



Impact of Noise on the Mental Health of Megapolis Adolescents

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Abstract

BACKGROUND: Mental health is one of the most significant components of overall health conditions. Mental health well-being results from genetic, psychological, and neuropsychological processes interacting with environmental and social influences.

AIM: The study aims to examine the impact of noise on the psyche of megapolis adolescents and determine their levels of anxiety, depression, and stress susceptibility depending on the level of noise.

MATERIALS AND METHODS: The study included 322 adolescents (180 girls and 142 boys) aged 15–17 years, divided into two groups.

RESULTS: Higher noise levels lead to greater vulnerability of adolescents to depression, anxiety, and stress. High noise levels provoke 1.56 times ($p < 0.05$) greater incidence of depression on the HAM-D scale than among adolescents living with lower noise levels. Constant exposure to moderate noise levels showed 1.60 times ($p < 0.05$) higher anxiety levels on the HAM-A scale.

CONCLUSIONS: High noise levels adversely affect the psyche of megapolis adolescents. The higher the noise level, the more adolescents were exposed to depression, anxiety, and stress. Increased noise levels negatively affect the psyche of megapolis adolescents.

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Introduction

Mental health is one of the most significant components of overall health conditions [1], [2]. For many years, the WHO has declared that “health is complete physical, mental, and social well-being rather than merely the absence of illness or physical defects [3].” The physical health of individuals is determined by their mental well-being [4]. It is not exaggerated to say that mental health is a global human good that ensures countries’ social and economic development and constitutes an absolute human right for each individual [5]. Mental health well-being results from genetic, psychological, and neuropsychological processes interacting with environmental and social influences [5], [6]. Unfortunately, little attention is paid to the population’s mental health in many countries worldwide [7]. Therefore, it is necessary to turn mental health into an absolute priority within all nations’ health-care systems, not an overlooked aspect [1], [7].

Ensuring the mental health of children and youth is essential because they represent a quarter of the world’s population. It is their health status

that indicates the country’s social and economic development progress [8].

Mental health affects all critical development stages of children and adolescents, the acquisition of social skills, their relationships with peers and family, the formation of their self-esteem, identity, etc. [9] Mental health problems that develop during childhood or adolescence can become a burden on the individual, his or her family, and society as a whole [9], [10]. The prevalence of mental health problems in adolescents and children varies from 10% to 20% in different countries [11], [12]. For instance, in Australia, the prevalence of mental disorders among children and adolescents aged 4–17 is about 14%, [13] in Germany – 10% [14]. The most common mental diseases are depression (D), anxiety disorders (ADs), behavioral disorders, and hyperkinetic disorders [15]. In particular, the worldwide prevalence of D among adolescents is around 5% [16]. Moreover, this is not merely a statistic. Any mental disorder can be a motive for suicide, especially during adolescence. It is undoubtedly better to prevent an illness rather than face its consequences. For this purpose, there is a necessity to study and identify those factors that can negatively affect the psyche of adolescents.

For quite a long time, some socioeconomic, biological, genetic, and other aspects played a leading role in influencing the human psyche, particularly adolescents, apart from external influences like their social environment and habitat [9]. Studying the effect of environmental factors on the psyche of adolescents has gained particular relevance in the last decade, which is associated with lightning processes of urbanization in the rapid city development [17]. More than 50% of the world's population lives in urban areas, and by 2050, this figure is expected to reach 70% [18]. Due to urbanization, teenagers are highly exposed to numerous environmental (air pollution, road noise, and electromagnetic radiation) and social factors (poverty, quality of education, security, employment, income, social support, and household). All of them negatively influence mental health [17].

Environmental factors vary and have different impacts on the psyche of children and adolescents who are more vulnerable to the influence of these factors than adults [19]. The toxic effects of adverse environmental factors are cumulative, resulting in disorders that can lead to permanent physical and mental health problems [20].

Researchers are now actively investigating the influence of different environmental factors on the psyche of children and adolescents. Exposure to heavy metals and pesticides is related to hyperreactivity in children, including attention deficit disorder [19]. Children and adolescents living in poor urban neighborhoods with low income and low-quality housing have been established to have more frequent behavioral and emotional disorders than housing type, affordability, and residential instability [21].

Air pollution by carbon monoxide, nitrogen, and sulfur oxides may affect neuronal plasticity, cognitive functions, and behavior characteristics [22], [23]. It was found that while riding a bicycle in a heavily polluted area, no increase in the concentration of the brain's neurotrophic factor is evidenced. Its appearance is generally observed after physical activity and is required to provide neuroplasticity. In particular mental disorders and illnesses, such as D, this factor can change [24]. Air pollution by various contaminants disturbs the synthesis of serotonin, leading to oxygen deficiency in the body. The result is hypoxia, which may be associated with a higher risk of suicide [25].

Some studies examined the negative influence of noise and road traffic on the mentality of adolescents [26], [27], [28]. There is evidence that children who are constantly exposed to road noise often have hyperactivity syndrome [29], emotional and behavioral disorders [30], depression, and AD [28].

Given the above, it is necessary to examine this matter in greater detail. This would help to better understand the influence of environmental factors on the mental health of adolescents, especially those living in cities with a particularly pronounced influence of

environmental factor. The results of these studies could be used to develop appropriate recommendations for improving adolescents' mental health.

The study aimed to investigate the effect of noise on the psyche of megapolis adolescents and determine levels of anxiety, depression, and stress susceptibility based on noise levels.

Materials and Methods

A total of 322 adolescents (180 girls (55.9%) and 142 boys (4.1%)) aged 15–17 years were included in the study. Of the total number of participants, Group 1 (control) included 65 adolescents (39 girls [60.0%] and 26 boys [40.0%]) who lived and studied in rural areas far from primary noise sources, such as highways with heavy traffic, railways, airports, industrial plants, and large construction sites. Group 2 (main group) consisted of 257 adolescents (137 girls (53.3%) and 120 boys [46.7%]) who lived in Moscow. Their daily activities were concentrated in high-traffic urban areas, industrial plants, and construction sites.

Inclusion criteria were as follows: Age 15–17 years; absence of acute somatic or chronic pathology; voluntary consent form to participate in the study signed by a parent or guardian; and adolescent's willingness to participate in the study. Exclusion criteria were as follows: Age under 15 and over 17 years; mental disorders; exacerbation of chronic disease; acute somatic pathology; and lack of compliance.

Clinical-anamnestic and clinical-psychopathological research methods, questionnaires, and bibliosemantic methods were used during the study. On inclusion, each adolescent's mental status was assessed using the Clinical Global Inventory (CGI) and Hamilton scale (HAM-A and HAM-D). The CGI index consists of three global characteristics. CGI severity (CGI-S) is scored from 1 (normal, not at all ill) to 7 (among the most severely ill patients). "0" is given if a patient has not been evaluated. CGI-S was assessed on admission (CGI-S adm) and on discharge (CGI-S dis). The degree of global CGI improvement (CGI-I) is scored from 1 (very improved) to 7 (significantly worse). Again, "0" means "not graded." CGI-I was only rated at discharge. The third score is called the CGI-E performance index. The HAM-D scale was applied to examine the depression level in adolescents studied with the following grading: 0–7 points – normal state, 8–13 points – mild D, 14–18 points – moderate D, 19–22 points – severe D, and 23 or more points – very severe D. The HAM-A scale was used to assess anxiety level (A): 0–6 points – no symptoms of A, 7–13 points – possible AD, 14–20 points – pronounced A, 21–28 points – symptomatic A, and 29 and more points – severe AD. The Perceived Stress Scale (PSS)

was used to assess stress susceptibility: 0–6 points indicated low susceptibility to S, 7–19 points –normal condition, 20–30 points – high susceptibility, and 31–40 points – very high susceptibility.

The instruments used were validated using Cronbach's alpha. The interpretation of Cronbach's alpha values is as follows: >0.9 excellent; >0.8 good; 0.7 acceptable; 0.6 questionable; and >0.5 poor [31]. The composite Cronbach's alpha value for CGI was 0.92 with values (0.95, 0.92, 0.93, 0.87, 0.96, and 0.94); for HAM-A and HAM-D, 0.91 with values (0.95, 0.88, 0.89, 0.91, 0.9, and 0.91) for the six measurements in the order they were mentioned above.

The level of annoying noise was determined by surveys administered to adolescents using the Felscher-Suhr *et al.* methodology with questionnaires [32]. Adolescents were supposed to answer questions about the intensity, frequency, and duration of their noise exposure. The responses to the questions were estimated by scores of 0–3, which evaluated the degree of influence/presence of a specific noise factor. For example, 0 points suggested no factor/noise, 1 point – low noise level/little influence/short exposure, 2 points – moderate noise level/medium influence/medium duration, 3 points – high noise level/intensive exposure/long influence, etc.

Microsoft Excel 2013 (Microsoft, USA) and SPSS™17 software were used for statistical data processing. Mann–Whitney U-criterion and Wilcoxon T-criterion were applied to compare quantitative parameters. Qualitative characteristics were compared using the past software method of odds ratio (OR) calculation. The difference was considered statistically significant at $p < 0.05$.

Observance of ethical norms and principles

The study protocol and the form of informed consent to participate in the study were studied in detail and approved by the Biomedical Ethics Commission of (BLINDED) University. The study included adolescents who volunteered to participate in the research and after one of their parents/official guardians signed a corresponding informed consent. The study was guided by international ethical standards approved by the Declaration of Helsinki (1964–2013), International Ethical Guidelines for Biomedical Research Involving Human Subjects of the Council for International Organization of Medical Sciences, ICH GCP Principles (1996), Council of Europe Convention on Human Rights and Biomedicine (dated April 4, 1997), and EU Council Directive No. 609 (dated November 24, 1986).

Limitations

The study was not able to completely exclude the influence of other harmful factors from the megacity

environment (e.g., air pollution, electromagnetic waves, etc.) on adolescents as all of them were present and affected simultaneously. Hence, the data obtained are a consequence of harmful environmental factors impacting the psyche of adolescents, but noise pollution was the main one.

Results

The study design is shown in Figure 1.

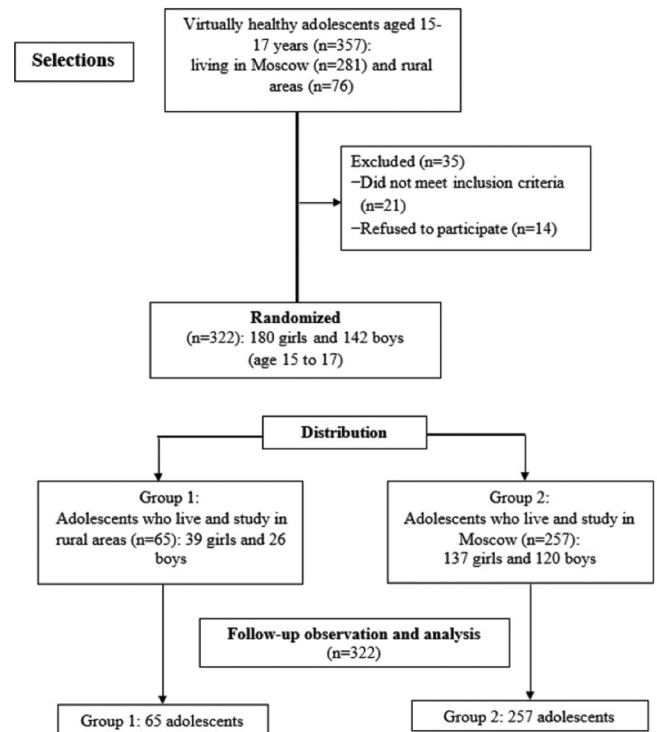


Figure 1: Study design

The analysis of questionnaires showed that adolescents in the megacity have higher levels of D, A, and adherence to stress than those in the countryside (Table 1). Thus, the D level on the HAM-D scale for adolescents who live in the megacity (Moscow) is 1.69 times ($p < 0.05$) higher compared to adolescents living in the countryside; the A level on the HAM-A scale is 1.87 ($p < 0.05$) higher in megacity adolescents compared to those from rural areas. A similar pattern was observed for stress susceptibility, being 1.42 times ($p < 0.05$) higher on the PSS scale in metropolitan adolescents than in rural areas.

Table 1: Indicators of depression, anxiety, and stress susceptibility in rural and metropolitan adolescents, M ± m

Indicator	Study groups	
	Rural adolescents (n = 65)	Metropolitan adolescents (n = 257)
HAM-D, points	4.79 ± 0.60	8.11 ± 0.84*
NAM-A, points	5.83 ± 0.71	10.90 ± 0.93*
PSS, points	16.44 ± 0.52	23.28 ± 1.16*

*The difference is statistically significant compared to adolescents in rural areas ($p < 0.05$). PSS: Perceived Stress Scale.

According to the NAM-D scale, D was present in 72 (28.0%) metropolitan adolescents and in 6 (9.2%) rural adolescents (odds ratio [OR] = 3.83, 95% confidence interval [CI] [1.58–9.25], $p < 0.05$). Anxiety on the NAM-A scale was present in 79 (30.7%) metropolitan adolescents and in 7 (10.8%) rural adolescents (OR = 3.68, 95% CI [1.61–8.42], $p < 0.05$).

There were also other signs of neuropsychological exhaustion among adolescents, the incidence of which varied by region of residence. Thus, fast fatigability was observed in 159 adolescents (61.9%) in the metropolitan area and in 19 adolescents (29.2%) in the rural area (OR = 3.93, 95% CI [2.18–7.09], $p < 0.05$); sleep disorders in 102 (39.7%) megapolis adolescents and 8 (12.3%) rural adolescents (OR=5.01, 95% CI [2.29–10.96], $p < 0.05$); irritability in 117 (45.5%) megapolis and 16 (24.6%) rural adolescents (OR = 2.56, 95% C [1.38–4.74], $p < 0.05$), difficulties with remembering in 60 (23.3%) megapolis and 8 (12.3%) rural adolescents (OR = 2.17, 95% CI [0.98–4.80], $p > 0.05$); and reduced attention concentration in 94 (36.6%) megapolis and 10 (15.4%) rural adolescents (OR = 3.17, 95% CI [1.54–6.52], $p < 0.05$).

Analysis of noise sources showed that road traffic noise was complained of by 257 (100.0%) adolescents in the metropolis, household noise by 169 (65.8%) adolescents, subway noise by 75 (29.2%) adolescents, railroad noise by 45 (18.2%) adolescents, aircraft noise by 43 (17.5%) adolescents, and industrial noise by 38 (14.8%) adolescents. Besides, it was found that adolescents' highest levels of D, A, and stress susceptibility were observed with regular exposure to aircraft noise. Thus, the D level on the HAM-D scale was 9.22 ± 0.75 points, the A level on the NAM-A scale was 12.48 ± 0.86 points, and stress susceptibility on the PSS scale was 26.12 ± 1.15 points. The lowest levels of D, A, and stress susceptibility were observed during exposure to industrial noise: The D level on the HAM-D scale was 7.80 ± 0.82 , the A level on the HAM-A scale was 10.55 ± 0.83 , and stress susceptibility on the PSS scale was 20.94 ± 1.13 .

Among the megapolis adolescents studied, 73 (28.4%) adolescents complained of a low noise level, 103 (40.1%) of moderate, and 81 (31.5%) of high. It is noteworthy that any youth did not report the absence of noise in the metropolitan area.

The study of D, A, and stress susceptibility levels depending on noise intensity showed that the higher the noise level, the more adolescents were susceptible to D, A, and stress (Table 2). Thus, D on the HAM-D scale at high noise levels occurred 1.56 times ($p < 0.05$) more often compared to low noise levels. The same trend was observed for the A level on the HAM-A scale. This score was 1.60 times ($p < 0.05$) higher at a moderate noise level compared to that at a low level, 2.45 times ($p < 0.05$) higher at a high noise level compared to that at a low level, and 1.54 times ($p < 0.05$) higher at a high noise level compared to a moderate level.

Table 2: Indicators of depression, anxiety, and stress susceptibility in metropolitan adolescents as a function of noise levels, M \pm m

Indicator	Noise level		
	Low (n=73)	Moderate (n=103)	High (n=81)
HAM-D, points	6.16 \pm 0.75	8.61 \pm 0.87	9.59 \pm 0.80*
NAM-A, points	6.41 \pm 0.91	10.24 \pm 1.00*	15.74 \pm 0.93***
PSS, points	17.50 \pm 1.10	22.46 \pm 1.22*	27.65 \pm 1.17***

*The difference is statistically significant compared to low noise level ($p < 0.05$). **The difference is statistically significant compared to moderate noise level ($p < 0.05$). PSS: Perceived Stress Scale.

When comparing PSS stress susceptibility as a function of noise level among metropolitan adolescents, those exposed to moderate noise levels demonstrated 1.28 times ($p < 0.05$) higher stress levels compared to those experiencing low noise levels, with high levels 1.58 times ($p < 0.05$) higher compared to low levels and 1.23 times higher ($p < 0.05$) when comparing high to moderate noise levels.

Discussion

This study examined the influence of everyday noise (road, household, and industrial) of the megapolis (Moscow) on the psyche of adolescents. The control group was composed of 65 adolescents who lived and studied in a rural area remote from high traffic roads, railways, airports, industrial plants, and construction sites. Consequently, an attempt was made to consider a control group with adolescents in which the impact of the noise factor (along with other adverse environmental factors) was minimal.

The study result allowed establishing that daily chronic exposure to noise in a megacity has an adverse negative effect on the psyche of adolescents, increasing their susceptibility to stress, D, and A. Corresponding levels on the HAM-D scale evidence this for depression, HAM-A scale for anxiety, and PSS scale for stress (Table 1). The intergroup differences were statistically significant for these indicators compared with those in adolescents from rural areas, where noise exposure was minimal. Furthermore, metropolitan adolescents had a higher incidence of clinically significant D on the HAM-D scale compared with rural adolescents (28.0% vs. 9.2% [OR=3.83, 95% CI (1.58–9.25), $p < 0.05$]) and a higher proportion of A on the HAM-A scale (30.7% vs. 10.8% [OR = 3.68, 95% CI (1.61–8.42), $p < 0.05$]). The levels of D, A, and stress depended on noise intensity. Thus, with the increasing noise level, the vulnerability of megapolis adolescents to noise was higher. The presence of a statistically significant difference between levels of D, A, and stress susceptibility reflects low, moderate, and high noise levels (Table 2). No gender differences were found concerning sensitivity to noise and its influence on the psyche.

The results obtained are comparable with the findings of other studies in the same direction. In particular, a study [28] conducted in Germany involving

15,010 people aged 35–74 years reported that A and D increased with higher intensity of noise exposure. In the individuals studied, D and A increased from moderate noise intensity (PR depression 1.20; 95% CI 1.00–1.45; PR anxiety 1.42; 95% CI 1.15–1.74) to high noise intensity (PR depression 1.97; 95% CI 1.62–2.39; PR anxiety 2.14; 95% CI 1.71–2.67) when compared to those not exposed to the noise factor [28].

Some studies have focused on noise effects on adolescents' cognitive functions [26], [27], [33]. For example, a study conducted in France involving 746 children aged 8–9 years found that chronic exposure to aircraft and road noise significantly impaired students' performance in French and mathematics [33]. A similar study was conducted in South Africa among 151 primary school students. Reading comprehension was severely impaired when chronically exposed to aircraft noise [27]. A study performed by Belojevic *et al.* [26] in Serbia involving 311 pupils aged 7–11 examined the effects of noise on children's executive functions. The noise did not significantly impact schoolchildren in general but the executive functions of boys, indicating an adverse effect of the noise factor on male participants.

This negative influence of noise on the psyche is explained by the fact that the activation of the auditory nerve causes perturbations in the structures of the central nervous system, particularly the hypothalamic-pituitary-adrenal axis, which can be that endogenous way of interrelation A, D, and noise influence. In addition, due to noise exposure, there may be irritation and other negative emotions, which can cause various psychophysiological reactions to stress, which are also associated with D and T [23]. Chronic noise exposure, visual and motor reactions, and nervous process mobility have slowed considerably, bioelectrical activity in the brain has been disrupted, and biopotential and electroencephalographic indicators have deteriorated [22], [24].

Conclusions

High noise levels adversely affect the psyche of megapolis adolescents. The higher the noise level, the more adolescents were exposed to depression, anxiety, and stress. Thus, the level of depression on the HAM-D scale in metropolitan adolescents at high noise levels was 1.56 times ($p < 0.05$) higher than those who reported low noise levels. At constant exposure to moderate noise levels, the anxiety level on the HAM-A scale was 1.60 times ($p < 0.05$) higher compared to low noise levels, at high levels, it was 2.45 times ($p < 0.05$) higher compared to that at low noise level, and 1.54 times ($p < 0.05$) higher at the high noise level compared to the moderate noise level. In addition, among the metropolitan area adolescents studied,

73 (28.4%) adolescents complained of low noise levels, 103 (40.1%) of moderate noise levels, and 81 (31.5%) of high noise levels. Notably, no youth reported no noise in the metropolitan area. Stress susceptibility on the PSS scale at moderate noise level was 1.28 times ($p < 0.05$) higher compared to that for low noise level, 1.58 times ($p < 0.05$) higher for high compared to low, and 1.23 times ($p < 0.05$) higher for high compared to the moderate noise level. The study is subjective, given the chosen region of the survey and the number of respondents who took part in it. It is also necessary to emphasize the factor of the limited age range of the respondents and the monotony of the stress factor – noise in the megapolis.

Prospects for further research

A prospect for further research is the study of the effect of electromagnetic radiation on the psyche of schoolchildren. Future researchers might also look in more detail at differences in academic achievement and physical and mental health between urban and rural schoolchildren. It was also interesting to investigate the effects of social media and the popularization of distance learning on adolescents' mobility.

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