

Hearing Loss in Adults in Older Age Groups

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Abstract—There has been a steady increase in the prevalence of hearing loss among people in many countries around the world. One of the main reasons for this negative trend is the growing life expectancy and increasing proportion of the elderly people, which leads to an increase in the number of people with age-related changes in the auditory system (presbycusis). Aging is accompanied primarily by damage to the structures of the inner ear, but it can also affect the central parts of the auditory analyzer, causing disorders at all levels of the auditory neural pathway. Presbycusis is accompanied by impaired hearing and speech intelligibility. Along with speech hearing, spatial hearing is also impaired. As in other countries of the world, in Russia the prevalence of age-related hearing loss is increasing year by year. The data on the prevalence of hearing impairment in the Russian Federation vary due to the lack of uniform approaches to the registration of individuals with impaired hearing. It is necessary to create an audiological register to provide informational support for a comprehensive medical and social rehabilitation of audiological patients. Since hearing loss has a significant negative impact on patients' quality of life, knowledge of the prevalence of hearing disorders among the population will make it possible to plan properly the demand for technical means of hearing and speech rehabilitation at the state level and to promote social rehabilitation and active longevity of citizens of older age groups.

Keywords: prevalence of hearing loss, presbycusis, quality of life

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GLOBAL STATISTICS ON THE PREVALENCE OF HEARING LOSS IN ADULTS

Hearing loss is a serious medical and social problem. This pathology is common throughout the globe and affects all age groups. According to the WHO, 4–7% of the population suffers from impaired auditory function. Thus, in 2015, there were 360 million people in the world (approximately 5% of the world population) with disabling hearing loss, including 328 million adults. According to the WHO data published in 2018, the number of patients suffering from hearing loss reached 466 million, with a forecasted increase up to 630 million by 2030 and up to 900 million by 2050. In the period 1990–2016, the number of individuals with disabling hearing loss in the 12 most densely populated countries of the world (Bangladesh, Brazil, China, India, Indonesia, Japan, Mexico, Nigeria, Pakistan, the Philippines, the Russian Federation, and the United States) almost doubled. The number of hearing-impaired people currently reaches 46 million in North America, 34 million in central and eastern Europe, 100 million in east Asia, and 49 million in Africa [56].

Thus, hearing loss is becoming more common. If this trend is not reversed, it will lead to unjustified costs in health care systems. The need for hearing aids, cochlear implants, and other technical means of auditory-speech rehabilitation will grow. In addition, the need for qualified specialists working in the field of diagnostics and rehabilitation of hearing impairment will increase. The lack of proper auditory rehabilitation can adversely affect not only individuals, who will increasingly find themselves in situations of social isolation, but also society as a whole. A few countries around the world, including the Russian Federation, have recognized that the current dynamics must be confronted primarily with the prevention and treatment of diseases that lead to hearing impairment [56].

The reasons for the growing number of deaf and hearing-impaired people in many countries of the world are the spread of infectious diseases, especially influenza; the use of ototoxic drugs; the damaging effects of noise and vibration, including the widespread use of personal audio devices with unsafe levels of sound exposure, as well as noise exposure associated with professional activities [9, 11, 56]. Another important factor contributing to the development of

hearing loss is an increase in life expectancy, which leads to a greater number of people with age-related changes in the auditory system.

Presbycusis is the most common sensory impairment in older adults and the third most common chronic condition in elderly Americans after hypertension and arthritis [20, 41].

According to the WHO and the U.S. Department of Health, more than 50 million Americans suffered from hearing loss in 2016, accounting for about 16% of the country's total population. Hearing loss, especially at high frequencies, was detected in 8.5% of people aged 20–29 years and in 17% of people aged 30–39 years. In the US, 70% of people aged 70–79 years, 92% of people aged 80–89 years old, and up to 100% of people aged over 90 years and living in nursing homes suffer from hearing loss. In men, hearing loss is diagnosed 5.5 times more often than in women [16, 51]. In Australia, about 50% of people over 55 suffer from hearing loss [53].

A study on the prevalence of hearing loss in the Nigerian population aged 45–93 years revealed hearing loss in 88.4% of the sample. The risk factors for hearing loss included burdened family history, 11.6%; the use of ototoxic drugs, 24.6%; arterial hypertension, 34.8%; noise exposure, 21.7%; diabetes mellitus, 8.7%; arthritis, 13%; smoking, 7.3%; and the use of alcohol, 14.5% [54].

FEATURES OF AUDITORY FUNCTION IN THE ELDERLY

The term “presbycusis” refers to the gradual hearing loss that occurs in most people as their body ages. This is a complex disease with a multifactorial etiology, including both the physiological degeneration of the structures of the auditory analyzer and the result of “external” influences. For example, high-intensity noise and the ototoxic effects of pharmacological drugs have a significant effect on sensory cells. Diseases of the cardiovascular system and diabetes mellitus, accompanied by hyperglycemia and oxidative stress, can contribute to cochlear microangiopathy and auditory neuropathy [23, 26, 34, 39].

According to a number of researchers, presbycusis is primarily caused by damage to the structures of the inner ear, in particular, the loss of sensory hair cells in the cochlea (sensory presbycusis) [30, 39, 50]. However, with age, changes can also develop in other parts of the auditory system, including in the central parts of the analyzer and in the spiral ganglion (decrease in the number of ganglion cells). The *stria vascularis*, a metabolic pump generating endocochlear potential, can atrophy, and the stiffness of the basilar membranes of the cochlea can increase [19, 33]. Researchers are currently considering the pathogenesis of senile, involuntary hearing loss as a condition caused by disorders

at all levels of the auditory neural pathway as a single functional system [29].

Patients with presbycusis develop progressive bilateral sensorineural hearing loss. The hearing loss is usually symmetrical, but age-related hearing loss, mostly in individuals aged 95 years or older, can be accompanied by asymmetric hearing thresholds that are not associated with retrocochlear pathology according to the study of M.J. Leskowitz et al. (2016) [40]. Some believe that the increase in hearing asymmetry is associated with deterioration in the processes of binaural information integration, possibly due to the gradual demyelination of interhemispheric connections [5].

According to tonal threshold audiometry, in the case of presbycusis, a gently or steeply downsloping curve is most often diagnosed with a predominant increase in thresholds in the high-frequency region. These variants of audiograms make up more than 90% of cases [18, 26]. Other types of audiometric curves (ascending, *U*-shaped, “inverse” *U*-shaped) are rare. The flat type is more common in women, while the high-frequency steeply downsloping type is more common in men [26, 27, 38]. According to Turkish researchers, a steeply downsloping type of the audiometric curve is the most commonly observed (48.5%), while gently downsloping (26.9%) and flat ones (24.5%) are less common. However, no statistically significant differences in speech intelligibility in patients were obtained with various types of audiograms [38].

Not all patients with presbycusis complain about hearing loss and consult specialists in a timely manner. According to A.O. Ogunleye et al. (2005), about 50% of patients who visit an audiologist complain about hearing loss, about 25% of patients do not report hearing loss but complain about subjective ear noise, or tinnitus; a combination of complaints about hearing loss and tinnitus is observed in approximately 25% of patients [45]. At the same time, no association was found between the level of increase in hearing thresholds and the tinnitus volume. In addition, the elderly with presbycusis complain that the speech of others is inaudible and experience special difficulties perceiving sibilants (for example, *ch*, *f*, *k*, *s*, *t*, or *z*) as compared to lower sounds of vowels. The greatest difficulties are experienced when listening to a speech delivered by higher voices (women and children) than with the low voices of men. It is usually difficult to understand conversations in the presence of background noise. Some sounds may be distorted or perceived to be excessively loud [52].

Along with speech hearing, spatial hearing, which provides a number of vital functions for patients, also suffers: hearing orientation, the ability to detect and isolate a useful target signal, and effective communication in a noisy environment [44]. In presbycusis, hearing loss at high frequencies leads to problems in

localizing sound sources vertically [28, 46] and by distance [17]. In asymmetric hearing, distortions of the auditory space also arise in the direction from left to right, mainly from the side of the worse hearing ear [48].

Both lower speech intelligibility and disturbed spatial hearing are associated with damage to not only peripheral but also central parts of the auditory system. There is not enough evidence to confirm the existence of isolated "central" presbycusis, but central auditory dysfunction (involvement of the auditory ducts and the cortical part of the analyzer in the pathological process) is an important component of presbycusis as a whole; it makes listening difficult under noisy conditions and in competitive speech, disturbing the temporal resolution auditory system and binaural perception of speech (especially with dichotic listening). With age, the function of the central parts of the auditory system may decrease faster than the function of peripheral ones [35, 37, 39, 50]. In these cases, sound-reinforcing devices, including those used for rehabilitation, cannot compensate for the deficiency of the central processing of the sound signal; on the contrary, additional amplification can aggravate this dysfunction [33].

Risk factors for the development of presbycusis can be grouped into four main categories: (1) aging; (2) external influences, such as exposure to noise; the ototoxic effects of certain drugs, including platinum drugs used to treat cancer, some antibiotics, especially aminoglycosides, loop diuretics, aspirin, and other anti-inflammatory drugs; (3) genetic predisposition; (4) concomitant diseases and bad habits, such as cigarette smoking, cerebral arteriosclerosis, hypertension, diabetes mellitus, and renal failure [21, 34, 47, 58].

RUSSIAN RESEARCH DATA ON THE PREVALENCE OF AGE-RELATED HEARING LOSS

As in other countries of the world, in Russia the prevalence of age-related hearing loss is increasing year by year. According to international criteria, a population is considered old if the proportion of people aged 65 years or more exceeds 7%. At the beginning of 2010, according to the Federal State Statistics Service, almost one in eight Russians, that is, 12.9% of the country's population, was 65 years old or more (Federal State Statistics Service [15]). According to the official demographic forecast, in 2030 the proportion of the population aged 65 years and over will increase to 18% (according to the most optimistic version of the increase in the total number of Russian residents) or up to 19.4% (according to the pessimistic version) [4]. The number of people with hearing impairment in the Russian Federation exceeds 12 million, which includes more than 3 million of those who need hearing prosthetics. According to the WHO, from 1990 to 2016, the number of individuals with dis-

abling hearing loss in the Russian Federation increased by 7 million [57].

The works of Russian researchers contain only some information on the prevalence of hearing loss in different regions of Russia. Analysis mainly reveals the extent of the spread of hearing loss in the structure of diseases of the otorhinolaryngological profile. In Russia, acquired hearing impairment occurs in 14% of people aged 34–45 years, 20% of people aged 50–60 years, 30% of people aged over 65 years, and 40% of people aged over 70 years [7, 12]. A study of the epidemiological situation of three oblasts of the Central Federal District (CFD) revealed that people of working age account for more than half (51.8%) of all patients with hearing loss and deafness living in the territories of the three oblasts of the Central Federal District, most of whom (68.9%) are over 40 years old [10].

Z.N. Farvaeva et al. (2001) studied the prevalence of hearing loss in the population of Ufa in the structure of ENT pathology. Sensorineural hearing loss had the highest incidence among people of working age, 22.3%. With age, the proportion of hearing loss in the structure of ear diseases increases: up to 42.2% in people aged 60–69 years and up to 51% in people aged 70 years and more. Analysis of the data from the Ufa Audiological Center showed that the prevalence of hearing loss per 100 000 adults was 488.9 in men and 403.6 in women [13].

Many people with mild to moderate high-frequency hearing loss consider it natural hearing loss, and do not go to an audiologist for examination, but their speech intelligibility suffers, especially in large and noisy rooms. In 2006, according to 64 specialized audiological offices, they had 65811 registered individuals. The patients were distributed according to the degree of hearing impairment: I degree, 401 individuals; II, 7384; III, 19863; IV, 9108; deafness, 3499 individuals. The elderly and senile age prevailed: 61–70 years old, 10577 individuals; 71–80 years old, 11346 individuals [8].

The majority of adults (77.6%) who turned to audiological offices in our country for help are diagnosed with socially significant hearing impairment, hearing loss of the III–IV degree [12]. At the same time, according to an analysis of the work of the Audiological Center for Adults, it was found in St. Petersburg that patients with II degree of hearing loss account for the highest proportion, 37.8%. The proportion of people with I degree of hearing loss is 32.2%, with III is 15.3%, and with IV degree of hearing loss and deafness is 6.6%. Patients with normal hearing complain in only 8.1% of cases [3].

Information on the prevalence of hearing impairment in the Russian Federation varies due to the lack of unified approaches to counting this category of patients. The registration of individuals with hearing loss is carried out according to their appeals to specialized centers and offices, which obviously provides

underestimated results. A survey of elderly people living in social houses in St. Petersburg showed a lack of audiological assistance and rehabilitation measures necessary to compensate for hearing impairment. The prevalence of hearing loss in this category of citizens reaches 81.7%, and 47.6% of cases reveal hearing impairment that requires the use of hearing aids. However, only 16.6% of the examined individuals were using those devices. A high degree of need for hearing prosthetics and inadequate availability of audiological care require a wider coverage of the population, including the elderly, with diagnostic and rehabilitation measures [2].

The organization of an audiological service in the Russian Federation is regulated by the order of the Ministry of Health of the Russian Federation, No. 178n, from April 4, 2015, On Approving the Procedure for Providing Medical Care to the Population for the "Audiology-ENT" Profile. The first specialist to receive patients with hearing impairment is the ENT doctor. The ENT doctor carries out diagnostics and treats diseases of the ear, nose, and throat, including those accompanied by hearing impairment, which can be diagnosed in the ENT office of the clinic. The next stage is in the audiological office of a medical organization, where it is possible to carry out threshold tonal audiometry in a standard or extended frequency range (impedancemetry). Rehabilitation measures may include hearing prosthetics. An in-depth examination and rehabilitation of patients with hearing impairments is carried out in an audiological center, which is equipped with specialized facilities, and the staff, in addition to audiologists-ENT specialists, includes neurologists, medical psychologists, speech pathologists, speech trainers, and speech therapists. In the conditions of the audiology center, a comprehensive diagnostics of auditory function disorders is carried out, including not only audiometry and impedancemetry but also various audiological techniques aimed at the identification of disorders of the central department of the auditory analyzer, speech audiometry, endoscopic and microscopic methods for examining ENT organs, and objective methods for hearing examination (recording otoacoustic emission, brainstem evoked potentials). Comprehensive rehabilitation is also carried out in the conditions of the audiology center: hearing prosthetics with bone and air conduction devices, adjustment of speech processors of cochlear implants, audioverbal psychological-pedagogical, speech therapy, and medical support. In accordance with the above order, staffing standards are formed on the basis of one position of an audiologist-ENT specialist per 100000 of the served population.

The relevant problem in the optimization of audiological assistance is the identification of the actual number of people suffering from auditory disorders [12]. A proper accounting of individuals with hearing impairment will contribute to the quality organization

of audiological treatment and social rehabilitation. The principles of the use of information systems in the organization of audiological assistance to the population and the creation of the audiological register were considered in the study by I.V. Otvagin (2004). Although more than ten years have passed since the study, the relevance of the creation of such a register in our time is still obvious. It is necessary for the information support of the comprehensive medical and social rehabilitation of patients with an audiological profile. The creation of an automated audiological register will help bring audiological care to a new level of information, which will make it possible to obtain data on the dynamics of key health indicators and to monitor the implementation of medical and social rehabilitation programs for patients with hearing loss, including hearing prosthetics [10].

QUALITY OF LIFE FOR PATIENTS WITH HEARING LOSS AND METHODS FOR ITS ASSESSMENT

Due to the increase in the number of patients with an audiological profile, the problem of the quality of life (QoL) of this category of citizens is urgent. According to the WHO definition, QoL refers to individuals' perception of their position in life in the context of the culture and value system in which they live, in accordance with their goals, expectations, norms, and concerns. QoL is determined by the physical, social and emotional factors of human life, which are of great importance for the person and affect them. QoL is the degree of an individual's comfort within themselves and the framework of their society.

The WHO research team proposed to consider the problems of the effectiveness and quality of medical care with the consideration of three main criteria: adequacy, cost-effectiveness, and scientific and technical level. Here, the adequacy of medical care is understood as the need to achieve an acceptable QoL for the patient. Research on QoL is carried out in almost all areas of medicine, including otorhinolaryngology and audiology. The main tool for QoL research is questionnaires, which are divided into two types: (1) general, e.g., Medical Outcomes Study (MOS SF-36), Quality of Well-Being Index (QWB), Peds QL TM 4.0, and Generic Care Scales (Peds QL); (2) specialized, e.g., Audiological Disabilities Preference Index (ADPI), Glasgow Hearing And Benefit Profile (GHABP), Ear Infection Survey (EIS), Nijmegen Cochlear Implant Questionnaire (NCIQ), and Tinnitus and Handicap Support Scales (THSS).

General questionnaires are used to assess QoL in both healthy and sick people, regardless of the type of disease. Special questionnaires examine QoL from the point of view of problems of the audiological profile. Unfortunately, not all questionnaires were culturally and linguistically adapted for Russia. The questionnaires adapted for the Russian Federation are cur-

rently MOS SF-36, WHO Quality of Life Questionnaire (WHOQOL-100), Hearing Handicap Inventory for the Elderly (HHIE), Hearing Handicap Inventory for Adults (HHIA), Hearing Handicap Inventory for the Elderly Screening Version (HHIE-S), and Hearing Handicap Inventory for Adults Screening Version (HHIA-S) [14].

A number of authors also single out private questionnaires, in addition to general and special questionnaires. They assess not the state of health in general but individual QoL components, such as mood, depression levels, and pain syndrome, e.g., the Hamilton Depression Rating Scale in normal and depressive people [1]. Questionnaires are being increasingly introduced into foreign audiological practice, making it possible to simultaneously characterize the quality of patient's speech and spatial hearing. Two questionnaires received the most recognition and distribution: The Speech, Spatial and Qualities of Hearing Scale and the Spatial Hearing Questionnaire [31, 55].

In recent years, works have been carried out on the territory of the Russian Federation to identify the relationship between QoL and hearing loss. A study on the professional incidence of sensorineural hearing loss due to exposure to the noise factor and its relationship with QoL in miners was carried out in Kuzbass. The analysis was carried out with the personal records of the Center for Occupational Pathology of the State Autonomous Educational Institution of Kemerovo Oblast, Regional Clinical Center for Miners' Health Protection (Leninsk-Kuznetsk) for the period of 2009–2014 with the MOS SF-36 and WHOQOL-100 questionnaires. The study revealed that both patients with sensorineural hearing loss and individuals of the control group had reduced QoL, mainly due to indicators of the psychological component and to a much lesser extent due to physical and social components. In the group of patients with sensorineural hearing loss, QoL was affected more as compared to the control group [6].

Today, in the assessment of the effectiveness of treatment, it is especially important to rely not only on objective data but also on patients' subjective assessment of their condition and to examine QoL associated with health. In accordance with the new paradigm of clinical medicine, the patient's QoL is either the main or additional goal of treatment. The order of the Ministry of Health of the Russian Federation and the Federal Compulsory Medical Insurance Fund no. 363/77 from October 24, 1996, On Improving the Quality Control of Medical Care for the Population of the Russian Federation obliges doctors to study patients' opinions about their health and quality of life after various treatment methods as an indicator of medical-care effectiveness. In this regard, the assessment of changes in the patients' quality of life can be used to determine the effectiveness of the rehabilitation of patients with hearing impairment, including

the use of methods of medical rehabilitation, cochlear implantation, hearing prosthetics, etc.

Hearing impairment has a significant negative impact on the lives of deaf patients and their relatives. A study carried out by the American Academy of Audiology has shown that the use of hearing aids for hearing loss has a positive effect on QoL of patients [22]. The authors of international studies EuroTrak 2015 (ET 2015) and MarkeTrak 9 (MT9) on hearing loss, hearing aids, and their positive effects on life came to the same results. The authors of these studies are specialists from the European Association of Hearing Aid Manufacturers, the Anovum Institute (Zurich, Switzerland), and EHIMA (Brussels, Belgium). It was found that an average of eight of ten hearing aid users feel that the hearing aid has a positive effect on their QoL, with Swiss residents noting the highest positive impact of hearing aids. Approximately half of all hearing aid users indicate an improvement in social communications, as well as family and work relationships, through regular use of hearing aids. Residents of Italy reported a positive impact of hearing aids on their relationships at home and at work. It was noted that hearing-impaired people who wear hearing aids forget much less information than people with severe hearing impairment who do not use the hearing aids. Approximately half of hearing aid users noted a greater sense of security when using the device. In addition, they became more independent and self-sufficient [36].

Leading to communication disruption, hearing loss contributes to loneliness, isolation, dependence, and frustration [23]. In elderly people with cognitive impairment or dementia, additional communication difficulties associated with hearing loss can exacerbate cognitive dysfunction, as well as contribute to the development of paranoia. In this regard, compensation for hearing loss using hearing aids, listening accessories, and cochlear implants is an important factor in improving the quality of life of older people [24, 32, 42, 43]. An equally important factor in improving QoL is the proper organization of communication with hearing-impaired people on the part of interlocutors, primarily family members. When talking to hearing-impaired people, it is necessary that the interlocutor can easily see the movements of the face and lips, try to speak in a deeper voice with short simple sentences, eliminating extraneous background sounds when possible. Lip reading is an important compensatory strategy that improves speech understanding [49].

Information exchange with other people, which is an important aspect of everyday life, is usually seriously impaired in people with hearing loss. These communication difficulties can lead to a noticeable decrease in QoL. As life expectancy increases and older people live longer, an increasing number of people will suffer from hearing loss in old age [25]. Under-

standing the impact of hearing loss on QoL is of great importance, contributing to the organization of timely social rehabilitation and active longevity in citizens of older age groups.

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