nasazhdenii na komfortnost' sredy v gorodskikh parkakh [Influence exerted by location of different types of trees and bushes in parks on creating a comfortable environment in them]: the abstracts of the thesis for a degree of Candidate of Agricultural Sciences. Moscow, 2011, 20 p. (in Russian).

[17] "Konvoiry aplodirovali, kogda menya otpuskali na svobodu" ["Escort applauded when I was being released"]: an interview with S. Polonskiy. *Novaya gazeta*, 2021, no. 37, pp. 12–13. Available at: https://novayagazeta.ru/articles/2021/04/05/konvoiry-aplodirovali-kogda-menia-otpuskali-na-svobodu (June 15, 2021) (in Russian).

most successful master plans created by Giprogor Institute and was granted several awards. An industrial zone in the city is located several kilometers away from residential areas with remaining forests, parks, and public gardens. The city has been repeatedly awarded as a winner of "Comfortable urban environment" contest.

The situation in Moscow is quite the opposite. Population density varies from 7 to 21 thousand people/square km in 112 Moscow districts located within the Moscow Automobile Ring Road with its average value being 11.1 thousand people per square km. It is close to New York (10.8 thousand people/square km) and higher than in such large European cities as London, Berlin, or Madrid. Building density is high in Moscow and other million cities, predominantly in their centers with only small green spaces. This creates "heat islands" where air temperature is by 2–3 °C higher than on average in a city, insolation is poorer, ambient air pollution, noise and electromagnetic fields are elevated in some locuses.

Population density in other 56 "conditional" megacities in Russia which are regional capitals (without 13 capitals of autonomous republics, regions, and areas with population density being lower than 1 thousand people / square km) can be divided into 4 quartiles. The list also includes 9 cities with population exceeding 200 thousand people (Table).

High building density creates certain health risks for urban population. They occur due to hindered dispersion of pollutants in ambient air when residential areas are located too close to industrial zones and motorways with intense traffic, smaller green spaces and greater "closed" territories, and formation of heating microclimate. Some municipal authorities make a lot of effort to increase population in their cities but it is not arithmetical values of human resources that should measure management efficiency in the post-industrial era. If we look at a rating showing life quality in megacities, then we can see that, according to estimates by Economist Intelligence Unit, leading places are occupied by relatively small Canadian (Calgary, Vancouver, and Toronto) and European cities (Vienna, Hamburg, and Helsinki).

Growing climatic changes, temperature rise in Russia included, have brought about the necessity to work out such town planning decisions that could allow achieving optimal microclimate in residential blocks located on territories with the most severe climate in Arctic regions and in the southern regions in the country where air temperatures are extremely high. This necessity is dictated by excessive mortality during heat and cold temperature waves since their number will only grow given further global warming. Therefore, it is vital to build up variable town planning models that provide an opportunity to create optimal microclimate in residential areas [24].

Direct inclusion of hygienic recommendations into construction standards and rules became a considerable, though temporary, success in town planning. Thus, T.E. Bobkova, a leading expert on the environmental hygiene, Doctor of Medical Sciences, Professor, took

RF regional capitals and large cities distributed as per population density

A quartile as per average city square, km^2	Average square, km^2	Average population, thousand people	Average population density, thousand people/km^2
1st	276.6	359.9	1.3
2nd	228.4	438.4	1.9
3rd	185.8	427.1	2.3
4th	129.9	395.8	3.2
Large industrial cities (Angarsk, Bratsk, Volzhskiy, Komsomolsk-na-Amure, Magnitogorsk, Novokuznetsk, N. Tagil, Sterlitamak, Cherepovets)	314.1	264	1.6

N o t e : all calculations are based on data provided by Rosstat.

part in development of Construction standards and rules 07.01.89. "Town planning. Building planning and development of urban and rural settlements". She acted as a co-author in preparing important sections in this document including environmental protection, residential areas, and standards for calculating and designing parking lots for various objects. This document establishes standards for building density in residential areas but they have been neglected for a long time [25]. Shorter sanitary gaps between residential areas and children facilities and parking lots also make the urban environment less comfortable. This reduction has become possible since requirements stipulated by Construction rules SP 42.13330.2016 "Town planning. Building planning and development of urban and rural settlements. The updated edition" are no longer valid. And it should be noted that according to those rules parking lots were to be located not less than 10–30 meters away from residential buildings.

Unfortunately, there is no such a juridical concept in Russia as infill development and it is not regulated by any standards or norms. In the RF the Town Planning Code, Moscow Town Planning Code or regional documents in the sphere do not determine this concept and do not contain any up-to-date hygienic recommendations on how to assess population density bearing preservation of people's health in mind. Moreover, any issues related to infill development are considered in town planning only with a focus on effective development of a city, although certain social risks caused by such development are recognized [26] since it involves reduction in sanitary gaps between residential buildings, schools and pre-schools and parking lots and sometimes there are even demands to open pre-school playgrounds for public access [26]. These issues are vital in foreign countries as well, even in such ecologically-oriented states as Sweden where massive development can cause damage to green infrastructure [27].

There are certain limitations imposed on construction in foreign megacities, for example, in a situation when sanitary conditions can deteriorate. For example, Moscow with its new sky-scrapers would use experience of New York City administration. New York authorities introduced provisions according to which when a new building was constructed with its height exceeding heights of neighboring buildings by 15 meters, it was necessary to calculate trajectories of its shade for a whole year. Variable limitations imposed on construction of such buildings are also valid in Canada, Great Britain, and some other countries [28].

Infill development in Russian cities has resulted in multiple complaints of people living in low-rise buildings when high buildings were constructed in close proximity. People complain of poor insolation and lack of natural light and courts have been asking for an inspection in such cases [29]; there are court decisions on insufficient insolation due to a new multi-storey building. We can't fail to mention an opinion held by S. Kuznetsov, the Chief Architect in Moscow, who believes that standards on insolation are archaic documents developed at the time when prevalence of tuberculosis was high among population and now they only create difficulties for "qualitative development of city architecture".

An insolation issue in Russia cities is truly vital at the moment. Insolation standards exist in Germany, Italy, the Netherlands, Sweden, France, and some other countries [30]; proper insolation produces bactericide effects thus improving quality of living spaces as per their microbiological parameters since it prevents pathogenic microflora from developing. Ultraviolet insolation is known to produce a lot of health-improving effects including better immune and psychophysiological state, better metabolism, increased hemoglobin, better wound healing and some others. But apart from that, some recent research works have shown that insufficient insolation can be a risk factor of a stroke [31].

Sanitary standards for insolation were first established by the USSR Public Healthcare Ministry in 1963 and amounted to 3 hours a day. They were based on the results produced by examining bactericide effects of insolation, that is, its capacity for providing bacteriological wellbeing in living and public spaces. 40 years later, in 2002 required insola-

tion period was reduced to 2 hours and we have every reason to believe that it was primarily done in the interests of developers. There was no such concept as land value in the USSR but transition to the market economy resulted in drastic increase in land value in cities, especially in their downtowns and places with developed infrastructure. Construction businesses and developers are extremely interested in maximum compact building on city territories and, obviously, lobby for the revision of existing regulatory documents including standards on insolation. There was another change in these standards in 2017 when insolation period was reduced further by 0.5 hours. We can hardly say that this change is favorable for public health. These new standards permit to considerably increase height of new buildings to be constructed and to reduce a number of hours during which sunlight can enter apartments in neighboring houses in areas with compact building, especially those located on lower stories. Previously sanitary standards stipulated a period of insolation for living spaces from March 22 to September 22. Now this period is one month shorter in spring and one month shorter in autumn, that is, we have lost insolation by low spring and autumn sun. Now it is allowed in Moscow to build higher buildings that cast a shade over windows of neighboring lower ones [32]. If this new standard is followed, a number of sun hours in living spaces will fall down in a situation when a new building is being constructed in cities located in the center of the European part of the country and this building is by 5–6 stories higher than neighboring ones. It is especially true for apartments with their windows facing north-west and north-east. We can also state that people living in Moscow will have less sunlight in their apartments than people living in Moscow region [33]. Insolation issues can also occur in rooms with windows facing south in case they have deep recessed balconies [31]. A study focusing on bactericide effects produced by insolation revealed its low effectiveness in living spaces with northward windows [34]. Experts from RosBuzinessConsulting (RBC) believe that an actual coefficient of building density in towns reaches 2.18 in locuses with high-rise buildings and imposes a real threat to a comfortable urban environment [35]. Some foreign standards on insolation stipulate certain periods of insolation in winter that amount to 4 hours a day from September 21 to March 21 in Germany and more than 5 hours a day in northern Sweden. Unfortunately, there are no such regulations in Russian standards in spite of insolation being especially necessary exactly in this time of the year [30]. Changes in insolation standards, buildings with a greater number of stories, and an increase in building density in residential areas can lead to shading of living spaces, fewer hours during which direct sunlight can reach them, and greater energy consumption, whereas in Russia the energy saving strategy has already been implemented for 9 years.

It seems inadequate to estimate positive influence by solar radiation based only on bactericide effects in megacities with compact and extremely compact building without taking into account its psychophysiological effects on urban population. We should also bear in mind that insolation in cities to a great extent depends on relief peculiarities, especially given growing building density, since the European part of Russia is located on territories where vertical wall structures are typically used in construction [36]. The author suggests estimating influence exerted by a certain relief on insolation conditions with an indicator showing a deviation in its maximum permissible density on this relief from its maximum density on a plane surface.

The second issue of insufficient insolation is associated with poor availability of green spaces in dense town building. There are huge green areas in Moscow, “Losinyi ostrov” for example, and they are very important for the overall ecological situation in the city; still, they are not enough for improving mobility and health of people living in Moscow. The WHO Regional Office for Europe recommends placing open green spaces not farther from a residential area than a 20-minute walk on foot. Even these small spaces can provide people with certain amount of ultraviolet which is in great deficiency in a northern country and sup-

ply them with vitamin D (protohormone D, to be more exact). Over the last years a much better insight into significance of this substance for health has been achieved and it is obvious that this vitamin helps prevent various chronic non-communicable diseases. And here we mean not only metabolic disorders where its contribution has long been examined profoundly but also oncologic, cardiovascular, and other diseases. However, as opposed to any other vitamin, vitamin D is not a vitamin in a classical meaning of this term due to not being biologically active whereas other vitamins are. In the body, vitamin D transforms into a biologically active hormonal form through a 2-stage metabolization using genomic and non-genomic mechanisms. It produces variable biological effects due to interactions with specific receptors localized in cell nuclei in many tissues and organs as well as on plasmatic cellular membranes. In this respect an active metabolite of vitamin D acts as a true steroid hormone; that's why this vitamin is called "D-hormone" [37]. Low D-hormone concentration creates elevated risks of ischemic heart disease, type II diabetes mellitus, and some other diseases. Vitamin D deficiency is typical in people who live on territories located to the north from 35°, that is, practically on the whole territory of Russia. Vitamin D deficiency leads to osteoporosis and osteopathy. This has been proved by studies on its contents in blood of people living in the northwestern region where vitamin D deficiency is detected in 50 % of pregnant women and this condition results in statistically significant growth in anxiety and depression ($r = –0.11$, $p = 0.03$) [38]. When this hormone deficiency is detected in men, it is a risk factor of chronic prostatitis, prostate hyperplasia and other andrologic disorders [39]. Another issue is D-hormone deficiency detected in 13 % of European children. This results in improper bone mineralization, developing rachitis, bronchial asthma, diabetes mellitus, and many other diseases [40].

Conclusion. So far creating a comfortable urban environment hasn't become the main objective of urbanists, architects, and other experts on town planning in Russia. The rules are dictated by developers, especially in downtowns; there is infill development involving high-rise buildings shading neighboring lower ones; less strict limitations are now imposed regarding insolation; a number of state standards and other regulatory documents in the sphere of construction has gone down by 1/3. Russian regulatory documents on town planning don't incorporate recommendations developed by the WHO on open green spaces that should be available to reach on foot. Population density is growing persistently in large cities. Russian indicators in ratings for sustainable urban development [41] don't include a very significant one, namely, average annual concentrations of fine particulate matter in ambient air. This indicator is included in the Sustainable Development Goal No. 11 "Make cities and human settlements inclusive, safe, resilient, and sustainable". Instead of this indicator that gives the most precise idea of ambient air quality in a city, our regulations rely on archaic ones developed as far back as in 70ties last century. An example can be "specific emissions of pollutants from stationary sources and motor transport per 1 square km". To assess health risks caused by motor transport, we should apply calculated concentrations of pollutants caused by traffic flows instead of this indicator that can hardly be considered informative. Starting from 2019, the ecological situation in cities has been assessed by the Analytical Credit Rating Agency (ACRA) that has developed a new complex indicator showing environmental conditions in a given region. This indicator incorporates emissions of hazardous chemicals, discharges of polluted sewage, industrial wastes, communal wastes, etc., calculated per a unit of gross regional products (GDP) as well as environmental expenses per a unit of budget expenditure. Still, these indicators do not give a clear picture of urban environment quality. Foreign estimates indicate that urban environment quality is rather poor in Russian cities. As per estimates given by The Economist, only Moscow was included into the rating of cities with the comfortable urban environment occupying the 68th place (New York holds the 58th place; London, 48th; Berlin, 21st; and Vienna is the

leader). Experts from IESE business school have made up a rating that includes 174 cities all over the world and estimates their stability. Moscow is on the 87th place in this rating; Saint Petersburg, 124th; and Novosibirsk, 159th place. The leaders with the most comfortable urban environment are London, New York, Paris, Tokyo, and Reykjavik [42].

If we turn to such fashionable concepts as "smart city" or "healthy city", we can see that most publications about them don't contain any hygienic assessment and this fact makes their image "not so ideal". A good example is Volgograd as a "smart city" [43]. Architects consider any issues with respect to public health only bearing in mind medical aid provision and building new medical centers; the only things important about green spaces are their volume and a number of planted trees. There is a postulate that "a density of a city is directly proportionate to its development rate and inversely proportionate to comfortable living conditions which influence its appeal" [44]. But Russian cities haven't yet reached enormous scales of Asian megacities and we still have a possibility to make our urban environment truly comfortable. There is certain progress even in cities with the highest ambient air pollution and population mortality and new activities are being developed aiming to reduce health risks due to decreasing emissions of priority pollutants [45].

This paper was accomplished in summer 2021 when experts from a lot of spheres including epidemiologists, geographers, economists, physicians and others were trying to determine risk factors in the urban environment that could make for COVID-19 spread. There was a review of foreign research works focusing on relationships between ambient air pollution and COVID-19 mortality among population [46]. Relationships between the disease and another indicator of urban environment quality, namely population density, are not so obvious [47]. But it is important to note that these research works also gave some attention to such risk factors as a degree of urbanization, socioeconomic status, public transport availability, ambient air quality, strictness of quarantine measures, etc. Two basic processes occur in cities during an epidemic due to various factors. One of them results in an improving epidemiological situation due to better access to high-quality medical aid; the other makes this situation worse due to higher population density and more frequent trips on public transport. As new data on COVID-19 incidence and mortality among urban population are being accumulated, relationships with other risk factors in the urban environment will be studied more profoundly. This will allow developing new prevention activities aimed at protecting health of urban population. Hopefully, this will also help estimate infill compact development in Russian downtowns differently and better understand the significance of ambient air quality and open green spaces in cities.

Funding. The research was not granted any financial support.

Conflict of interests. The authors declare there is no any conflict of interests.

Reference

1. Revich B.A., Kharkova T.L., Kvasha E.A. Selected health parameters of people living in cities included into «Clean air» federal project. *Health Risk Analysis*, 2020, no. 2, pp. 16–27. DOI: 10.21668/health.risk/2020.2.02.eng

2. Urban green space interventions and health: A review of impacts and effectiveness. Full report (2017). *WHO, Regional Office for Europe*, 2017, 57 p.

3. Tompson W.C., Aspinali P., Roe J., Robertson L., Miller D. Mitigating stress and supporting health in deprived urban communities: The importance of green space and the social environment. *Int. J. Environ. Res. Public Health*, 2016, vol. 13, no. 4, pp. 440. DOI: 10.3390/ijerph13040440

4. Engemann K., Pedersen K.B., Arge L., Tsirogiannis C., Mortensen P.B., Svenning J.-C. Residential green space in childhood is associated with lower risk of psychiatric disorders from adolescence into adulthood. *PNAS*, 2019, vol. 116, no. 11, pp. 5188–5193. DOI: 10.1073/pnas.1807504116

5. Mitchell R., Popham F. Effect of exposure to natural environment on health inequalities: an observational population study. *Lancet*, 2008, vol. 372, no. 9650, pp. 1655–1660. DOI: 10.1016/S0140-6736(08)61689-X

6. Villeneuve P.J., Jerrett M., Su J., Burnett R.T., Chen H., Wheeler A.J., Goldberg M.S. A cohort study relating urban green space with mortality in Ontario, Canada. *Environ. Res.*, 2012, vol. 115, pp. 51–58. DOI: 10.1016/j.envres.2012.03.003

7. Wilker E.H., Wu C.D., Mcneely E., Mostofsky E., Spengler J., Wellenius G.A., Mittleman M.A. Green space and mortality following ischemic stroke. *Environ. Res.*, 2014, vol. 133, pp. 42–48. DOI: 10.1016/j.envres.2014.05.005

8. Park B.J., Tsunetsugu Y., Kasetani T., Kagawa T., Miyazaki Y. The physiological effects of Shinrin-yoku (taking in the forest atmosphere or forest bathing): evidence from field experiments in 24 forests across Japan. *Environ. Health Prev. Med.*, 2010, vol. 15, no. 1, pp. 18–26. DOI: 10.1007/s12199-009-0086-9

9. Lee J., Park B.J., Tsunetsugu Y., Ohira T., Kagawa T., Miyazaki Y. Effect of forest bathing on physiological and psychological responses in young Japanese male subjects. *Public Health*, 2011, vol. 125, no. 2, pp. 93–100. DOI: 10.1016/j.puhe.2010.09.005

10. Song C., Ikei H., Miyazaki Y. Physiological effects of nature therapy: A review of the research in Japan. *Int. J. Environ. Res. Public Health*, 2016, vol. 13, no. 8, pp. 781. DOI: 10.3390/ijerph13080781

11. Cohen D., Sehgal A., Williamson S., Golinelli D., Lurie N., McKenzie T.L. Contribution of public parks to physical activity. *Am. J. Public Health*, 2007, vol. 97, no. 3, pp. 509–514. DOI: 10.2105/AJPH.2005.072447

12. Cohen D.A., Marsh T., Williamson S., Derose K.P., Martinez H., Setodji C., McKenzie T.L. Parks and physical activity: why are some parks used more than others? *Prev. Med.*, 2010, vol. 50, suppl. 1, pp. S9–12. DOI: 10.1016/j.ypmed.2009.08.020

13. Maas J., Verheij R.A., de Vries S., Spreeuwenberg P., Schellevis F.G., Groenewegen P.P. Morbidity is related to a green living environment. *J. Epidemiol. Community Health*, 2009, vol. 63, no. 12, pp. 967–973. DOI: 10.1136/jech.2008.079038

14. Schipperijn J., Bentsen P., Troelsen J., Toftager M., Stigsdotter U.K. Associations between physical activity and characteristics of urban green space. *Urban For. Urban Green.*, 2013, vol. 12, no. 1, pp. 109–116. DOI: 10.1016/j.ufug.2012.12.002

15. Ellaway A., Macintyre S., Bonnefoy X. Graffiti, greenery, and obesity in adults: secondary analysis of European cross sectional survey. *BMJ*, 2005, vol. 331, no. 7517, pp. 611–612. DOI: 10.1136/bmj.38575.664549.F7

16. Cattella V., Dines N., Gesler W., Curtis S. Mingling, observing, and lingering: Everyday public spaces and their implications for well-being and social relations. *Health Place*, 2008, vol. 14, no. 3, pp. 544–561. DOI: 10.1016/j.healthplace.2007.10.007

17. Astell-Burt T., Mitchell R., Hartig T. The association between green space and mental health varies across the life course. A longitudinal study. *J. Epidemiol. Community Health*, 2014, vol. 68, no. 6, pp. 578–583. DOI: 10.1136/jech-2013-203767

18. Dzhambov A.M., Dimitrova D.D., Dimitrakova E.D. Association between residential greenness and birth weight: Systematic review and meta-analysis. *Urban For. Urban Green.*, 2014, vol. 13, no. 4, pp. 621–629. DOI: 10.1016/j.ufug.2014.09.004

19. Burden of disease from environmental noise: quantification of healthy life years lost in Europe. Copenhagen, WHO, Regional Office for Europe, 2011, 106 p.

20. Yang C.Y., Bao Z.Y., Zhu Z.J. An assessment of psychological noise reduction by landscape plants. *Int. J. Environ. Res. Public Health*, 2011, vol. 8, no. 4, pp. 1032–1048. DOI: 10.3390/ijerph804103

21. Terentiev N.E., Revich B.A. Green environment in megacities as health saving factor. *Problemy teorii i praktiki upravleniya*, 2018, no. 9, pp. 43–53 (in Russian).

22. Cities and Climate Change. OECD Publ., 2010, 278 p.

23. Bowler D.E., Buyung-Ali L., Knight T.M., Pullin A.S. Urban greening to cool towns and cities: A systematic review of the empirical evidence. *Landscape and Urban Planning*, 2010, vol. 97, no. 3, pp. 147–155. DOI: 10.1016/j.landurbplan.2010.05.006

24. Drobotov V.I., Shagieva E.V. Formation of town-planning entities in adverse climatic conditions. *Vestnik Volgogradskogo gosudarstvennogo arkhitekturno-stroitel'nogo universiteta. Seriya: Stroitel'stvo i arkhitektura*, 2018, vol. 71, no. 52, pp. 166–173 (in Russian).

25. Chepchugov M.A. Sealing development as a form of effective (qualitative) city development. *Noema (Arkhitektura, Urbanistika, Iskusstvo)*, 2019, vol. 3, no. S3, pp. 44–50 (in Russian).

26. Dubynin N., Bobkova T., Dubynin V., Panova A. Architecture in the context of contemporary ecology. *Proekt Baikal*, 2019, vol. 16, no. 60, pp. 123–127. DOI: 10.7480/projectbaikal.60.1484 (in Russian).

27. Berg P.G., Eriksson F., Eriksson T. Paradoks uplotnitel'noi zastroiki: umen'shenie zelenykh prostranstv s rostom ikh vostrebovannosti [The paradox of compact building: a decrease in green spaces with an increasing demand for them]. *Formirovanie komfortnoi gorodskoi sredy. Vodnye landshafty v epokhu urbanizatsii: sbornik trudov mezhdunarodnoi konferentsii*. In: M.E. Ignat'eva, I.A. Mel'nichuk, A.B. Bubnova eds. St. Petersburg, Saint Petersburg State Forest Technical University Publ., 2019, pp. 49–50 (in Russian).

28. Akimova M.I., Chechulina A.S. Infill development of large cities: internal and external. *Izvestiya vuzov. Stroitel'stvo*, 2015, vol. 678, no. 6, pp. 55–62 (in Russian).

29. Timofeeva S.S., Kustov O.M. Insolation as a factor of litigation. *Vestnik IrGTU*, 2015, vol. 99, no. 4, pp. 105–110 (in Russian).

30. Shmarov I.A, Zemtsov V.A., Korkina E.V. Insolyatsiya: praktika normirovaniya i rascheta [Insolation: practice of regulation and calculation]. *Zhilishchnoe stroitel'stvo*, 2016, no. 7, pp. 48–53 (in Russian).

31. Kent S.T., McClure L.A., Judd S.E., Howard V.J., Crosson W.L., Al-Hamdan M.Z., Wadley V.G., Peace F., Kabagambe E.K. Short and Long-Term Sunlight Radiation and Smoke Incidence. *Ann. Neurol.*, 2013, vol. 73, no. 1, pp. 32–37. DOI: 10.1002/ana.23737

32. Danilov P.B., Benuzh A.A. Evolution of insolation requirements for residential real estate in Moscow. *Nedvizhimost': ekonomika, upravlenie*, 2019, no. 2, pp. 42–44 (in Russian).

33.Grabovyy P.G., Manukhina L.A. National strategy of introduction of energy resources and ecologically safe (green) technologies and productions in construction and housing and communal services. *Nedvizhimost': ekonomika, upravlenie*, 2014, no. 1–2, pp. 6–8 (in Russian).

34. Fokin S.G., Bobkova T.E., Shishova M.S. Assessment of hygienic principles in the standardization of insolation under the conditions of a city in case of Moscow. *Gigiena i sanitariya*, 2003, no. 2, pp. 9–11 (in Russian).

35. Andreeva P.N. The insolation rights and renovation programme in Moscow. *Pravovaya politika i pravovaya zhizn'*, 2018, no. 1, pp. 42–48 (in Russian).

36. Kharchenko S.V. Relief as a factor of solar exposure in urban areas. *Vestnik Moskovskogo universiteta. Seriya 5: Geografiya*, 2013, no. 4, pp. 30–35 (in Russian).

37. Schwarz G.Ya. Renaissance of Vitamin D: molecular biological, physiological and pharmacological aspects. *Meditsinskiy sovet*, 2015, no. 18, pp. 102–103. DOI: 10.21518/2079-701X-2015-18-102-103 (in Russian).

38. Karonova T.L., Mikheeva E.P., Nikitina I.L., Belyaeva O., Todieva A.M., Popova P.V., Andreeva A.T., Globa P.Yu., Beletskaya I.S. [et al.]. Uroven' obespechennosti vitaminom D u zhitelei Severo-Zapadnogo regiona RF i znachenie defitsita vitamina D dlya zdorov'ya [The level of vitamin D supply in residents of the North-Western region in the Russian Federation and the importance of vitamin D deficiency for health]. *Osteoporoz i osteopatiya*, 2016, vol. 19, no. 2, pp. 45–46 (in Russian).

39. Kalinichenko S.Yu., Tyuzikov I.A., Gusakova D.A., Vorslov L.O., Tishova Yu.A., Grekov E.A., Fomin A.M. Vitamin D as a novel steroid hormone and its role for men's health. *Effektivnaya farmakoterapiya*, 2015, no. 27, pp. 38–47 (in Russian).

40. Zakharova I.N., Dolbnya S.V., Kuryaninova V.A., Klimov L.Y., Kipkeev S.O., Tsutsaeva A.N., Yagupova A.V., Enina E.A. [et al.]. Role of vitamin D in pre-school children's health. *Meditsinskii sovet*, 2021, no. 1, pp. 37–49. DOI: 10.21518/2079-701X-2021-1-37-48 (in Russian).

41. Reiting ustoichivogo razvitiya gorodov Rossii 2020 [Rating of sustainable development of cities in Russia 2020]. *SGM*, 2020, no. 8. Available at: https://www.agencysgm.com/projects/%D0%91%D1%80%D0%BE%D1%88%D1%8E%D1%80%D0%B02019.pdf (20.04.2021) (in Russian).

42. IESE Cities in Motion Index 2020. IESE Business School University of Navarra, 2020. Available at: https://media.iese.edu/research/pdfs/ST-0542-E.pdf (20.04.2021).

43. Maksimchuk O.V., Baulina O.A., Klyushin V.V. "Smart" living as one of the aspects of the formation of a "smart" city. *Sotsiologiya goroda*, 2017, no. 1, pp. 61–77 (in Russian).

44. Bashkaev T. Vektor razvitiya – effektivnost' [The vector of development is efficiency]. Moskovskii tsentr urbanistiki, 2020. Available at: https://urbanru.ru/almanahs/vektor-razvitiya-effektivnost-timur-bashkaev/ (09.04.2021) (in Russian).

45. Zaitseva N.V., May I.V. Main results, prospects of application and improvement of the health risk assessment of the population of Siberian cities – participants of the "Clean air" project (Bratsk, Norilsk, Krasnoyarsk, Chita). *Gigiena i sanitariya*, 2021, vol. 100, no. 5, pp. 519–527. DOI: 10.47470/0016-9900-2021-100-5-519-527 (in Russian).

46. Revich B.A., Shaposnikov D.A. The COVID-19 pandemic: New knowledge on the impact of air quality of the spread of coronavirus infection in cities. *Stud. Russ. Econ. Dev.*, 2021, vol. 32, no. 4, pp. 357–363. DOI: 10.1134/S1075700721040134

47. Teller J. Urban density and COVID-19: towards an adaptive approach. *Buildings and Cities*, 2021, vol. 2, no. 1, pp. 150–165. DOI: 10.5334/ bc.89

Revich B.A. Urban planning and public health: analytical review. Health Risk Analysis, 2022, no. 1, pp. 147–161. DOI: 10.21668/health.risk/2022.1.17.eng

Received: 23.09.2021
Approved: 18.01.2022
Accepted for publication: 13.03.2022