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Self-Reported Hearing Loss in Russians. The Ural Eye and Medical Study

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Self-Reported Hearing Loss in Russians. The Ural Eye and Medical Study

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Abstract

Objectives: With information about frequency of hearing loss in Russia and Eastern Europe mostly missing, we assessed the prevalence of hearing loss in a Russian population.

Setting: The population-based study Ural Eye and Medical Study was conducted in a rural region of Bashkortostan and in the city of Ufa/Bashkortostan/Russia.

Participants: With an inclusion criterion of 40+ years, the study included 5899 (80.5%) out of 7328 eligible individuals (mean age:59.0±10.7 years; range:40-94 years).

Primary and secondary outcome measures: Hearing loss examined in 5397 (91.5%) study participants, as it was assessed in a standardized interview with questions on self-reported hearing difficulties.

Results: The prevalence of hearing loss (26.1%;95% confidence interval (CI):24.2,27.2) increased from 10.9% (95%CI:8.0,13.7) in the 40-45 year-olds to 59.0% (95%CI:51.6,66.4) in the 80+ year-olds. It was higher for men than for women in the age group of 60-80 years (38.93%;95%CI:35.8,42.1 vs. 32.8%;95%CI:30.2,35.3;*P*=0.003). In multivariable analysis, higher prevalence of hearing loss was associated with older age (*P*<0.001;odds ratio (OR):1.06;95%CI:1.06,1.07), male gender (*P*<0.001;OR:1.26;95%CI:1.09,1.47), higher depression score (*P*<0.001;OR:1.06;95%CI:1.04,1.08), and higher prevalence of headache (*P*=0.001;OR:1.27;95%CI:1.10,1.47), history of cardiovascular disease including stroke (*P*=0.001;OR:1.32;95%CI:1.13,1.55), osteoarthritis (*P*<0.001;OR:1.40;95%CI:1.18,1.67), physically vigorous activity during work (*P*<0.001;OR:1.40;95%CI:1.21,1.62), alcohol consumption (*P*<0.001;OR:1.51;95%CI:1.28,1.78) and dry eye feeling (*P*<0.001;OR:1.67;95%CI:1.30,2.16). It was marginally correlated with a higher anxiety score (*P*=0.07;OR:1.03;95%CI:0.998,1.06). It was independent of diabetes (*P*=0.52), arterial hypertension (*P*=0.20), level of education (*P*=0.11;OR:0.97;95%CI:0.93,1.01), region of habitation (*P*=0.70), blood concentration of high-density lipoproteins (*P*=0.17) and low-density lipoproteins (*P*=0.52), current smoking (*P*=0.95) and smoking package years (*P*=0.37), and best corrected visual acuity (*P*=0.93).

Conclusions: As in other countries the prevalence of hearing loss is high in this elderly population in Russia. It is primarily or secondarily associated with older age, depression, male gender, cardiovascular disease and alcohol consumption.

Article Summary

Strengths and limitations of this study:

- The prevalence of hearing loss as a major parameter of the global burden of disease and the correlations of hearing loss with some other parameters have been examined so far mostly in Western countries.
- The study adds information about the prevalence and associated factors of hearing loss in Russia where so far almost no information about the epidemiology of hearing loss was available.
- The study adds information about the associations of hearing loss with a multitude of systemic parameters assessed in a multivariate analysis.

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- Limitation of our study were that hearing loss was assessed in a series of 11 standardized questions without performing an audiometric examination,

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Introduction

Deficits of sensory organ function form a major part of the causes for disability associated life years (DALYs) as assessed by the Global Burden of Disease Study (GBD).[1] In the GBD 2016, sense organ diseases caused 66.7 million DALYS (95% uncertainty interval (UI): 46.5 million to 92.3 million) or 2.8% of all DALYs in 2016, up from 39.4 million DALYS (95%UI: 27.3 million to 54.5 million) in 1995 and 54.8 million DALYs (95%CI: 38.2 million to 76.0 million) in 2006.[1] Sense organ diseases-associated DALYs increased in the ranking of the most common causes of DALYs from position #16 in 1995 to rank #14 in 2006 and to rank #7 in 2016.[1] Age-related and other hearing loss accounted for 29.7 million DALYS (95%UI: 25.3 million to 50.9 million) or 44.5% of all sense organs-associated DALYs in 2016. The age-standardized DALY rate per 100,000 individuals for hearing loss was 524.3 (95%UI: 368.0 to 734.0) in 2016 and accounted for 54.7% of the age-standardized DALY rate for all sense organs-associated DALYs (959.3; 95%UI: 670.2 to 1331.0).[1]

Despite its importance for public health, the prevalence of hearing loss and its associated factors have not widely been investigated worldwide.[2-11] For many countries, information on the prevalence of hearing loss has not been available yet, nor on the factors associated with hearing loss. It holds true in particular for Russia and Eastern Europe. We therefore conducted this study to assess the prevalence of hearing loss in a population in a Russian population and explored associations of hearing loss with other parameters such as gender, region of habitation and level of education. The aim was to investigate the prevalence of self-reported hearing problems, that is, hearing difficulties in general and difficulties in following a conversation in noise.

Methods

The Ural Eye and Medical Study (UEMS) is a population-based study which was carried out in the urban region of Kirovskii of the city of Ufa and in villages of the rural region of the Karmaskalinsky District in a distance of 65 km from Ufa.[12,13] According to the Declaration of Helsinki, the Ethics Committee of the Academic Council of the Ufa Eye Research Institute approved the study and all participants gave informed written consent. The ethics committee confirmed that all methods were performed in accordance with the relevant guidelines and regulations. Inclusion criterion for the participation in the study was living in the study region and having an age of 40+ years. There were no exclusion criteria.

Trained social workers performed a standardized interview including more than 250 questions on socioeconomic parameters such as level of education, family income and family possessions, living conditions, diet, smoking or other types of tobacco consumption, daily physical activity, alcohol consumption, depression and suicidal ideas, and medical history including known diagnosis and therapy of major diseases. The interview consisted of standardized questions which had been validated in previous studies such as the mini–mental state examination or Folstein test or in Zung´s self-rated depression scale.[14,15] We collected and reported the data using the Guidelines for Accurate and Transparent Health Estimates Reporting (GATHER statement guidelines).[16]

For all study participants, we measured the arterial blood pressure and pulse rate and the anthropomorphic parameters of body height, body weight and circumference of the hip and waist. The

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handgrip strength was determined using a dynamometer (dynamometer - dk 140, ZAO Nizhnetagilskiy Medical Instrument Plant, Nizhniy Tagil, Russia). Blood samples taken under fasting conditions were biochemically examined. All participants underwent a pulmonary function test by spirometry (Riester spirotest, Riester Company, Jungingen, Germany). We defined arterial hypertension by a systolic blood pressure ≥140 mmHg and/or a diastolic blood pressure ≥90 mmHg, and/or self-reported history or current treatment of arterial hypertension with antihypertensive medication. A glucose concentration ≥7.0 mmol/L or a self-reported history of physician diagnosis of diabetes mellitus or a history of drug treatment for diabetes (insulin or oral hypoglycemic agents) characterized the presence of diabetes mellitus. Depression was assessed applying the Center for Epidemiologic Studies Depression Scale (CES-D) Scoresheet. The study design has been described in detail recently.[12]

Hearing loss was assessed by a series of 11 standardized questions (Table 1). The questions could be answered by "no" (0 points), "sometimes" (2 points) and "yes (4 points). The total hearing loss score was the sum of all points and could range between 0 points and 44 points. The amount of hearing loss was assessed by the hearing loss score. As a binary variable, hearing loss was additionally defined as a definite answer of "Yes" (in contrast to the answer of "Sometimes" or "No") to the question "Do you experience a hearing loss?"

We used a commercially available statistical software program (Statistical Package for Social Science, SPSS, version 25.0; IBM-SPSS Inc., Chicago, USA) for statistical analysis. In a first step, we determined the frequency of hearing loss, presenting the results as mean and 95% confidence intervals (CI). In a second step, we searched for associations in univariate analysis between the hearing loss score and other parameters. In a third step, we conducted a multivariable regression analysis with the hearing loss score as dependent variable and as independent variables all those parameters which were significantly associated with the hearing loss score in the univariate analysis. All variables in the list of independent parameters were tested for multicollinearity. Associations of the prevalence of hearing loss as binary variable were examined in binary regression analysis. Odds ratios (OR) and their 95% confidence intervals (CI) were calculated. All *P*-values were two-sided and considered statistically significant when the values were less than 0.05.

Patient and Public Involvement

Patients were not involved in the study.

Results

The study included 5899 individuals (2580 (43.7%) men) out of a population of 7328 eligible individuals, who resided in the study regions and who fulfilled the inclusion criterion of an age of 40+ years. The participation rate as ratio of 5899 / 7328 was 80.5%. Out of the 5889 individuals primarily participating in the Ural Eye and Medical Study, the present study included 5397 (91.5%) individuals with available information on the hearing loss score. The mean age of the study population (2450 (45.4%) men) was 58.6 ± 10.6 years (median: 58 years; range: 40 – 94 years). The composition of the study population with respect to gender and age corresponded to the gender and age distribution in the Russian population according to the most recent census carried out in 2010.[17] The mean body height was 165.0 ± 8.8 cm (median: 164 cm; range: 112 – 196 cm), and the mean body mass index

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was 27.9 ± 5.0 kg/m^2 (median: 27.3 kg/m^2; range: 13.96 – 60.96 kg/m^2). Illiteracy was present for 14 (0.3%) individuals, 86 (1.6%) participants had passed the fifth grade, 557 (10.3%) participants the 8th grade, 628 (11.6%) participants the 10th grade, and 638 (11.8) individuals the 11th grade. Graduates were 1785 (33.1%) individuals, and post graduates were 51 (0.9%) study participants, and 1634 individuals had a specialized secondary education. .

The group of individuals with information on hearing loss as compared with the group of subjects without hearing loss data was significantly younger (58.6 ± 10.6 years versus 63.0 ± 11.3 years; *P*<0.001), and had significantly more men (2450 (45.4%) men / 2947 (54.6%) women) versus 130 (25.9%) men / 372 (74.1%) women); *P*<0.001). The mean hearing loss score was 5.13 ± 10.95 (median: 0; range: 0 – 44). Within the ethnically Russian group (n=1185; 508 men, 677 women) with a mean age of 60.1 ± 11.1 years, the mean hearing loss score was 5.58 ± 11.09 (median: 0; range: 0 – 44), with no significant (*P*=0.11) difference to the non-Russian group. An abnormal result of Weber´s test was found for 210 (3.9%; 95%CI: 3.4, 4.4) study participants and an abnormal result for Rinné test for 3390 (63.0%; 95%CI: 61.7, 64.3) individuals. The hearing loss score differed significantly between individuals with a positive Weber´s test and individuals with a negative Weber´s test (23.9 ± 14.7 vs. 4.4 ± 10.1; *P*<0.001).

In univariate analysis, the hearing loss score was correlated with parameters such as older age (*P*<0.001) (Table 2) (Fig. 1), male gender (*P*<0.001) (Fig. 1) and other parameters (Supplementary Table 1). The multivariable regression analysis included the hearing loss score as dependent variable and as independent variables all those parameters which were significantly associated with the hearing loss score in the univariate analysis. Due to collinearity, we first dropped body weight (variance inflation factor (VIF): 6.8) and waist circumference (VIF: 4.0). We then dropped step by step those parameters which were no longer statistically significantly associated with hearing loss in the multivariate analysis. In the resulting final model, a higher hearing loss score was associated (regression coefficient r: 0.33) with older age (*P*<0.001), male gender (*P*<0.001), a higher depression score (*P*<0.001), a higher prevalence of headache (*P*<0.001) and a higher prevalence of history of cancer (*P*=0.008), cardiovascular disease including stroke (*P*=0.003), osteoarthritis (*P*=0.006) and skin disease (*P*=0.01), a lower number of days with intake of fruits (*P*=0.02), and a higher amount of physically vigorous activity during work (*P*=0.008) and of physically moderate activity during leisure time (*P*<0.001) (Table 3).

Hearing loss defined as binary variable by a definite answer of “Yes” to the question “Do you experience a hearing loss?” was prevalent in 1406 (26.1%; 95%CI: 24.2, 27.2) participants. It was significantly associated with a positive Weber´s test (OR: 24.0; 95%CI: 15.7, 36.7). The prevalence of hearing loss increased with older age (*P*<0.001; OR: 1.06; 95%CI: 1.05, 1.07) (Table 4). In the age group between 60 and <80 years, prevalence of hearing loss was significantly (*P*=0.003) higher for men than for women (38.93% (95%CI: 35.8, 42.1) vs. 32.8% (95%CI: 30.2, 35.3). For the age group of less than 60 years (*P*=0.57) and for the age group of 80+ years (*P*=0.87), both gender did not differ significantly in the prevalence of hearing loss (Fig. 2). In the total study population, the prevalence of hearing loss increased from 10.9% (95%CI: 8.0, 13.7) in the age group of 40 to <45 years, to 22.7% (95%CI: 20.0, 25.4) in the age group of 55 to <60 years, and to 59.0% (95%CI: 51.6, 66.4) in the age group of 80+ years (Fig. 2).

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In multivariable binary regression analysis, higher prevalence of hearing loss was associated with older age (P<0.001), male gender (P<0.001), a higher depression score (P<0.001), a higher prevalence of headache (P=0.001) and a higher prevalence of history of cancer (P=0.04), cardiovascular disease including stroke (P=0.001) and osteoarthritis (P<0.001), a higher amount of physically vigorous activity during work (P<0.001), higher prevalence of alcohol consumption (P<0.001) and of dry eye feeling (P<0.001) (Table 5). Prevalence of hearing loss was marginally correlated with a higher anxiety score, when added to the model (P=0.07; OR: 1.03; 95%CI: 0.998, 1.06). If diabetes (P=0.52), arterial hypertension (P=0.20), level of education (P=0.11; OR: 0.97; 95%CI: 0.93, 1.01), urban versus rural region of habitation (P=0.70), blood concentration of high-density lipoproteins (P=0.17) and low-density lipoproteins (P=0.52), current smoking (P=0.95) and smoking package years (P=0.37), and best corrected visual acuity (P=0.93) and presenting visual acuity (P=0.62) and anxiety score (P=0.07; OR: 1.03; 95%CI: 0.998, 1.06) were added to the model, these variables were not significantly associated with hearing loss.

Discussion

In this Russian population, hearing loss, increasing in its prevalence from 10.9% (95%CI:8.0,13.7) in the 40 to 45 year-olds to 59.0% (95%CI:51.6,66.4) in the 80+ years-olds, was associated with older age, male gender, a higher depression score and a higher prevalence of headache, history of cardiovascular disease including stroke, osteoarthritis, physically vigorous activity during work, alcohol consumption and dry eye feeling. It was marginally significantly correlated with a higher anxiety score (P=0.07).

The findings obtained in our study on a population in Russia can be compared with observations made in previous investigations conducted in other world regions. The high overall prevalence of hearing loss of 26.1% (95%CI: 24.2, 27.2) in our study population aged 40+ years agreed well with the data of the World Health Organization WHO that over 5% of the world's population – or 466 million people – has disabling hearing loss (432 million adults and 34 million children).[18] The prevalence of hearing loss as found in our study population also compared well with figures reported by Ikeda and colleagues and by the Health, Aging and Body Composition Study after adjusting for age differences in the study populations.[19,20] It was lower than the figures found by Hannula and associates (prevalence of self-reported hearing problems of 37.1% and of 43.3% for difficulties in following a conversation in noise),[21] and it was lower than the prevalence of unilateral and bilateral speech-frequency hearing impairment in the National Health and Nutrition Examination Survey.[22-24]

In all studies as in our investigation, the prevalence of hearing loss strongly increased with older age for both gender (Fig. 1, 2).[26-42] In our study population, the age-related increase in the prevalence of hearing loss was less marked for women than for men in the age group of 60 to <80 years (Fig. 1, 2). As in the previous studies on other ethnicities, the frequency of hearing loss was higher for men than for women.[24-42] In our study, the gender difference hold true for the age group of 60 to <80 years (38.93%;95%CI:35.8,42.1 vs. 32.8%;95%CI:30.2,35.3;P=0.003). In the age group between 60 and <80 years, prevalence of hearing loss was significantly (P=0.003) higher for men than

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for women (38.93% (95%CI: 35.8, 42.1) vs. 32.8% (95%CI: 30.2, 35.3). For the age group of less than 60 years (P=0.57) and for the age group of 80+ years (P=0.87), both gender did not differ significantly in the prevalence of hearing loss.

In our study, a higher prevalence of hearing loss was associated with a higher prevalence of vigorous physical activity during work. It was in contrast to the finding reported by Gispen and coworkers who used data of the National Health and Nutritional Examination Survey (2005-06) and found that individuals with moderate or greater hearing impairment had greater odds than those with normal hearing of being in a lower category of physical activity.[34] The association between vigorous physical activity at work and higher prevalence of hearing loss in our study might have been due to a potentially confounding correlation between heavy work and higher noise level at work.

In the National Health and Nutrition Examination Survey and in a study by Sommer et al. hearing impairment was more prevalent among adults with diabetes in a multivariable analysis.[8] It is in contrast to our study in which neither diabetes nor blood concentrations of glucose were significantly correlated with hearing loss (Supplementary Table 1). As a corollary, hearing loss in our study was not significantly correlated with the body mass index (Supplementary Table 1). It is in partial contrast to the results of the study by Lalwani and colleagues who found that in children of 12 to 19 years of age, obese adolescents as compared adolescents with normal body weight had elevated pure tone hearing thresholds and greater prevalence of unilateral low-frequency sensorineural hearing loss (P=0.01).[32]

A higher prevalence of self-reported hearing impairment was associated with a higher depression score in our study as well as in the study by Li and colleagues who used data of the National Health and Nutrition Examination Survey (NHANES), 2005-2010, and who found that that self-reported hearing impairment and audiometrically determined hearing loss were significantly associated with depression, particularly in women.[33]

The association between hearing loss and cardiovascular risk factors has remained unclear so far. While in our study population and in a study by Lohi et al. cardiovascular risk factors were not significantly associated with hearing loss, the National Health and Nutrition Examination Survey and the Health, Aging and Body Composition Study reported that cardiovascular risk generated by smoking and diabetes was associated with both high- and low-frequency hearing loss.[21,24,26,30,36] Reasons for the discrepancy between the studies may be differences in the study population (lifestyle in Russia versus lifestyle in the US or in Korea), differences in the multivariable analysis and others.

Limitations of our study should be discussed. First, the main outcome parameter was self-reported hearing loss assessed in a series of 11 standardized questions. In previous studies, audiometry was applied to quantify the hearing impairment. Although the latter method is a more quantitative one, the degree of self-reported hearing impairment as compared to audiometrically defined hearing loss may be more important to reflect the quality of the daily life of the individual. Interestingly, a study by Hannula et al. showed that self-reported hearing difficulties were more frequent than hearing impairment defined by audiometric measurement.[20] Hannula also reported that self-reported hearing difficulties predicted hearing impairment at high frequencies (4-8 kHz) rather than at the frequencies of 0.5-4 kHz, which were commonly used to define the degree of hearing impairment in medical and legal issues. Second, as for any population-based study the participation

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rate and the representativeness of the study population as compared to the population of the region or country the study is aiming at is critical. In our study, 80.5% of the eligible population participated in the survey so that a major bias in the inclusion of study participants appears unlikely. The multi-ethnic composition of our study population was typical for the region and showed as compared to North-Western Russia and Central Russia a lower percentage of Russians on the total population. To overcome this limitation, we assessed the frequency of hearing loss in dependence of the ethnic background and found that the prevalence of hearing impairment did not differ significantly between the Russian groups than in the non-Russian group.

In conclusion, in our typically ethically mixed, urban and rural Russian population aged 40+ years, the mean prevalence of hearing loss was 26.1% and increased from 10.9% in the 40 to 45 year-olds to 59.0% in the 80+ years-olds. In addition to older age, it was associated with male gender, depression and a higher prevalence of headache, history of cardiovascular disease including stroke, physically vigorous activity during work, alcohol consumption and dry eye feeling, and marginally significantly correlated with a higher anxiety score. These data may be useful to elucidate the epidemiology of hearing loss in Russia and to assess factors associated with hearing impairment.

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Tables

Table 1

Standardized questions to assess the presence and sequels of hearing problems

1. Do you experience a hearing loss?
2. Does a hearing problem make you feel embarrassed when meeting new people?
3. Does a hearing problem make you feel frustrated when talking to members of your family?
4. Do you have difficulties hearing when someone speaks in a whisper?
5. Do you feel handicapped by a hearing problem?
6. Does a hearing problem cause you difficulties when visiting friends, relatives, or neighbors?
7. Does a hearing problem make you attending religious services less often than you would like?
8. Does a hearing problem make you having arguments with family members?
9. Does a hearing problem cause you difficulties when listening to TV or radio?
10. Do you feel that any difficulty with your hearing limits or does it hamper your personal or social life?
11. Does a hearing problem cause you difficulty when you are in a restaurant together with relatives or friends?

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Table 2

Mean hearing loss score in the Ural Eye and Medical Study, stratified by sex and age

Age Group (Years)	n	Hearing Loss Score	95% Confidence Intervals
Men			
40-44	209	2.1 ± 7.4	1.0, 3.1
45-49	350	1.9 ± 6.9	1.2, 2.7
50-54	422	2.9 ± 8.4	2.1, 3.7
55-59	471	4.7 ± 10.6	3.7, 5.6
60-64	383	7.6 ± 13.2	6.3, 8.9
65-69	273	8.5 ± 13.4	6.9, 10.1
70-74	124	8.5 ± 13.1	6.1, 10.8
75-79	150	10.9 ± 14.7	8.5, 13.3
80+	68	15.9 ± 16.2	12.0, 19.8
Women			
40-44	252	1.2 ± 4.4	0.7, 1.8
45-49	361	2.2 ± 7.1	1.4, 2.9
50-54	465	3.1 ± 8.7	2.3, 3.9
55-59	500	4.1 ± 9.6	3.3, 5.0
60-64	449	4.8 ± 10.0	3.9, 5.7
65-69	430	5.8 ± 11.3	4.7, 6.8
70-74	182	6.2 ± 10.9	4.6, 7.8
75-79	203	10.8 ± 14.8	8.7, 12.8
80+	105	15.3 ± 15.6	12.2, 18.3

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Table 3

Associations (multivariate analysis) between the hearing loss score and other systemic parameters in the Ural Eye and Medical Study

Parameters	*P*-Value	Standardized Regression Coefficient beta	Non-Standardized Regression Coefficient B	95% Confidence Interval	Variance Inflation Factor
Age (Years)	<0.001	0.23	0.27	0.23, 0.31	1.14
Sex (Women / Men)	<0.001	0.07	1.69	0.89, 2.50	1.13
Depression Score	<0.001	0.07	0.22	0.11, 0.33	1.11
History of Headache	<0.001	0.07	1.50	0.71, 2.29	1.09
History of Cancer	0.008	0.05	3.53	0.91, 6.16	1.01
History of Cardiovascular Disease Including Stroke	0.003	0.05	1.45	0.51, 2.39	1.11
History of Osteoarthritis	0.006	0.05	1.43	0.42, 2.44	1.06
History of Skin Disease	0.01	0.04	2.18	0.48, 3.89	1.01
In a week how many days do you eat fruits?	0.02	-0.04	-0.24	-0.44, -0.04	1.03
„Does your work involve physically vigorous activity (like heavy lifting or digging) or moderately intensive activity (like brisk walking or carrying light loads during work for at least 10 minutes at a time?“	0.042	0.04	1.13	0.04, 2.22	1.04
„How many days a week do you do such physically vigorous activity during work?“	0.008	0.05	0.36	0.10, 0.63	1.10
„In your leisure time, do you do any moderate intensity activities like	<0.001	0.09	1.96	1.19, 2.74	1.03

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brisk walking, cycling or swimming for at least 10 minutes at a time?“					

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Table 4

Prevalence of self-reported hearing loss (definite answer of "Yes" (in contrast to the answer of "Sometimes" or "No") to the question "Do you experience a hearing loss?") stratified by age and gender in the Ural Eye and Medical Study

Age Group (Years)	n	Prevalence of Self-Reported Hearing Loss	95% Confidence Intervals
Men			
40-44	209	10.1	5.9, 14.2
45-49	350	13.4	9.8, 17.0
50-54	422	17.5	13.9, 21.2
55-59	471	22.3	18.5, 26.1
60-64	383	32.3	27.7, 37.1
65-69	273	40.3	34.4, 46.2
70-74	124	41.1	32.3, 49.9
75-79	150	51.3	43.2, 59.4
80+	68	60.3	48.4, 72.2
Women			
40-44	252	11.5	7.5, 15.5
45-49	361	14.7	11.0, 18.4
50-54	465	18.1	14.6, 21.6
55-59	500	23.0	19.3, 26.7
60-64	449	27.4	23.3, 31.5
65-69	430	31.9	27.4, 36.3
70-74	182	32.4	25.6, 39.3
75-79	203	46.8	39.9, 53.7
80+	105	58.1	48.5, 67.7

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Table 5

Associations (multivariate analysis) between the prevalence of hearing loss loss (definite answer of "Yes" (in contrast to the answer of "Sometimes" or "No") to the question "Do you experience a hearing loss?") and other systemic parameters in the Ural Eye and Medical Study

Parameters	*P*-Value	Odds Ratio	95% Confidence Interval
Age (Years)	<0.001	1.06	1.06, 1.07
Sex (Men / Women)	<0.001	1.26	1.09, 1.47
Depression Score	<0.001	1.06	1.04, 1.08
History of Headache	0.001	1.27	1.10, 1.47
History of Cancer	0.04	1.51	1.02, 2.24
History of Cardiovascular Disease Including Stroke	0.001	1.32	1.13, 1.55
History of Osteoarthritis	<0.001	1.40	1.18, 1.67
„Does your work involve physically vigorous activity (like heavy lifting or digging) or moderately intensive activity (like brisk walking or carrying light loads during work for at least 10 minutes at a time?"	<0.001	1.40	1.21, 1.62
Alcohol consumption	<0.001	1.51	1.28, 1.78
Dry eye Feeling	<0.001	1.67	1.30, 2.16

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Fig. 1

Graph showing the distribution of the hearing loss score stratified by age and gender in the Ural Eye and Medical Study

Fig. 2

Graph showing the prevalence of self-reported hearing loss (defined by a definite answer of “Yes” (in contrast to the answer of “Sometimes” or “No”) to the question “Do you experience a hearing loss?”) stratified by age and gender in the Ural Eye and Medical Study

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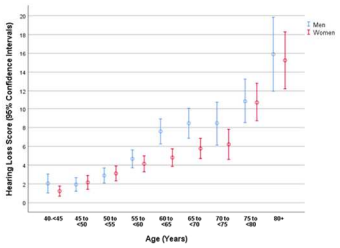

323x199mm (120 x 120 DPI)

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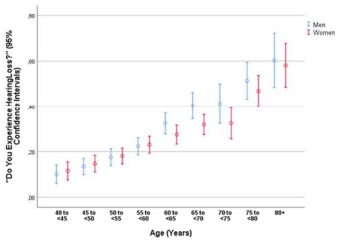

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Supplementary Table 1

Associations between the hearing loss score and other systemic parameters after adjusting for age in the Ural Eye and Medical Study

Parameter	*P*-Value	Standardized Regression Coefficient beta	Non-Standardized Regression Coefficient B	95% Confidence Interval of B
Gender: Women / Men	<0.001	0.05	1.03	0.47, 1.60
Urban / rural region of habitation	0.002	0.04	0.93	0.34, 1.52
Family status: Married versus any other status	0.64			
Family type: Joint (three generations) / nuclear (two generations) / single / family of 2 people	0.02	0.03	0.29	0.04, 0.53
Ethnicity: Russian / any other ethnicity	0.88	0.002	0.05	-0.63, 0.74
Body height (cm)	0.82	0.003	0.004	-0.03, 0.04
Body weight (kg)	0.03	-0.03	-0.02	-0.04, -0.002
Body mass index (kg/m^2)	0.01	-0.03	-0.07	-0.13, -0.02
Waist circumference (cm)	0.02	-0.03	-0.03	-0.05, -0.004
Hip circumference cm)	0.01	-0.03	-0.03	-0.05, -0.006
Waist-Hip-Ratio	0.61	-0.007	-0.81	-3.91, 2.29
Socioeconomic parameters				
Level of education	0.49	0.009	0.06	-0.11, 0.23
Monthly Income (Below poverty line / average / above average / high)	0.99	0.000	-0.01	-0.58, 0.58
Own ownership of house (yes / no)	0.90	-0.002	-0.09	-1.51, 1.33
Own ownership of refrigerator (yes / no)	0.19	-0.03	-2.98	-7.40, 1.44
Own ownership of second house (yes / no)	0.03	-0.04	-1.15	-2.18, -0.12
Own ownership of telephone (yes / no)	0.13	-0.02	-0.64	-1.48, 0.19
Own ownership of smartphone (yes / no)	0.87	-0.003	-0.07	-0.91, 0.77
Own ownership of television set (yes / no)	0.13	-0.02	-0.64	-1.48, 0.19
Own ownership of car (yes / no)	0.07	-0.03	-0.82	-1.72, 0.07
Own ownership of two-wheeler (yes / no)	0.87	-0.002	-0.05	-0.65, 0.56
Own ownership of tractor (yes / no)	0.73	0.007	0.34	-1.55, 2.23

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Own ownership of bullock cart (yes / no)	0.76	0.006	0.32	-1.71, 2.24
Own ownership of computer / laptop (yes / no)	0.13	-0.03	-0.71	-1.62, 0.21
Physical activity				
How long is your usual work day? (Minutes)	0.17	-0.02	-0.001	-0.002, 0.000
Does your work involve mostly sitting or standing with less than 10 minutes of walking at a time? (Yes / No)	0.76	0.004	0.11	-0.57, 0.78
Does your work involve physically vigorous activity (like heavy lifting or digging) or physically moderate intensity activity (like brisk walking or carrying light loads) (Yes / No)	<0.001	0.07	1.59	0.97, 2.20
How many days a week do you do such physically vigorous activity during work? (Yes / No)	0.001	0.06	0.47	0.21, 0.73
On a usual day how much time do you spend on such physically vigorous work during work? (Minutes)	<0.001	0.06	0.002	0.001, 0.004
Does your work involve physically moderate-intensive activity, like brisk walking or carrying light loads for at least 10 minutes at a time?	<0.001	0.06	1.32	0.66, 1.98
Do you walk or use a bicycle (pedal cycle) for at least 10 minutes continuously to get to and from places?	0.63	0.006	0.25	-0.77, 1.26
In your leisure time, do you do any moderate intensity activities like brisk walking, cycling or swimming for at least 10 minutes at a time?	<0.001	0.09	2.09	1.47, 2.72
Over the past 7 days, how much time did you spend sitting or reclining on a typical day?	0.40	0.01	0.000	0.000, 0.000
History of diseases				
History of angina pectoris	0.96	0.001	0.03	-0.97, 1-.02
History of asthma	0.03	0.03	1.95	0.20, 3.71
History of arterial hypertension	0.01	0.03	0.76	0.17, 1.36

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History of arthritis	<0.001	0.07	1.65	1.00, 2.29
History of previous bone fractures	0.18	0.02	0.42	-0.19, 1.03
History of low back pain	0.001	0.04	0.97	0.41, 1.53
History of thoracic spine pain	<0.001	0.07	1.72	1.06, 2.38
History of neck pain	<0.001	0.05	1.18	0.56, 1.80
History of headache	<0.001	0.07	1.54	0.98, 2.10
History of cancer	0.006	0.04	2.38	0.67, 4.08
History of cardiovascular disorders including stroke	<0.001	0.05	1.27	0.62, 1.92
History of dementia	0.004	0.04	5.05	1.63, 8.48
History of diabetes mellitus	0.52	-0.009	-0.34	-1.38, 0.69
History of diarrhea	0.86	0.002	0.37	-3.62, 4.36
History of iron-deficiency anemia	0.34	0.01	0.59	-0.63, 1.81
History of low blood pressure and hospital admittance	0.97	-0.001	-0.03	-1.67, 1.54
History of osteoarthritis	<0.001	0.07	1.89	1.16, 2.62
History of skin disease	0.07	0.02	1.16	-0.09, 2.41
History of thyreopathy	0.92	-0.001	-0.05	-1.00, 0.90
History of tumbling	0.11	0.02	0.58	--0.13, 1.29
History of unconsciousness	0.02	0.03	1.19	0.17, 2.22
Age of the last menstrual bleeding (years)	0.66	-0.009	-0.02	-0.11, 0.07
Age of last regular menstrual bleeding (years)	0.92	-0.002	-0.005	-0.09, 0.09
History of menopause	0.55	-0.01	-0.35	-1.51, 0.80
Blood concentrations (mmol/L) of:				
Alanine aminotransferase (IU/L)	0.41	0.01	0.01	-0.01, 0.03
Aspartate aminotransferase (IU/L)	0.50	0.009	0.009	-0.02, 0.03
Bilirubin, total (μmol/L)	0.65	0.006	0.006	-0.02, 0.03
High-density lipoproteins (mmol/L)	0.78	-0.004	-0.05	-0.36, 0.27
Low-density lipoproteins (mmol/L)	0.62	0.007	0.06	-0.18, 0.30
Cholesterol (mmol/L)	0.79	-0.03	-0.02	-0.19, 0.14
Triglycerides (mmol/L)	0.28	-0.01	-0.21	-0.59, 0.17
Rheumatoid factor (IU/mL)	0.14	-0.02	-0.25	-0.58, 0.09
Erythrocyte sedimentation rate (mm / hour)	0.95	-0.001	-0.001	-0.03, 0.03
Glucose (mmol/L)	0.48	-0.009	-0.06	-0.23, 0.11
Prevalence of diabetes mellitus	0.12	-0.02	-0.71	-1.62, 0.20
Creatinine (μmol/L)	0.45	0.01	0.004	-0.007, 0.02
Urea (mmol/L)	0.22	-0.02	-0.12	-0.32, 0.07

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Residual nitrogen (g/L)	0.74	-0.004	-0.66	-4.53, 3.21
Total protein (g/L)	0.75	0.004	0.007	-0.04, 0.05
International normalized ratio (INR)	0.13	-0.02	-1.50	-3.41, 0.42
Prothrombin time (%)	0.98	0.000	0.007	-0.53, 0.54
Hemoglobin	0.45	-0.01	0.007	-0.03, 0.01
Erythrocytes (10^6 cells / μL)	0.93	0.001	0.04	-0.71, 0.78
Leukocytes (10^9 cells / L)	0.55	-0.008	-0.06	-0.26, 0.14
Rod-core granulocyte (% of leukocytes)	0.77	0.004	0.03	-0.18, 0.24
Segment nuclear granulocyte (% of leukocytes)	0.45	-0.01	-0.02	-0.05, 0.02
Eosinophil granulocytes (% of leukocytes)	0.42	-0.01	-0.12	-0.40, 0.17
Lymphocytes (% of leukocytes)	0.11	0.02	0.04	-0.008, 0.08
Monocytes (% of leukocytes)	0.49	-0.009	-0.04	-0.17, 0.08
Blood pressure, systolic (mmHg)	0.74	0.005	0.002	-0.01, 0.02
Blood pressure, diastolic (mmHg)	0.77	0.004	0.004	-0.02, 0.03
Blood pressure, mean (mmHg)	0.45	.0.01	-0.01	-0.05, 0.02
Prevalence of arterial hypertension	0.03	0.03	0.64	0.05, 1.22
Prevalence of chronic obstructive pulmonary disease	0.67	0.006	0.24	-0.87, 1.35
Diet				
Vegetarian diet / mixed diet	0.57	0.007	2.43	-6.01, 10.9
Number of meals per day	0.22	0.02	0.23	-0.13, 0.58
In a week how many days do you eat fruits?	0.001	-0.05	-0.25	-0.40, -0.11
In a week how many days do you eat vegetables?	<0.001	0.05	0.005	0.002, 0.008
Type of oil used for cooking: vegetable oil / non-vegetable oil	0.058	-0.03	-0.20	-0.40, 0.006
Salt consumed per day (g)	0.10	0.02	0.002	0.000, 0.005
Degree of processing of meat (weak / medium / well done)	0.24	-0.02	-0.64	-1.71, 0.43
Smoking				
Do you currently smoke any tobacco products? (yes)	0.17	0.02	0.59	-0.26, 1.44
Do you smoke daily? (yes / no)	0.39	0.01	0.38	-0.48, 1.24
Package years (package = 20 cigarettes)	0.25	0.02	0.01	-0.009, 0.04
Alcohol Consumption				

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Alcohol consumed such as beer, whisky, rum, gin brandy or other local products? (yes / no)	0.05	0.03	0.67	-0.008, 1.35
How many alcoholic drinks do you have on a typical day when you are drinking)	0.16	0.04	0.003	-0.001, 0.007
How often do you have 6 or more drinks on one occasion? (never / rarely / sometimes / often / cannot say)	0.36	0.03	0.38	-0.43, 1.19
Depression				
Depression score	<0.001	0.08	0.25	0.17, 0.32
State-Trait Anxiety Inventory (STAI)				
Anxiety score	<0.001	0.08	0.25	0.17, 0.33
Dynamometry				
Manual dynamometry, right hand (dekaNewton)	0.40	0.01	0.01	-0.02, 0.04
Manual dynamometry, left hand (dekaNewton)	0.08	0.03	0.02	-0.003, 0.05

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Self-Reported Hearing Loss in Russians. The population-based Ural Eye and Medical Study

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Abstract

Objectives: With information about frequency of hearing loss in Russia and Eastern Europe mostly missing, we assessed the prevalence of hearing loss in a Russian population.

Setting: The population-based study Ural Eye and Medical Study was conducted in a rural and urban region of Bashkortostan/Russia.

Participants: With an inclusion criterion of 40+ years, the study included 5899 (80.5%) out of 7328 eligible individuals (mean age:59.0±10.7 years; range:40-94 years).

Primary and secondary outcome measures: Hearing loss examined in 5397 (91.5%) study participants, as it was assessed in a standardized interview with questions of the "Hearing Handicap Inventory for the Elderly Screening Version (HHIE-S)".

Results: The prevalence of self-reported hearing loss (26.1%;95% confidence interval [CI):24.2,27.2] increased from 10.9% [95%CI:8.0,13.7] in the 40-45 year-olds to 59.0% [51.6,66.4] in the 80+ year-olds. It was higher for men than for women in the age group of 60-80 years (38.93% [35.8,42.1] vs. 32.8% [30.2,35.3];*P*=0.003). In multivariable analysis, higher prevalence of hearing loss was associated with older age (*P*<0.001;odds ratio (OR) (per year of age):1.06 [1.06,1.07]), male gender (*P*<0.001;OR:1.26 [1.09,1.47]), higher depression score (*P*<0.001;OR:1.06 [1.04,1.08]), and higher prevalence of headache (*P*=0.001;OR:1.27 [1.10,1.47]), history of cardiovascular disease including stroke (*P*=0.001;OR:1.32 [1.13,1.55]), osteoarthritis (*P*<0.001;OR:1.40 [1.18,1.67]), physically vigorous activity during work (*P*<0.001;OR:1.40 [1.21,1.62]), alcohol consumption (*P*<0.001;OR:1.51 [1.28,1.78]) and dry eye feeling (*P*<0.001;OR:1.67 [1.30,2.16]). It was marginally correlated with a higher anxiety score (*P*=0.07;OR:1.03 [0.998,1.06]). It was independent of diabetes (*P*=0.52), arterial hypertension (*P*=0.20), level of education (*P*=0.11), region of habitation (*P*=0.70), blood concentration of high-density lipoproteins (*P*=0.17) and low-density lipoproteins (*P*=0.52), current smoking (*P*=0.95) and smoking package years (*P*=0.37), and best corrected visual acuity (*P*=0.93).

Conclusions: As in other countries the prevalence of hearing loss is high in this elderly population in Russia. It is primarily or secondarily associated with older age, depression, male gender, cardiovascular disease and alcohol consumption.

Article Summary

Strengths and limitations of this study:

- The assessment of hearing loss in an interview containing a series of 11 standardized questions without performing an audiometric examination was a limitation of the study.
- Although noise is a major determinant of hearing loss along with aging, the exposure to noise at the working place was not directly and specifically assessed in the study.
- Performing the study in Russia from where no population-based information on hearing loss has been available so far was a strength of the investigation.
- The study sample size of 5899 participants and the participation rate of 80.5% were strengths of the study.

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- The relatively high number of parameters examined in addition to hearing loss and enabling a wide search for associations between hearing loss and other parameters was strength of the investigation.

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Introduction

Deficits in the function of sensory organs are major reasons for so called disability associated life years (DALYs).[1] In the Global Burden of Disease Study (GBD) 2016, sense organ diseases caused 66.7 million DALYS (95% uncertainty interval (UI): 46.5 million to 92.3 million) or 2.8% of all DALYs in 2016, up from 39.4 million DALYS (95%UI: 27.3 million to 54.5 million) in 1995 and 54.8 million DALYs (95%CI: 38.2 million to 76.0 million) in 2006.[1] Sense organ diseases-associated DALYs increased in the ranking of the most common causes of DALYs from position #16 in 1995 to rank #14 in 2006 and to rank #7 in 2016.[1] Age-related and other hearing loss accounted for 29.7 million DALYS (95%UI: 25.3 million to 50.9 million) or 44.5% of all sense organs-associated DALYs in 2016.[1]

Despite its importance for public health, the prevalence of hearing loss and its associated factors have not widely been investigated worldwide.[2-11] For many countries, information on the prevalence of hearing loss has not been available yet, and the factors associated with hearing loss have not been examined in a detailed manner. It holds true in particular for Russia and Eastern Europe. We therefore conducted this study to assess the prevalence of hearing loss in a Russian population and to explore associations of hearing loss with other parameters such as gender, region of habitation and level of education.

Methods

The Ural Eye and Medical Study (UEMS) is a population-based investigation. It was performed in the Russian Republic of Bashkortostan, in its capital Ufa (region Kirovskii) and in a rural region consisting of villages in the Karmaskalinsky District. The latter was located in a distance of 65 km from Ufa.[12-14] The Ethics Committee of the Academic Council of the Ufa Eye Research Institute approved the study and informed written consent was obtained from all participants. Inclusion criteria were living in the study regions and an age of 40+ years. Assuming a participation rate of approximately 80% and aiming at a study population size of about 5500 to 6000 participants, the number of eligible individuals was calculated to be approximately 7000 to 7500 individuals. The number of 5500 to 6000 study participants was based on the experience gained in previous population-based investigations the study populations of which were assumed to have a similar prevalence of major diseases as the present study population.

The first part of the series of examinations was a standardized interview. It was conducted by trained social workers and it consisted of more than 250 standardized questions on parameters of various fields, such as socioeconomics, diet, alcohol and tobacco consumption, physical exercise and medical history.[12,13,15] The Guidelines for Accurate and Transparent Health Estimates Reporting (GATHER statement guidelines) were applied in reporting the data.[16]

As described in detail recently, the series of examination further consisted of measurements of arterial blood pressure, pulse rate and body height and weight, handgrip strength (as measured by dynamometry), blood concentrations of glucose, blood lipids and other substances, and pulmonary function (spirometry).[12,13] Arterial hypertension was defined by a systolic blood pressure ≥140 mmHg and/or diastolic blood pressure ≥90 mmHg, and/or self-reported history or current treatment of arterial hypertension with antihypertensive medication. Diabetes mellitus was defined by a blood glucose

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concentration ≥7.0 mmol/L or a self-reported history of physician diagnosis or of therapy of diabetes mellitus.

Hearing loss was assessed by a series of 11 standardized questions ten of which were derived from the "Hearing Handicap Inventory for the Elderly Screening Version (HHIE-S)" (Table 1).[17-19] The questions could be answered by "no" (0 points), "sometimes" (2 points) and "yes (4 points). The total hearing loss score was the sum of all points and could range between 0 points and 44 points. The amount of hearing loss was assessed by the hearing loss score. The HHIE-S had been applied in previous investigations.[17-19] The diagnostic performance of the HHIE-S against five definitions of hearing loss as assessed by pure-tone audiometry had assessed in a previous investigation on 178 elderly subjects.[20] The HHIE-S had sensitivities ranging from 53 to 72% and specificities ranging from 70 to 84% with the different definitions. The receiver-operating characteristics and the likelihood ratios of the HHIE-S were similar regardless of the hearing loss definitions. Another investigation had examined the reliability, validity, and associations of the HHIE-S with quality of life measures such as the subjective well-being, depressive symptoms, subjective loneliness, and physical functioning.[21] It revealed that the reliability of the HHIE-S was relatively high with a Cronbach's alpha coefficient of 0.91, a Spearman-Brown coefficient of 0.90 and an intra-class correlation coefficient of 0.85. The prevalence of self-reported hearing loss as a binary variable was assessed by the single question "Do you experience a hearing loss?". We additionally carried out Weber´s test and Rinne´s test.

Applying a statistical software program (Statistical Package for Social Science, SPSS, version 25.0; IBM-SPSS Inc., Chicago, USA), we first calculated the prevalence of hearing loss, and then assessed its associations with other parameters in a univariate analysis. Finally, we performed a multivariable regression analysis with the hearing loss score as dependent variable. The list of independent variables included all those variables which were associated ($P \leq 0.10$) with the hearing loss score in the univariate analysis. Multicollinearity was also tested. The prevalence of hearing loss as analyzed in a binary regression analysis. We assessed the odds ratios (OR) and their 95% confidence intervals (CI). The level of statistical significance for the *P*-values was set as <0.05.

Patient and Public Involvement

Patients were not involved in the study.

Results

Out of a total population of 7328 eligible individuals, 5899 (80.5%) individuals participated in the Ural Eye and Medical Study. Out of these, information on the hearing loss score was available for 5397 (91.5%) individuals (2450 (45.4%) men). Their mean age was 58.6 ± 10.6 years (range: 40-94 years). The study population did not differ markedly in its age and sex composition from the Russian population as published in the census of 2010.[22]

The subjects with information on hearing loss as compared with the individuals without hearing loss data had a significantly lower age ($P<0.001$) and were significantly more often men ($P<0.001$). The mean hearing loss score was 5.13 ± 10.95 (median: 0; range: 0 – 44). Within the group of ethnically Russians (n=1185; age: 60.1±11.1 years), the mean hearing loss score was 5.58 ± 11.09

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(median: 0; range: 0 – 44), with no significant (*P*=0.11) difference to the non-Russian group. An abnormal result of Weber´s test was found for 210 (3.9%; 95%CI: 3.4, 4.4) study participants and an abnormal result for Rinné test for 3390 (63.0%; 95%CI: 61.7, 64.3) individuals. The hearing loss score differed significantly between individuals with a positive Weber´s test and individuals with a negative Weber´s test (23.9 ± 14.7 vs. 4.4 ± 10.1; *P*<0.001).

In univariate analysis, a higher hearing loss score was correlated with parameters such as older age (*P*<0.001) (Table 2) (Fig. 1), male gender (*P*<0.001) (Fig. 1) and other variables (Supplementary Table 1). The multivariable regression analysis included the hearing loss score as dependent variable and as independent variables all those parameters which were associated (*P*≤0.10) with the hearing loss score in the univariate analysis. Due to collinearity, we first dropped the parameters of body weight (variance inflation factor (VIF): 6.8) and waist circumference (VIF: 4.0). We then dropped step by step those parameters, such as the prevalence of arterial hypertension, which were no longer statistically significantly associated with hearing loss in the multivariate analysis. In the resulting final model, a higher hearing loss score was associated (regression coefficient r: 0.33) with older age (*P*<0.001), male gender (*P*<0.001), a higher depression score (*P*<0.001), a higher prevalence of headache (*P*<0.001) and a higher prevalence of history of cancer (*P*=0.008), cardiovascular disease including stroke (*P*=0.003), osteoarthritis (*P*=0.006) and skin disease (*P*=0.01), a lower number of days with intake of fruits (*P*=0.02), and a higher amount of physically vigorous activity during work (*P*=0.008) and of physically moderate activity during leisure time (*P*<0.001) (Table 3).

Hearing loss defined as a binary variable (question “Do you experience a hearing loss?”) was prevalent in 1406 (26.1%; 95%CI: 24.2, 27.2) participants. It was significantly associated with a positive Weber´s test (OR: 24.0; 95%CI: 15.7, 36.7). The prevalence of hearing loss increased with older age (*P*<0.001; OR: 1.06; 95%CI: 1.05, 1.07) (Table 4). In the age group between 60 and <80 years, the prevalence of hearing loss was significantly (*P*=0.003) higher for men than for women (38.93% (95%CI: 35.8, 42.1) vs. 32.8% (95%CI: 30.2, 35.3). For the age group of less than 60 years (*P*=0.57) and for the age group of 80+ years (*P*=0.87), both genders did not differ significantly in the prevalence of hearing loss (Fig. 2). In the total study population, the prevalence of hearing loss increased from 10.9% (95%CI: 8.0, 13.7) in the age group of 40 to <45 years, to 22.7% (95%CI: 20.0, 25.4) in the age group of 55 to <60 years, and to 59.0% (95%CI: 51.6, 66.4) in the age group of 80+ years (Fig. 2).

In a multivariable binary regression analysis, higher prevalence of hearing loss was associated with older age (*P*<0.001), male gender (*P*<0.001), a higher depression score (*P*<0.001), a higher prevalence of headache (*P*=0.001) and a higher prevalence of history of cancer (*P*=0.04), cardiovascular disease including stroke (*P*=0.001) and osteoarthritis (*P*<0.001), a higher amount of physically vigorous activity during work (*P*<0.001), higher prevalence of alcohol consumption (*P*<0.001) and of dry eye feeling (*P*<0.001) (Table 5). Prevalence of hearing loss was marginally correlated with a higher anxiety score, when added to the model (*P*=0.07; OR: 1.03; 95%CI: 0.998, 1.06). If diabetes (*P*=0.52), arterial hypertension (*P*=0.20), level of education (*P*=0.11; OR: 0.97; 95%CI: 0.93, 1.01), urban versus rural region of habitation (*P*=0.70), blood concentration of high-density lipoproteins (*P*=0.17) and low-density lipoproteins (*P*=0.52), current smoking (*P*=0.95) and

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smoking package years (*P*=0.37), and best corrected visual acuity (*P*=0.93) and presenting visual acuity (*P*=0.62) and anxiety score (*P*=0.07; OR: 1.03; 95%CI: 0.998, 1.06) were added to the model, these variables were not significantly associated with hearing loss.

Discussion

In this Russian population, the prevalence of hearing loss increased from 10.9% in the 40 to 45 year-olds to 59.0% in the 80+ years-olds. It was associated with older age, male gender, a higher depression score and a higher prevalence of headache, history of cardiovascular disease including stroke, osteoarthritis, physically vigorous activity during work, alcohol consumption and dry eye feeling. It was marginally significantly correlated with a higher anxiety score (*P*=0.07).

The findings obtained in our study on a population in Russia can be compared with observations made in previous investigations conducted in other world regions. The high overall prevalence of hearing loss of 26.1% (95%CI: 24.2, 27.2) in our study population aged 40+ years agreed well with the data of the World Health Organization WHO that over 5% of the total world's population – or 466 million people – has disabling hearing loss (432 million adults and 34 million children).[23] The prevalence of hearing loss as found in our study population also well with figures found by Ikeda and colleagues for the United States, and with other data reported for the United States by the Health, Aging and Body Composition Study after adjusting for age differences in the study populations.[24,25] The prevalence of hearing loss in our study population was lower than the figures found by Hannula and associates for Northern Finland (prevalence of self-reported hearing problems of 37.1% and of 43.3% for difficulties in following a conversation in noise),[26] and it was lower than the prevalence of unilateral and bilateral speech-frequency hearing impairment in the National Health and Nutrition Examination Survey for the United States.[27-29]

In all the previous studies as in our investigation, the prevalence of hearing loss strongly increased with older age for both genders (Fig. 1, 2).[27,30-46] In our study population, the age-related increase in the prevalence of hearing loss was less marked for women than for men in the age group of 60 to <80 years (Fig. 1, 2). As in the previous studies on other ethnicities, the frequency of hearing loss was higher for men than for women.[27,29-46] In our study, the gender difference hold true for the age group of 60 to <80 years (38.93%;95%CI:35.8,42.1 vs. 32.8%;95%CI:30.2,35.3;*P*=0.003). In the age group between 60 and <80 years, the prevalence of hearing loss was significantly (*P*=0.003) higher for men than for women (38.93% (95%CI: 35.8, 42.1) vs. 32.8% (95%CI: 30.2, 35.3). For the age group of less than 60 years (*P*=0.57) and for the age group of 80+ years (*P*=0.87), both genders did not differ significantly in the prevalence of hearing loss.

In our study, a higher prevalence of hearing loss was associated with a higher prevalence of vigorous physical activity during work. It was in contrast to the finding reported by Gispen and coworkers who used data of the National Health and Nutritional Examination Survey (2005-06) and who found that individuals with moderate or greater hearing impairment had greater odds than those with normal hearing of being in a lower category of physical activity.[39] The association between vigorous physical activity at work and higher prevalence of hearing loss in our study might have been due to a potentially confounding correlation between heavy work and higher noise level at work.

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In the National Health and Nutrition Examination Survey and in a study by Sommer et al. hearing impairment was more prevalent among adults with diabetes in a multivariable analysis.[9] It is in contrast to our study in which neither diabetes nor blood concentrations of glucose were significantly correlated with hearing loss (Supplementary Table 1). As a corollary, the hearing loss in our study was not significantly correlated with the body mass index (Supplementary Table 1). It is in partial contrast to the results of the study by Lalwani and colleagues who found that in children of 12 to 19 years of age, obese adolescents as compared adolescents with normal body weight had elevated pure tone hearing thresholds and greater prevalence of unilateral low-frequency sensorineural hearing loss (P=0.01).[37]

A higher prevalence of self-reported hearing impairment was associated with a higher depression score in our study as well as in the study by Li and colleagues who used data of the National Health and Nutrition Examination Survey (NHANES), 2005-2010. They found that that self-reported hearing impairment and audiometrically determined hearing loss were significantly associated with depression, particularly in women.[38]

The association between hearing loss and cardiovascular risk factors has remained unclear so far. While in our study population and in a study by Lohi et al. cardiovascular risk factors were not significantly associated with hearing loss, the National Health and Nutrition Examination Survey and the Health, Aging and Body Composition Study reported that cardiovascular risk generated by smoking and diabetes was associated with both high- and low-frequency hearing loss.[26,29,30,35,41] Reasons for the discrepancy between the studies may have been differences in the study population (lifestyle in Russia versus lifestyle in the US or in Korea), differences in the multivariable analysis and others.

Limitations of our study should be discussed. First, the main outcome parameter was self-reported hearing loss assessed in a series of 11 standardized questions. In previous studies, audiometry was applied to quantify the hearing impairment. Although the latter method is a more quantitative one, the degree of self-reported hearing impairment as compared to audiometrically defined hearing loss may be more important to reflect the quality of the daily life of the individual. Interestingly, a study by Hannula et al. showed that self-reported hearing difficulties were more frequent than hearing impairment defined by audiometric measurement.[26] Hannula also reported that self-reported hearing difficulties predicted hearing impairment at high frequencies (4-8 kHz) rather than at frequencies of 0.5-4 kHz, which were commonly used to define the degree of hearing impairment in medical and legal issues. The test-retest reliability of the Hearing Handicap Inventory for Adults was evaluated in a study showing a correlation coefficient of r^2=0.94.[47] In another investigation, the HHIE-S showed a significant reduction in perceived emotional and social/situational effects of hearing impairment following the use of hearing aids.[48] Second, although noise is a major determinant of hearing loss along with aging, the exposure to noise at the working place was not specifically assessed in the study. This lack of data on noise exposure was therefore one of the limitations of the study. The amount of physical activity at the working place however was evaluated and in the multivariable model, a higher hearing loss score was associated with a higher amount of physically vigorous activity during work (P=0.008) (Table 3). Although the amount of physical activity at the working place is not a direct measure for the noise exposure, both parameters are correlated

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with each other so that a higher amount of physically vigorous activity during work may be a surrogate for an increased noise exposure.

In conclusion, in our typically ethically mixed, urban and rural, Russian population aged 40+ years, the mean prevalence of hearing loss was 26.1% and increased from 10.9% in the 40 to 45 year-olds to 59.0% in the 80+ years-olds. In addition to older age, the prevalence of hearing loss was associated with male gender, depression and a higher prevalence of headache, history of cardiovascular disease including stroke, physically vigorous activity during work, alcohol consumption and dry eye feeling, and marginally significantly correlated with a higher anxiety score. These data may be useful to assess the epidemiology of hearing loss in Russia and to assess factors associated with hearing impairment in Russia.

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Tables

Table 1

Standardized questions to assess the presence and sequels of hearing problems

1. Do you experience a hearing loss?
2. Does a hearing problem make you feel embarrassed when meeting new people?
3. Does a hearing problem make you feel frustrated when talking to members of your family?
4. Do you have difficulties hearing when someone speaks in a whisper?
5. Do you feel handicapped by a hearing problem?
6. Does a hearing problem cause you difficulties when visiting friends, relatives, or neighbors?
7. Does a hearing problem make you attending religious services less often than you would like?
8. Does a hearing problem make you having arguments with family members?
9. Does a hearing problem cause you difficulties when listening to TV or radio?
10. Do you feel that any difficulty with your hearing limits or does it hamper your personal or social life?
11. Does a hearing problem cause you difficulty when you are in a restaurant together with relatives or friends?

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Table 2

Mean hearing loss score in the Ural Eye and Medical Study, stratified by sex and age

Age Group (Years)	n	Hearing Loss Score	95% Confidence Intervals
Men			
40-44	209	2.1 ± 7.4	1.0, 3.1
45-49	350	1.9 ± 6.9	1.2, 2.7
50-54	422	2.9 ± 8.4	2.1, 3.7
55-59	471	4.7 ± 10.6	3.7, 5.6
60-64	383	7.6 ± 13.2	6.3, 8.9
65-69	273	8.5 ± 13.4	6.9, 10.1
70-74	124	8.5 ± 13.1	6.1, 10.8
75-79	150	10.9 ± 14.7	8.5, 13.3
80+	68	15.9 ± 16.2	12.0, 19.8
Women			
40-44	252	1.2 ± 4.4	0.7, 1.8
45-49	361	2.2 ± 7.1	1.4, 2.9
50-54	465	3.1 ± 8.7	2.3, 3.9
55-59	500	4.1 ± 9.6	3.3, 5.0
60-64	449	4.8 ± 10.0	3.9, 5.7
65-69	430	5.8 ± 11.3	4.7, 6.8
70-74	182	6.2 ± 10.9	4.6, 7.8
75-79	203	10.8 ± 14.8	8.7, 12.8
80+	105	15.3 ± 15.6	12.2, 18.3

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441 Table 3

442 Associations (multivariate analysis) between the hearing loss score and other systemic parameters in

443 the Ural Eye and Medical Study

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Parameters	*P*-Value	Standardized Regression Coefficient beta	Non-Standardized Regression Coefficient B	95% Confidence Interval	Variance Inflation Factor
Age (Years)	<0.001	0.23	0.27	0.23, 0.31	1.14
Sex (Women / Men)	<0.001	0.07	1.69	0.89, 2.50	1.13
Depression Score	<0.001	0.07	0.22	0.11, 0.33	1.11
History of Headache	<0.001	0.07	1.50	0.71, 2.29	1.09
History of Cancer	0.008	0.05	3.53	0.91, 6.16	1.01
History of Cardiovascular Disease Including Stroke	0.003	0.05	1.45	0.51, 2.39	1.11
History of Osteoarthritis	0.006	0.05	1.43	0.42, 2.44	1.06
History of Skin Disease	0.01	0.04	2.18	0.48, 3.89	1.01
In a week how many days do you eat fruits?	0.02	-0.04	-0.24	-0.44, -0.04	1.03
„Does your work involve physically vigorous activity (like heavy lifting or digging) or moderately intensive activity (like brisk walking or carrying light loads during work for at least 10 minutes at a time?“	0.042	0.04	1.13	0.04, 2.22	1.04
„How many days a week do you do such physically vigorous activity during work?“	0.008	0.05	0.36	0.10, 0.63	1.10
„In your leisure time, do you do any moderate intensity activities like brisk walking, cycling or swimming for at least 10 minutes at a time?“	<0.001	0.09	1.96	1.19, 2.74	1.03

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Table 4

Prevalence of self-reported hearing loss (definite answer of “Yes” (in contrast to the answer of “Sometimes” or “No”) to the question “Do you experience a hearing loss?”) stratified by age and gender in the Ural Eye and Medical Study

Age Group (Years)	n	Prevalence of Self-Reported Hearing Loss	95% Confidence Intervals
Men			
40-44	209	10.1	5.9, 14.2
45-49	350	13.4	9.8, 17.0
50-54	422	17.5	13.9, 21.2
55-59	471	22.3	18.5, 26.1
60-64	383	32.3	27.7, 37.1
65-69	273	40.3	34.4, 46.2
70-74	124	41.1	32.3, 49.9
75-79	150	51.3	43.2, 59.4
80+	68	60.3	48.4, 72.2
Women			
40-44	252	11.5	7.5, 15.5
45-49	361	14.7	11.0, 18.4
50-54	465	18.1	14.6, 21.6
55-59	500	23.0	19.3, 26.7
60-64	449	27.4	23.3, 31.5
65-69	430	31.9	27.4, 36.3
70-74	182	32.4	25.6, 39.3
75-79	203	46.8	39.9, 53.7
80+	105	58.1	48.5, 67.7

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Table 5

Associations (multivariate analysis) between the prevalence of hearing loss (definite answer of “Yes” (in contrast to the answer of “Sometimes” or “No”) to the question “Do you experience a hearing loss?”) and other systemic parameters in the Ural Eye and Medical Study

Parameters	*P*-Value	Odds Ratio	95% Confidence Interval
Age (Years)	<0.001	1.06	1.06, 1.07
Sex (Men / Women)	<0.001	1.26	1.09, 1.47
Depression Score	<0.001	1.06	1.04, 1.08
History of Headache	0.001	1.27	1.10, 1.47
History of Cancer	0.04	1.51	1.02, 2.24
History of Cardiovascular Disease Including Stroke	0.001	1.32	1.13, 1.55
History of Osteoarthritis	<0.001	1.40	1.18, 1.67
„Does your work involve physically vigorous activity (like heavy lifting or digging) or moderately intensive activity (like brisk walking or carrying light loads during work for at least 10 minutes at a time?“	<0.001	1.40	1.21, 1.62
Alcohol consumption	<0.001	1.51	1.28, 1.78
Dry eye Feeling	<0.001	1.67	1.30, 2.16

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Fig. 1

Graph showing the distribution of the hearing loss score stratified by age and gender in the Ural Eye and Medical Study

Fig. 2

Graph showing the prevalence of self-reported hearing loss (defined by a definite answer of “Yes” (in contrast to the answer of “Sometimes” or “No”) to the question “Do you experience a hearing loss?”) stratified by age and gender in the Ural Eye and Medical Study

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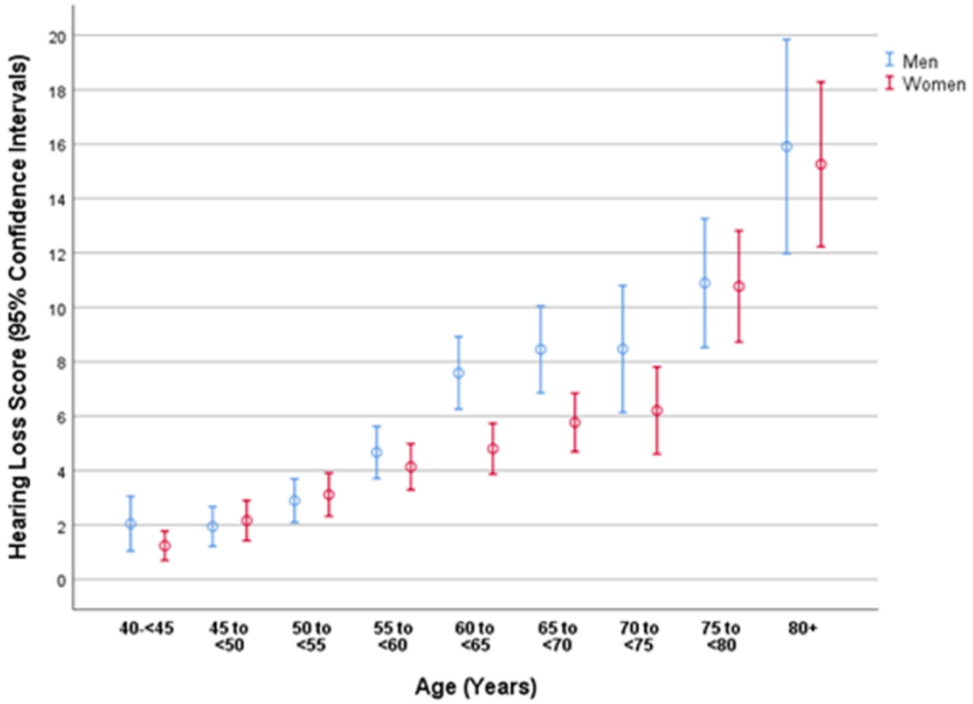

Fig. 1
Graph showing the distribution of the hearing loss score stratified by age and gender in the Ural Eye and Medical Study

128x92mm (300 x 300 DPI)

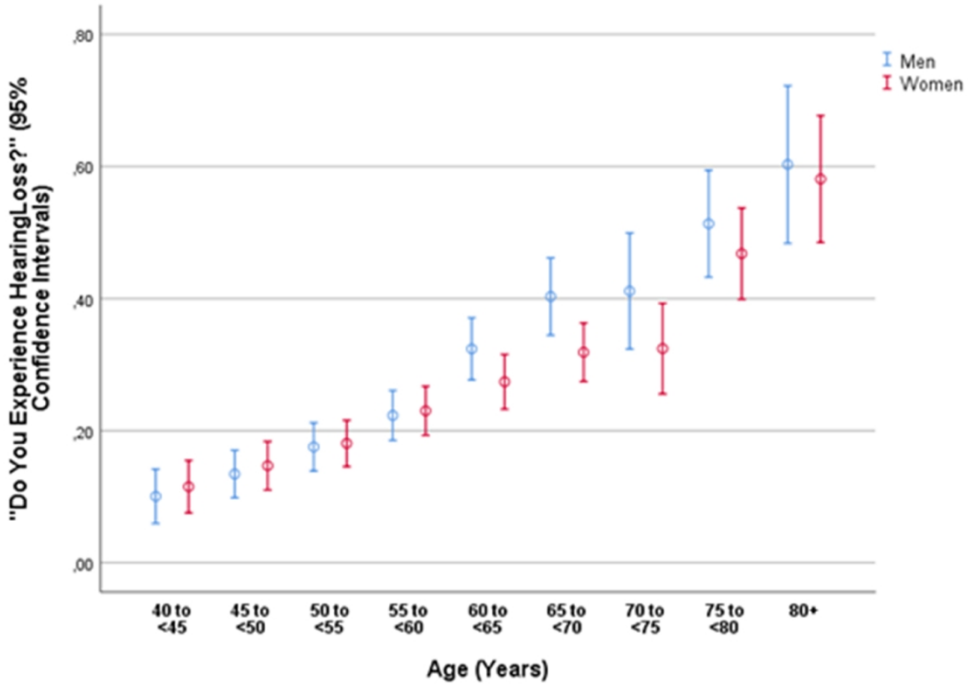

Fig. 2
Graph showing the prevalence of self-reported hearing loss (defined by a definite answer of "Yes" (in contrast to the answer of "Sometimes" or "No") to the question "Do you experience a hearing loss?") stratified by age and gender in the Ural Eye and Medical Study

125x87mm (300 x 300 DPI)

Supplementary Table 1

Associations between the hearing loss score and other systemic parameters after adjusting for age in the Ural Eye and Medical Study

Parameter	*P*-Value	Standardized Regression Coefficient beta	Non-Standardized Regression Coefficient B	95% Confidence Interval of B
Gender: Women / Men	<0.001	0.05	1.03	0.47, 1.60
Urban / rural region of habitation	0.002	0.04	0.93	0.34, 1.52
Family status: Married versus any other status	0.64			
Family type: Joint (three generations) / nuclear (two generations) / single / family of 2 people	0.02	0.03	0.29	0.04, 0.53
Ethnicity: Russian / any other ethnicity	0.88	0.002	0.05	-0.63, 0.74
Body height (cm)	0.82	0.003	0.004	-0.03, 0.04
Body weight (kg)	0.03	-0.03	-0.02	-0.04, -0.002
Body mass index (kg/m^2)	0.01	-0.03	-0.07	-0.13, -0.02
Waist circumference (cm)	0.02	-0.03	-0.03	-0.05, -0.004
Hip circumference cm)	0.01	-0.03	-0.03	-0.05, -0.006
Waist-Hip-Ratio	0.61	-0.007	-0.81	-3.91, 2.29
Socioeconomic parameters				
Level of education	0.49	0.009	0.06	-0.11, 0.23
Monthly Income (Below poverty line / average / above average / high)	0.99	0.000	-0.01	-0.58, 0.58
Own ownership of house (yes / no)	0.90	-0.002	-0.09	-1.51, 1.33
Own ownership of refrigerator (yes / no)	0.19	-0.03	-2.98	-7.40, 1.44
Own ownership of second house (yes / no)	0.03	-0.04	-1.15	-2.18, -0.12
Own ownership of telephone (yes / no)	0.13	-0.02	-0.64	-1.48, 0.19
Own ownership of smartphone (yes / no)	0.87	-0.003	-0.07	-0.91, 0.77
Own ownership of television set (yes / no)	0.13	-0.02	-0.64	-1.48, 0.19
Own ownership of car (yes / no)	0.07	-0.03	-0.82	-1.72, 0.07
Own ownership of two-wheeler (yes / no)	0.87	-0.002	-0.05	-0.65, 0.56
Own ownership of tractor (yes / no)	0.73	0.007	0.34	-1.55, 2.23

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Own ownership of bullock cart (yes / no)	0.76	0.006	0.32	-1.71, 2.24
Own ownership of computer / laptop (yes / no)	0.13	-0.03	-0.71	-1.62, 0.21
Physical activity				
How long is your usual work day? (Minutes)	0.17	-0.02	-0.001	-0.002, 0.000
Does your work involve mostly sitting or standing with less than 10 minutes of walking at a time? (Yes / No)	0.76	0.004	0.11	-0.57, 0.78
Does your work involve physically vigorous activity (like heavy lifting or digging) or physically moderate intensity activity (like brisk walking or carrying light loads) (Yes / No)	<0.001	0.07	1.59	0.97, 2.20
How many days a week do you do such physically vigorous activity during work? (Yes / No)	0.001	0.06	0.47	0.21, 0.73
On a usual day how much time do you spend on such physically vigorous work during work? (Minutes)	<0.001	0.06	0.002	0.001, 0.004
Does your work involve physically moderate-intensive activity, like brisk walking or carrying light loads for at least 10 minutes at a time?	<0.001	0.06	1.32	0.66, 1.98
Do you walk or use a bicycle (pedal cycle) for at least 10 minutes continuously to get to and from places?	0.63	0.006	0.25	-0.77, 1.26
In your leisure time, do you do any moderate intensity activities like brisk walking, cycling or swimming for at least 10 minutes at a time?	<0.001	0.09	2.09	1.47, 2.72
Over the past 7 days, how much time did you spend sitting or reclining on a typical day?	0.40	0.01	0.000	0.000, 0.000
History of diseases				
History of angina pectoris	0.96	0.001	0.03	-0.97, 1-.02
History of asthma	0.03	0.03	1.95	0.20, 3.71
History of arterial hypertension	0.01	0.03	0.76	0.17, 1.36

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History of arthritis	<0.001	0.07	1.65	1.00, 2.29
History of previous bone fractures	0.18	0.02	0.42	-0.19, 1.03
History of low back pain	0.001	0.04	0.97	0.41, 1.53
History of thoracic spine pain	<0.001	0.07	1.72	1.06, 2.38
History of neck pain	<0.001	0.05	1.18	0.56, 1.80
History of headache	<0.001	0.07	1.54	0.98, 2.10
History of cancer	0.006	0.04	2.38	0.67, 4.08
History of cardiovascular disorders including stroke	<0.001	0.05	1.27	0.62, 1.92
History of dementia	0.004	0.04	5.05	1.63, 8.48
History of diabetes mellitus	0.52	-0.009	-0.34	-1.38, 0.69
History of diarrhea	0.86	0.002	0.37	-3.62, 4.36
History of iron-deficiency anemia	0.34	0.01	0.59	-0.63, 1.81
History of low blood pressure and hospital admittance	0.97	-0.001	-0.03	-1.67, 1.54
History of osteoarthritis	<0.001	0.07	1.89	1.16, 2.62
History of skin disease	0.07	0.02	1.16	-0.09, 2.41
History of thyreopathy	0.92	-0.001	-0.05	-1.00, 0.90
History of tumbling	0.11	0.02	0.58	--0.13, 1.29
History of unconsciousness	0.02	0.03	1.19	0.17, 2.22
Age of the last menstrual bleeding (years)	0.66	-0.009	-0.02	-0.11, 0.07
Age of last regular menstrual bleeding (years)	0.92	-0.002	-0.005	-0.09, 0.09
History of menopause	0.55	-0.01	-0.35	-1.51, 0.80
Blood concentrations (mmol/L) of:				
Alanine aminotransferase (IU/L)	0.41	0.01	0.01	-0.01, 0.03
Aspartate aminotransferase (IU/L)	0.50	0.009	0.009	-0.02, 0.03
Bilirubin, total (µmol/L)	0.65	0.006	0.006	-0.02, 0.03
High-density lipoproteins (mmol/L)	0.78	-0.004	-0.05	-0.36, 0.27
Low-density lipoproteins (mmol/L)	0.62	0.007	0.06	-0.18, 0.30
Cholesterol (mmol/L)	0.79	-0.03	-0.02	-0.19, 0.14
Triglycerides (mmol/L)	0.28	-0.01	-0.21	-0.59, 0.17
Rheumatoid factor (IU/mL)	0.14	-0.02	-0.25	-0.58, 0.09
Erythrocyte sedimentation rate (mm / hour)	0.95	-0.001	-0.001	-0.03, 0.03
Glucose (mmol/L)	0.48	-0.009	-0.06	-0.23, 0.11
Prevalence of diabetes mellitus	0.12	-0.02	-0.71	-1.62, 0.20
Creatinine (µmol/L)	0.45	0.01	0.004	-0.007, 0.02
Urea (mmol/L)	0.22	-0.02	-0.12	-0.32, 0.07

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Residual nitrogen (g/L)	0.74	-0.004	-0.66	-4.53, 3.21
Total protein (g/L)	0.75	0.004	0.007	-0.04, 0.05
International normalized ratio (INR)	0.13	-0.02	-1.50	-3.41, 0.42
Prothrombin time (%)	0.98	0.000	0.007	-0.53, 0.54
Hemoglobin	0.45	-0.01	0.007	-0.03, 0.01
Erythrocytes (10^6 cells / μL)	0.93	0.001	0.04	-0.71, 0.78
Leukocytes (10^9 cells / L)	0.55	-0.008	-0.06	-0.26, 0.14
Rod-core granulocyte (% of leukocytes)	0.77	0.004	0.03	-0.18, 0.24
Segment nuclear granulocyte (% of leukocytes)	0.45	-0.01	-0.02	-0.05, 0.02
Eosinophil granulocytes (% of leukocytes)	0.42	-0.01	-0.12	-0.40, 0.17
Lymphocytes (% of leukocytes)	0.11	0.02	0.04	-0.008, 0.08
Monocytes (% of leukocytes)	0.49	-0.009	-0.04	-0.17, 0.08
Blood pressure, systolic (mmHg)	0.74	0.005	0.002	-0.01, 0.02
Blood pressure, diastolic (mmHg)	0.77	0.004	0.004	-0.02, 0.03
Blood pressure, mean (mmHg)	0.45	.0.01	-0.01	-0.05, 0.02
Prevalence of arterial hypertension	0.03	0.03	0.64	0.05, 1.22
Prevalence of chronic obstructive pulmonary disease	0.67	0.006	0.24	-0.87, 1.35
Diet				
Vegetarian diet / mixed diet	0.57	0.007	2.43	-6.01, 10.9
Number of meals per day	0.22	0.02	0.23	-0.13, 0.58
In a week how many days do you eat fruits?	0.001	-0.05	-0.25	-0.40, -0.11
In a week how many days do you eat vegetables?	<0.001	0.05	0.005	0.002, 0.008
Type of oil used for cooking: vegetable oil / non-vegetable oil	0.058	-0.03	-0.20	-0.40, 0.006
Salt consumed per day (g)	0.10	0.02	0.002	0.000, 0.005
Degree of processing of meat (weak / medium / well done)	0.24	-0.02	-0.64	-1.71, 0.43
Smoking				
Do you currently smoke any tobacco products? (yes)	0.17	0.02	0.59	-0.26, 1.44
Do you smoke daily? (yes / no)	0.39	0.01	0.38	-0.48, 1.24
Package years (package = 20 cigarettes)	0.25	0.02	0.01	-0.009, 0.04
Alcohol Consumption				

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Alcohol consumed such as beer, whisky, rum, gin brandy or other local products? (yes / no)	0.05	0.03	0.67	-0.008, 1.35
How many alcoholic drinks do you have on a typical day when you are drinking)	0.16	0.04	0.003	-0.001, 0.007
How often do you have 6 or more drinks on one occasion? (never / rarely / sometimes / often / cannot say)	0.36	0.03	0.38	-0.43, 1.19
Depression				
Depression score	<0.001	0.08	0.25	0.17, 0.32
State-Trait Anxiety Inventory (STAI)				
Anxiety score	<0.001	0.08	0.25	0.17, 0.33
Dynamometry				
Manual dynamometry, right hand (dekaNewton)	0.40	0.01	0.01	-0.02, 0.04
Manual dynamometry, left hand (dekaNewton)	0.08	0.03	0.02	-0.003, 0.05

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STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation	Changes Made
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	The title contains the description of the study design ("population-based")
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	"As in other countries the prevalence of hearing loss is high in this elderly population in Russia. It is primarily or secondarily associated with older age, depression, male gender, cardiovascular disease and alcohol consumption"
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	Page 4, para 1, 2
Objectives	3	State specific objectives, including any prespecified hypotheses	Page 4, para 1, 2
Methods			
Study design	4	Present key elements of study design early in the paper	Page 4, para 3
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	Page 4, para 3
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants	Page 4, para 3
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case	--
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	Page 4, para 4, page 5, page 6, para 1
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	Page 4, para 4, page 5, page 6, para 1
Bias	9	Describe any efforts to address potential sources of bias	Page 4, para 4, page 5, page 6, para 1
Study size	10	Explain how the study size was arrived at	Page 4, para 3
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	Page 6, para 1
Statistical methods	12	(*a*) Describe all statistical methods, including	Page 6, para 1

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		those used to control for confounding	
		(*b*) Describe any methods used to examine subgroups and interactions	Page 6, para 1
		(*c*) Explain how missing data were addressed	Page 6, para 1
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy	Page 6, para 1
		(*e*) Describe any sensitivity analyses	

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Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	Page 6, para 2
		(b) Give reasons for non-participation at each stage	Page 6, para 2
		(c) Consider use of a flow diagram	
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	Page 6, para 2
		(b) Indicate number of participants with missing data for each variable of interest	Page 6, para 2, 3
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)	--
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time	
		Case-control study—Report numbers in each exposure category, or summary measures of exposure	
		Cross-sectional study—Report numbers of outcome events or summary measures	Page 7, para 2, 3, 4
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	Page 7, para 2, 3, 4
		(*b*) Report category boundaries when continuous variables were categorized	
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	
Discussion			
Key results	18	Summarise key results with reference to study objectives	Page 8, para 1
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	Page 9, para 4
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	Page 8, para 2
Generalisability	21	Discuss the generalisability (external validity) of the study results	Page 8, para 2-4; page 9 para 1-3
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	Page 1

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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