Urban population health risk assessment from traffic noise exposure

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Abstract. The aim of research was to identify health damage probability when traffic noise exposed. Instrumental noise measurements were carried out at 4 control points on the street highways of Voronezh city. The equivalent level of day, evening and night noise was determined. MR 2.1.10.0059-12 "Public health risk assessment from the traffic noise impact" was used as a methodological basis. It was found that the equivalent level of daytime noise varied from 45 to 65 dB, evening – from 40 to 49 dB, night – from 34 to 46 dB. According to the level of diseases reduce risk the cardiovascular system from noise load exposure for time exposure of 70-85 years the risk indicators (0.6861-1.0) refer to the level of "extreme risk", 60-67 years (0.3551-0.5594) – to the "high risk" level. The diseases reduced risk of the nervous system and hearing organs from traffic noise exposure is classified as "low".

1. Introduction
Nowadays urbanization is considered as a health risk factor and among urban environment priority unfavorable factors attention is drawn to traffic noise [1]. In this regard on large cities territory proactive studies are being carried out to assess the impact on the population of the noise factor and associated health risk. In particular according to acoustic measurements data carried out during the investigation of the population complaints the assessment of the negative impact of road traffic noise on the living conditions of St. Petersburg residents was made [2]. Similar studies were carried out in Irkutsk [3], Chita [4], Vladivostok [5], Arkhangelsk [6]. Studies carried out in Smolensk have shown that noise problem exists not only on residential buildings territory but also in urban recreational areas [7].

Methodology development for health risk assessment from the noise factor made it possible to find out that when exposed to night noise at levels from 40 to 55 dBA health harmful effects increase, with a noise level of more than 55 dBA the cardiovascular diseases probability is high and at the level of 80 dBA cerebral cortex retardation and hearing organs disturbances are developed [8]. National and foreign data generalization as well as the World Health Organization data made it possible to develop a...
methodology for public health risk quantitative assessment caused by road traffic noise impact which is reflected in the methodological recommendations approved in Russia [9].

The aim of the study was to identify the public health damage probability when traffic noise exposed.

2. Material and research methods
Exposure was estimated based on instrumental noise measurements. As part of social and hygienic monitoring during 2019-2020 in Voronezh noise monitoring was carried out at 4 monitoring control points: Leninsky Prospect 117, st. Antonova-Ovseenko 25a, st. Eletskaya 8, st. Lomonosov 114/8 in accordance with NSS R 53187-2008 “Acoustics. Urban areas noise monitoring”. To identify the trend of changes in the acoustic environment the noise indexes at each point were determined by days of the week: on working days (Tuesday or Wednesday), on Friday and on one of the days off. At each point noise measurements were carried out in accordance with NSS 31296.2. At the same time in the daytime the equivalent and maximum noise levels were measured for at least five minutes three times: the first time is in the interval 7:00-9:00 h, the second time is in the interval 9:00-17:00, the third time is in the interval 17:00-23:00 h. In the evening noise parameters were measured once for at least five minutes at 23:00-23:30 h and the measured levels were considered valid in the evening. At night measurements were carried out for at least five minutes two times: the first time is in the interval 23:30-00:00 h, the second time is in the interval 01:00-05:00 h. To determine the effect of noise indicators seasonal changes measurement in each point were carried out on the basis of weekly observations made four times a year – in winter, spring, summer and autumn.

The noise exposure is estimated based on the analysis of the chronology and duration of noise events in researched area.

When assessing the risk the L indicator (equivalent level of average weighted daily noise) which was determined by the formula taking into account the day and night noise levels was taken as the main effective noise levels unit.

As a methodological basis the methodological recommendations MP 2.1.10.0059-12 “Public health risk assessment from traffic noise impact” approved by the chief state sanitary doctor of the Russian Federation on March 23, 2011 were used. The main stages of this work were: hazard identification; exposure assessment; assessment of the “exposure-response” relationship; risk characteristic. The basis of the method algorithm is the solution of recurrent formulas system – mathematical models of negative effects development under the noise influence integrating a set of national and foreign data on the probability of the development of adverse effects of health disorders. It is understood that noise as an unfavorable factor has a threshold effect on the human body. Moreover, the threshold noise levels according to the World Health Organization taken into account when health risk assessing in the algorithm of the method, are different when they affect the nervous system, circulatory system and hearing diseases. The main indicator is the reduced risk which as negative effect display probability can range from 0 to 1 (0 – no risk; less than 0.05 - low risk; from 0.05 to 0.35 – average risk; from 0.35 up to 0.60 – high risk; more than 0.60 – extreme risk).

3. Results and discussion
Assessment initial data for population health risk were the results of instrumental measurements of the city street highways noise level. In general according to 4 control points it was found that the equivalent level of the average weighted daytime noise varied from 45 to 65 dB, evening – from 40 to 49 dB, night – from 34 to 46 dB (table 1).

Data detailed analysis showed that during the year the highest values of the equivalent noise level were recorded in the daytime at the monitoring point of control at Leninsky Prospekt 117 (interdistrict city street highway with six driving lanes) – in the range from 53 to 65 dB. At the monitoring point of control at st. Antonova-Ovseenko 25a (part of the Moscow-Kursk intra-city ring road with six driving lanes) the equivalent level of average weighted daytime noise was recorded in the range from 45 to 55 dB. At the monitoring point of control at st. Eletskaya 8 (inter-quarter city street with two driving lanes) the equivalent level of the average weighted daytime noise during the year was in the range from 52 to
56 dB. At the monitoring point of control at st. Lomonosov 114/8 (interdistrict city street highway with four driving lanes) the equivalent level of the average weighted daytime noise varied from 56 to 58 dB.

Table 1. Average weighted noise equivalent level values.

| Monitoring point address and driving lanes number | Day time | Average weighted noise equivalent level, dB (L) |
|--------------------------------------------------|----------|-----------------------------------------------|
|                                                  |          | Average value | Lowest value | Highest value |
| Antonova-Ovseenko 25a (6 lanes)                  | day      | 52            | 45           | 55           |
|                                                  | evening  | 44            | 40           | 47           |
|                                                  | night    | 40            | 34           | 45           |
|                                                  | day      | 63            | 53           | 65           |
| Leninsky Prospect 117 (6 lanes)                  | evening  | 48            | 47           | 49           |
|                                                  | night    | 44            | 43           | 46           |
|                                                  | day      | 54            | 52           | 56           |
| Eletskaya 8 (2 lanes)                            | evening  | 44            | 41           | 46           |
|                                                  | night    | 39            | 37           | 41           |
|                                                  | day      | 57            | 56           | 58           |
| Lomonosov 114/8 (4 lanes)                        | evening  | 47            | 44           | 48           |
|                                                  | night    | 43            | 41           | 44           |
|                                                  | day      | 57            | 45           | 65           |
| All monitoring points                            | evening  | 46            | 40           | 49           |
|                                                  | night    | 41            | 34           | 46           |

Noise impact assessment on diseases risk of the cardiovascular system showed that at the point at Leninsky Prospekt 117 (interdistrict city street highway with six driving lanes) with exposure duration of 1-20 years the risk ranges from 0.0014 to 0.0362 and classified as low, with exposure duration of 30-57 years – from 0.0650 to 0.2965 (medium risk), 60-67 years – from 0.3551 to 0.5594 (high risk), 70-85 years – from 0.6861 to 1.0 (extreme risk). At other points of control the level of risk is classified as low or medium.

According to the level of diseases reduced risk of the nervous system under the influence of noise load in two monitoring points at the addresses Leninsky Prospekt 117 and st. Lomonosov 144/8 the risk is classified as low. In particular along an interdistrict city street highway with six driving lanes the risk of nervous system diseases with exposure duration from 1 to 85 years ranges from 0.0003 to 0.0368; along the interdistrict city street highway with four driving lanes – from 0.00008 to 0.00848.

According to the level of diseases reduced risk of the hearing aid under the influence of noise load the risk in two monitoring points at the addresses Leninsky Prospekt 117 and st. Lomonosov 144/8 with exposure duration from 1 to 85 years is classified as "low" and ranges from 0.0002 to 0.0255 and from 0.00005 to 0.00583 respectively.

During health risk assessment research there are almost always uncertainties that need to be accommodated. In our research the main uncertainty sources were the population parameters heterogeneity and inconstancy and the physical properties of sound vibrations and the peculiarities of their propagation on the territory of populated areas; insufficient completeness, reliability and representativeness of noise data; exposure models used to calculate the noise load in the affected area; lack of data on the number of exposed population.
4. Conclusion
Health risk level for the population living along the six- and four-lane urban street highways can be classified as high or extreme.

The highest risk indicators from noise load exposure are typical for diseases of the cardiovascular system: with exposure time 70-85 years risk indicators (0.6861-1.0) refer to "extreme risk" level, 60-67 years (0.3551-0.5594) – to "high risk" level.

Nervous system and organs of hearing diseases risk from traffic noise exposure is classified as "low".

Based on the research results it is recommended to take measures to reduce the noise load in near short term during the year with an annual review of the risk degree; to install architectural structures that help to reduce noise levels or special noise screens; to redistribute traffic flows in Voronezh city if possible taking into account the prospective urban development in order to reduce traffic load on problem street highways.

Conflict of interest
The authors declare no conflicts of interest.

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