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Hearing threshold levels and noise exposure in employees using communication headsets

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ABSTRACT

The overall objective of the study was to analyse the noise exposure and risk of noise-induced hearing loss (NIHL) in employees using communication headsets (CHs). The study group comprised 104 workers, including military aviation personnel (n=12), transcribers (n=18) and call centre operators (n=74). Sound pressure levels under communication headsets were determined using the artificial ear technique as specified in CSA Z107.56-13, while the background noise levels were measured according to PN-N-01307:1994 and PN-EN ISO 9612:2011. Data on typical work pattern and equipment used, preferred volume control settings were also gathered from users of CHs. Standard pure-tone audiometry and extended high-frequency audiometry were also performed in part of call centre operators (n=30). The risk of NIHL was evaluated using the method described in the ISO 1999:2013 standard. It was found out that communication headsets emitted noise at the diffuse-field-related A-weighted equivalent-continuous sound pressure level of 68−88 dB (10−90th percentile), while the background noise level ranged from 55 to 79 dB (10−90th percentile). The study subjects used headsets from 1.5 to 8 hours (10−90th percentile) per day. Such noise exposures for 40 years of employment might cause the risk of NIHL (expressed as mean hearing threshold level for 2, 3 and 4 kHz > 25 dB) varying from 0 to 35%. Actual HTLs of examined call centre operators in the frequency of 0.25-11.2 kHz were higher (worse) than the expected median values for age-related reference highly screened (otologically normal) population specified in ISO 7029:2017. They were also higher than predicted (for 500-4000 Hz) according to ISO 1999:2013. Further studies are needed before firm conclusions concerning the risk of NIHL in workers using headsets can be drawn.

Keywords: Noise, Communication Headsets, Noise-Induced Hearing Loss.
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1. INTRODUCTION

Wired and wireless communication headsets are recently more widely used in various sectors of industry, including workplace settings such as call centres, retail stores, fast food outlets, airport ground and control tower operations, industrial and construction sites, and military sites[1]. However, relatively little research has been published on the risk of hearing impairment from usage communication headsets. Such a situation has probably been in part due to the difficulties in the measurement set-up and in the evaluation of the exposure itself.

Traditional methods for measuring the occupational noise exposure with the use of a sound level meter or noise dosimeter (e.g. those described in PN-EN ISO 9612:2011[2]) are not suitable for noise assessments under communication headsets. For measurements under occluded ears, specialized methods have been specified by the International Standards Organization such as the microphone in a real ear (MIRE)[3] and manikin techniques[4]. Simpler methods have also been proposed in some national standards such as the use of general purpose artificial ears and ear simulators in conjunction with single number corrections to convert measurements to the equivalent diffuse field (AS/NZS 1269.1:2005, CSA Z107.56-13)[5,6].

Nowadays in Poland the noise exposure evaluation from communication headsets is not routinely carried out. Only a few studies have, to date, been conducted[7,8]. Thus, there is no data on the scale of noise exposure and risk of noise-induced hearing loss (NIHL) in employees using headsets. Therefore, the overall objective of the study was to assess the noise exposure and risk of noise-induced hearing loss (NIHL) among employees of various industry using communication headsets.

2. MATERIALS AND METHODS

Noise measurements were carried out in 104 workers, including military aviation personnel (n=12) (i.e. pilots and cabin crew (n=5), technical service of aircrafts (n=4) and aircraft controllers (n=3)), transcribers (n=18) and call centre operators (n=74). All subjects were also inquired about (a) age and gender, (b) education and/or profession, (c) work history, including time of employment/exposure to noise and/or usage of headsets at previous workplaces, and (d) current job (details of work pattern and equipment used, preferred volume control setting, type of calls typically handled, etc.). On the basis of that data, the risk of the NIHL was assessed according to ISO 1999:2013 standard[9].

In addition, audiometric tests were carried out in a part of call centre operators (n=30). Actual hearing thresholds of examined call centre operators were compared to age-related reference data from non-noise-exposed highly screened population specified in ISO 7029:2017[10] and the theoretical predictions calculated according to ISO 1999:2013[9] based on exposure.

The study design and methods were approved by the Bioethical Commission of the Nofer Institute of Occupational Medicine, Lodz, Poland (resolution no. 13/2016 of 18 November 2016 and resolution no. 17/2018 of 20 November 2018).

2.1 Noise exposure evaluation

To assess workers' exposure to noise, sound pressure levels generated by communication headsets and background noise levels were measured and information on typical working pattern was also collected. The following noise parameters were determined according to PN-N-01307:1994[11] and PN-EN ISO 9612:2011[2]: a) A-weighted equivalent-continuous sound pressure level (SPL), b) maximum A-weighted SPL with S (slow) time constant, and c) peak C-weighted SPL.

Noise exposure from communication headsets was evaluated using the artificial ear technique as specified in CSA Z107.56-13 standard[6]. This method involved the usage of two identical headsets, one placed on the subject's head, the other connected in parallel with the headset in use. The parallel headphone was placed on an artificial ear, the G.R.A.S type 43AG-2, that was connected to the SVANTEK sound analyser type SVAN 958, and the aforesaid noise parameters together with sound pressure levels in 1/3-octave bands (from 20 to 10 000 Hz) were measured. Simultaneously, the SVANTEK dual channel noise dosimeter type SV102 (equipped with standard ½ inch microphone type SV25D) was used for measurement of background noise (outside the headphone or ear without headphone).

According to the CSA Z107.56-13[6] standard, results of the frequency analysis under headphone were then converted into corresponding diffused-field levels to obtain the diffuse-field related A-weighted sound pressure levels. A task-based measurement strategy according to PN-EN ISO 9612:2011[2] was applied for exposure evaluation from both the headsets and background noise.

Results of the aforesaid sound pressure level measurements and questionnaire data on the declared time of daily usage of communication headsets were used to evaluate individual daily noise exposure levels in examined call center operators as well as to estimate noise exposure in various groups of workers.

In the latter case, first, the distributions of diffuse-field-related equivalent-continuous A-weighted sound pressure levels ($L_{\mathrm{Aeq,T,\,DF}}$) in various groups of workers (e.g. transcribers) were determined. Then, on the basis of the declared time of daily usage and the $L_{\mathrm{Aeq,T,\,DF}}$ levels, the limit values of daily noise exposure levels ($L_{\mathrm{EX,8h,10}}$, $L_{\mathrm{EX,8h,50}}$ and $L_{\mathrm{EX,8h,90}}$) for various groups of the headsets' users were calculated using the following formulas:

$$L_{\mathrm{EX,8h,10}} = L_{\mathrm{Aeq,T,\,DF,10}} + 10 \times \log\,(T_{\mathrm{d,10}}/T_{\mathrm{o}}) \tag{1}$$

$$L_{\mathrm{EX,8h,50}} = L_{\mathrm{Aeq,T,\,DF,50}} + 10 \times \log(T_{\mathrm{d,50}}/T_{\mathrm{o}}) \tag{2}$$

$$L_{\mathrm{EX,8h,90}} = L_{\mathrm{Aeq,T,\,DF,90}} + 10 \times \log(T_{\mathrm{d,90}}/T_{\mathrm{o}}) \tag{3}$$

where $L_{\mathrm{Aeq,T,\,DF,10}}$; $L_{\mathrm{Aeq,T,\,DF,50}}$ and $L_{\mathrm{Aeq,T,\,DF,90}}$ – 10^{th}; 50^{th} and 90^{th} percentiles of the diffuse-field-related A-weighted equivalent-continuous sound pressure level emitted by headsets in the respective group of workers, in dB, $T_{\mathrm{d,10}}$; $T_{\mathrm{d,50}}$ and $T_{\mathrm{d,90}}$ – 10^{th}; 50^{th} and 90^{th} percentiles of declared time of daily usage of headsets, in hours, T_{o} − reference duration, T_{o} =8 h.

2.3 Hearing examination

The conventional pure-tone air conduction audiometry (PTA) and extended high-frequency audiometry (EHFA) were performed in all subjects of the study. The auditory rest before the audiological evaluations was 14 hours.

Hearing threshold levels (HTLs) for each ear were determined for both standard frequencies from 0.125 to 8 kHz and extended frequencies from 8 to 18 kHz with 5 dB steps. However, HTLs at 18 kHz were not included into analysis due to many missing data. The bracketing method as specified ISO 8253-1:2010[12] has been used in case of PTA. A similar methodology has been applied for EHFA. Standard pure-tone audiometry was always determined first, followed by the EHFA. In both cases, the right ear was tested first.

The hearing examinations were conducted with the VIDEOMED Smart Solution (Poland) clinical audiometer, model AUDIO 4002 with the Holmberg GMBH & CO. KG Electroacoustik (Germany) headphones type HOLMCO P-81 for the PTA, and the Sennheiser Electronic GmbH & Co. KG (Germany) headphones type HAD 200 for

EHFA. Prior to the audiological evaluations, otoscopy was performed. Hearing tests were carried out in a quiet room located in the call centre where the A-weighted equivalent-continuous sound pressure level of background noise did not exceed 35 dB.

2.4 Assessment of risk of noise-induced hearing loss

The ISO 1999:2013 standard[9] was used to evaluate the risk of hearing impairment due to noise and age, and due to noise alone in various groups of employees using communication headsets. This standard defines the risk of hearing impairment due to age and noise as the percentage of population with hearing threshold levels (HTLs) exceeding the accepted limit value (e.g. 25 dB). In turn, the risk due to noise alone is defined as a difference between the percentage of noise-exposed population and non-exposed to noise population (otherwise equivalent to the former) with HTLs greater than the accepted limit value.

In this study, for various groups of workers (separately females and males), for the assumed hypothetical period of professional exposure (from 5 to 45 years) and age (from 25 to 65 years), varying in 5-year steps, percentages of subjects with HTLs exceeding the limit value of 25 or 45 dB and the risk of hearing loss due to noise alone were evaluated. These calculations were performed on the basis of $L_{\mathrm{EX,8h,10}}$, $L_{\mathrm{EX,8h,50}}$ and $L_{\mathrm{EX,8h,90}}$ that were established for various groups of headsets' users.

2.4 Data analysis

Audiometric hearing threshold levels in call centre operators were compared to age-related reference data from highly screened non-noise-exposed population as well as noise-exposed population according to ISO 7029:2017[10] and ISO 1999:2013[9], respectively.

The prevalence of normal audiograms, high- and speech-frequency hearing losses and extended high-frequency hearing threshold shifts were analysed in the study subjects (ears). Normal hearing was defined as having HTLs between 0.25 and 8 kHz lower than or equal to 20 dB HL. The speech- and high-frequency hearing loss were defined as pure-tone mean of > 20 dB HL at 0.5, 1, 2 and 4 kHz, and 3, 4 and 6 kHz, respectively. In turn, the participants with the mean hearing threshold at 9, 10, 11.2, 12.5, 14 and 16 kHz above 20 dB HL were considered as having the extended high-frequency hearing threshold shift.

In addition, to identify early signs of noise-induced hearing loss, the prevalence of high frequency notched audiograms was also analysed. According to Cole's recommendation, a high-frequency notch was defined as a hearing threshold level at 3 and/or 4 and/or 6 kHz at least 10 dB HL greater than at 1 or 2 kHz and at 6 or 8 kHz (Coles et al. 2000).

The t-test for dependent data or Wilcoxon singed-rank test was applied for comparison of hearing threshold levels in call centre operators with reference data from noise-exposed and non-noise-exposed populations. The STATISTICA (version 9.1. StatSoft, Inc.) software package was used for statistical analysis.

3. RESULTS

The study group comprised 104 subjects (58 females and 46 males), aged 18–59 years (32.1±7.0 years). They used headsets (or headphones) on average from 1.5 to 8 hours per day (6.2±2.3 hours), for period of 0.3 to 28.0 years. Almost all workers (99.0%) used supra-aural headsets, of which 61.5% used mono-aural headsets.

Subgroup of call centre operators examined using PTA and EHFA comprised 15 females and 15 males, aged 22—47 years (32.2±6.5 years), employed from 1.0 to 16.5 years (5.0±3.2 years) in a call centre.

Table 1 summarizes the measurement results of the background noise and noise from headsets. In particular, it presents both, uncorrected and corrected (diffuse-field-related) A-weighted equivalent-continuous sound pressure levels measured using the artificial ear.

Table 1: Result of noise measurements at workplaces equipped with the headsets

Job	Noise parameter [dB]	Artificial ear technique		Background noise	
		M±SD 10th / 50th/ 90th percentile			
Pilots and crew members (n=3)	$L_{Aeq,T}$	99.5±12.3	85/106/107	86.9±1.6	85/88/88
	$L_{Aeq,T, DF}$	90.0±7.5	81/94/95	-	-
	L_{Amax}	119.9±12.7	105/126/129	100.9±5.1	95/103/105
	L_{Cpeak}	137.5±3.7	133/139/139	126.1±6.0	120/127/132
	T_d [h]	3.0±1.0		2.0/3.0/4.0	
Technical service of aircrafts (n=4)	$L_{Aeq,T}$	91.6±10.8	77/95/100	77.8±12.3	60/81/89
	$L_{Aeq,T, DF}$	85.4±12.1	71/88/96	-	-
	L_{Amax}	99.7±8.3	88/103/106	89.1±12.5	74/90/102
	L_{Cpeak}	116.3±3.2	113/116/116	111.1±11.3	99/111/124
	T_d [h]	2.1±0.9		1.5/1.8/3.5	
Air traffic controllers (n=1)	$L_{Aeq,T}$	78.3	-	55.1	-
	$L_{Aeq,T, DF}$	75.4	-	-	-
	L_{Amax}	91.6	-	69.1	-
	$L_{C\ peak}$	103.2	-	102.9	-
	T_d [h]	1.3±0.4		1.0/1.3/1.5	
Tanscribers (n=17)	$L_{Aeq,T}$	76.1±11.0	54/75/89	54.7±6.8	44/56/62
	$L_{Aeq,T, DF}$	71.7±10.6	52/72/85	-	-
	L_{Amax}	86.8±7.4	76/86/96	75.1±8.7	63/73/83
	$L_{C\ peak}$	109.6±4.3	103/110/110	101.6±6.3	96/101/107
	T_d [h]	3.2±1.8		0.4/3.0/6.0	
Call centre operators (n=68)	$L_{Aeq,T}$	84.2±6.5	77/85/91	72.1±4.7	66/72/78
	$L_{Aeq,T, DF}$	79.0±6.7	72/80/87	-	-
	L_{Amax}	107.1±11.3	92/106/120	87.2±5.3	81/87/94
	$L_{C\ peak}$	113.7±6.3	105/114/121	107.3±5.7	101/107/115
	T_d [h]	7.4±0.9		7.0/8.0/8.0	
Total (n=93)	$L_{Aeq,T}$	83.6±9.1	74/84/92	69.3±9.4	55/71/79
	$L_{Aeq,T, DF}$	78.3±8.7	68/79/88	-	-
	L_{Amax}	103.6±13.6	87/104/120	85.1±8.6	73/86/95
	$L_{C\ peak}$	113.8±7.7	105/113/122	106.9±7.5	99/106/117
	T_d [h]	6.2±2.3		1.5/7.0/8.0	

$L_{Aeq,T}$ – A-weighted equivalent-continuous sound pressure level,
$L_{Aeq,T, DF}$ – corrected diffuse-field related A-weighted equivalent-continuous sound pressure level.
$L_{A\ max}$ – maximum A-weighted sound pressure level, $L_{C\ peak}$ – peak C-weighted sound pressure level.
T_d – declared time of headsets usage per working day, n – number of investigated workplaces.

Communication headsets generated noise at diffuse-field-related A-weighted equivalent-continuous SPL ranging from 68 to 88 dB (10−90th percentile), with 18.3% and 41.9% of cases exceeding 85 dB and 80 dB, respectively. On the other hand, background noise remained within the range of 55−79 dB (10−90th percentile). Exposure to both $L_{Aeq,T,DF}$ and $L_{Aeq,T,BN}$ was highest among pilots, crew members and technicians involved in aircraft maintenance.

According to responses to the questionnaire, workers used headsets from 1.5 to 8.0 hours per day (10−90th percentile). Subsequently, the limit values of daily noise exposure levels ranged from 61 to 88 dB ($L_{EX,8h,10}$ − $L_{EX,8h,90}$). It is worth noting that the subgroup of examined call center operators were exposed to sounds at daily noise exposure levels varying from 70 to 87 dB (79.9±7.4 dB).

It is worth noting that the $L_{EX,8h,90}$ levels for pilots (and cabin crew), technical service of aircraft and call center operators exceeded the Polish maximum admissible intensity (MAI) value for occupational noise ($L_{EX,8h}$=85 dB)[13]. Furthermore, in almost all groups of workers, excluding aircraft controllers, the $L_{EX,8h,90}$ levels were higher than the lower exposure action value ($L_{EX,8h}$=80 dB) specified by the 2003/10/EC Directive[14]. Thus, the obtained results are in line with some earlier observations that a part of headset users, especially those working in noisy environment, might be exposed to harmful noise levels[15-18].

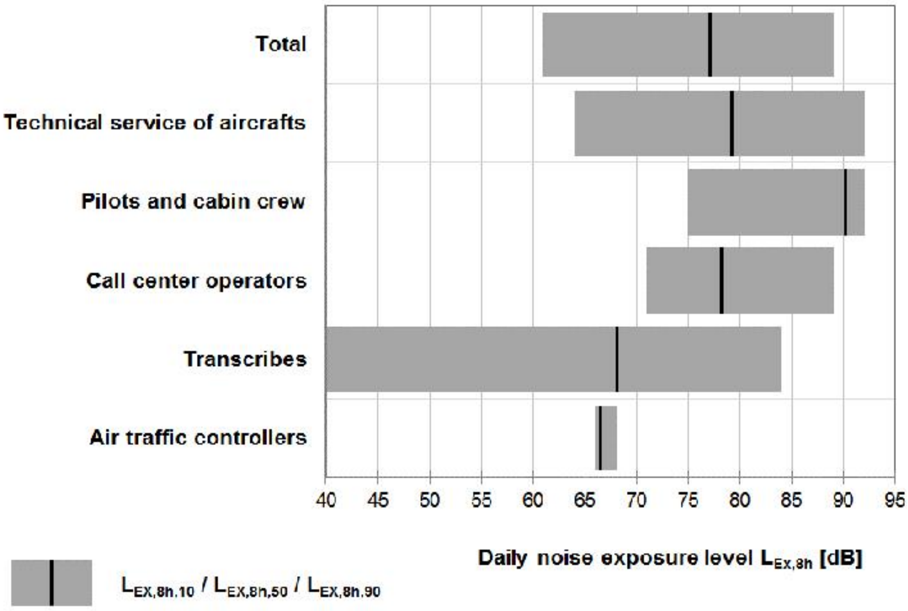

Figure 1: Evaluation of noise exposure in various groups of workers using headsets ($L_{EX,8h,10}$ / $L_{EX,8h,50}$ / $L_{EX,8h,90}$ - daily noise exposure levels, corresponding to 10th/ 50th /90th percentiles of the A-weighted equivalent-continuous sound pressure level and 10th/ 50th /90th of the declared time of daily usage).

3.2 Risk of noise-induced hearing loss

According to the ISO 1999:2013[9], the risk of NIHL can be evaluated separately at frequencies of 1, 2, 3, 4 and 6 kHz as well as for combination of various frequencies. In this study the risk of hearing loss was calculated as the average value for: a) 0.5, 1, 2 and 4 kHz, b) 3, 4 and 6 kHz, and c) 1, 2 and 3 kHz. The latter frequency range corresponds to the most important speech frequency range of the Polish language. Thus, it is considered to be crucial for social efficiency of hearing. Moreover, the mean hearing threshold level at 1, 2 and 3 kHz equal to or higher than 45 dB is the pre-condition for diagnosis of the occupational hearing loss in Poland[19]. The mean value of the hearing threshold level (associated with age and noise) for 0.5, 1, 2 and 4 kHz up to 25 dB corresponds to grade 0 of the hearing impairment. According to the classification of the World Health Organization in the case of grade 0 (“no impairment”) no or very slight hearing problems can occur and one is able to hear whispers[20]. On the other hand, the frequencies of 2, 3 and 4 kHz are considered as optimal for early detection of occupational hearing loss[21].

Tables 2–3 summarise the results of assessing the risk of hearing impairment due to noise and age, as well as due to noise exposure alone, in 60-year old workers using communication headsets after approximately 40 years of employment. On the other hand, Fig. 2 shows the results of risk evaluations as a function of age (time of exposure in years) on the basis of the limit values of daily noise exposure level ($L_{EX,8h,10}$, $L_{EX,8h,50}$ and $L_{EX,8h,90}$) for various groups of workers.

Generally, the risk of hearing loss due to noise and age or due to noise alone depends on the frequency range (see Tab. 2) The highest values were obtained for the average of hearing threshold level (HTL) at 2, 3 and 4 kHz, while the lowest for the average of HTL at 0.5, 1, 2 and 4 kHz. Regardless of the frequency range, in the initial period of exposure the risk of hearing loss (due to noise alone) increases with time (Fig. 2). After about 30−40 years of exposure (i.e. at the age of 50−55 or 60–65 years in case of males and females, respectively) the risk reaches the maximum and then begins to decrease.

Table 2: Results of risk assessment of NIHL due to noise and age and due to noise alone in 60-years old workers using communication headsets after approx. 40 years of work (calculations for an accepted limit value of HTL equal to 25 dB)

Group of workers	Risk due to noise and age [%]			Risk due to noise [%]		
	Mean HTL > 25 dB					
	0.5-1- 2-4 kHz	1- 2-3 kHz	2-3-4 kHz	0.5-1- 2-4 kHz	1- 2-3 kHz	2-3-4 kHz
Females						
Pilots and cabin crew	9/19/23*	9/23/29	18/44/53	0/9/14	0/9/14	0/26/35
Technical service of aircrafts	9/9/23	9/9/29	18/19/53	0/0/14	0/0/14	0/1/35
Air traffic controllers	9/9/9	9/9/9	18/18/18	0/0/0	0/0/0	0/0/0
Tanscribers	9/9/11	9/9/12	18/18/26	0/0/2	0/0/2	0/0/7
Call centre operators	9/9/15	9/9/17	18/19/23	0/0/5	0/0/8	0/0/15
Males						
Pilots and cabin crew	19/29/33	18/32/38	39/61/68	0/9/14	0/13/20	0/22/29
Technical service of aircrafts	19/19/33	18/18/38	39/40/68	0/0/14	0/0/20	0/1/29
Air traffic controllers	19/19/19	18/18/18	39/39/39	0/0/0	0/0/0	0/0/0
Tanscribers	19/19/21	18/18/21	39/39/45	0/0/2	0/0/3	0/0/6
Call centre operators	19/19/24	18/18/25	39/39/51	0/0/5	0/0/7	0/0/12
*Calculation on the basis on daily noise exposure levels $L_{EX,8h,10}$ / $L_{EX,8h,50}$ / $L_{EX,8h,90}$.						

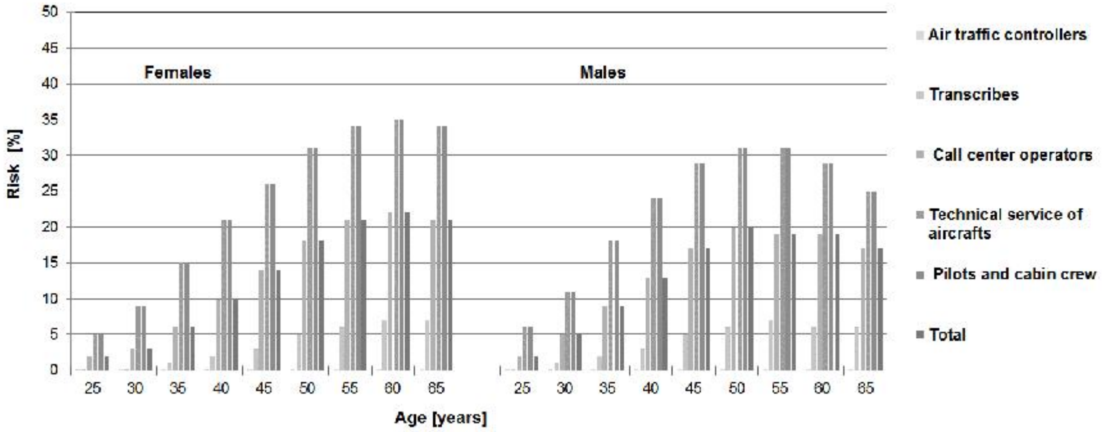

Figure 2: Risk of hearing impairment (mean HTL at frequencies of 2, 3 and 4 kHz > 25 dB) due to noise exposure only by age (tenure) and gender in various groups of workers using communication headsets (calculations on the basis on daily noise exposure level $L_{EX,8h,90}$).

As it can be seen from Table 2, occupational exposure for 40 years to noise from headsets causes the risk of NIHL (expressed as the mean HTL at 2, 3 and 4 kHz > 25 dB) ranging from 0 to 35% (assessment on the basis of $L_{EX,8h,90}$ for individual groups of workers). The highest risk (up to 29–35%) was noted in case of pilots, cabin crew and technicians involved in aircraft maintenance (Tab. 2).

As a result of the 40-year occupational exposure, up to 9−27% of call centre operators (Tab.2) might experience hearing loss corresponding to grade 1 (or higher) according to the WHO classification[20]. Furthermore, permanent hearing threshold shifts that suffices to diagnose occupational hearing loss might occur in a small percentage (max. 2–4%) of pilots and aircraft maintenance personnel (Tab. 3).

Table 3: Results of risk assessment of NIHL due to noise and age in 60-years old workers using communication headsets after approx. 40 years of work (calculations for an accepted limit value of HTL equal to 45 dB)

Group of workers	Risk of NIHL due to noise and age [%] Mean HTL (1-2-3 kHz) > 45 dB					
	Total	Pilots and cabin crew	Technical service of aircrafts	Air traffic controllers	Transcribers	Call centre operators
Females	0/0/1	0/1/2	0/0/2	0/0/0	0/0/0	0/0/1
Males	1/1/2	1/3/4	1/1/4	1/1/1	1/1/1	1/1/2
*Calculation on the basis on daily noise exposure levels $L_{EX,8h,10}$ / $L_{EX,8h,50}$ / $L_{EX,8h,90}$.						

3.3 Results of audiometric tests

Figure 3 presents the standard pure-tone hearing thresholds and extended high-frequency hearing thresholds determined in the 30 call centre operators (60 ears) together with the expected HTLs (in the frequency range of 0.250−12.5 kHz) for comparable highly screened non-noise-exposed population specified in the ISO 7029:2017 standard[10]. In turn, Figure 4 shows results of the audiometric tests together with predicted for call centre operators hearing losses according to ISO 1999 (2013) based on their noise exposure level.

As demonstrated, call centre operators' hearing threshold levels in the frequency range of 0.25–11.2 kHz were significantly higher than the expected median values for comparable (due to age and gender) highly screened (otologically normal) non-noise-exposed population specified in the ISO 7029:2017[10], while at 12.5 kHz they were close to those expected (Figure 3). Furthermore, in the frequency range of 500–4000 Hz, the actual HTLs were also higher (worse) than expected from noise exposure, while at 6 kHz they were comparable (Figure 4).

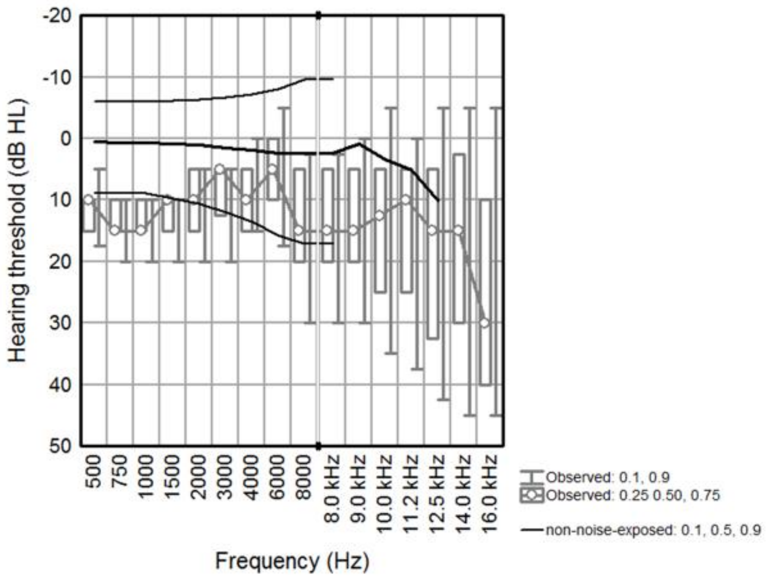

Figure 3: Distribution of hearing threshold levels in call centre operators compared to hearing threshold levels in equivalent (due to age and gender) non-noise-exposed population specified in ISO 7029:2017[10].

Generally, 56.7% (95% CI: 39.2–72.6%) of the study subjects had in both ears normal hearing in the standard frequency range (HTLs ≤ 20 dB HL between 0.25 and 8 kHz), while only 26.7% (95% CI: 14.1–44.7%) of them in the extended frequency range from (HTLs ≤ 20 dB HL between 9 and 16 kHz).

High-frequency hearing loss (mean HTL at 3, 4 and 6 kHz > 20 dB HL) and speech-frequency hearing loss (mean HTL at 0.5, 1, 2 and 4 kHz > 20 dB HL) were only noted in 3.3% (95% CI: 0.3–12.2%) ears. In turn, the extended high-frequency threshold shift (mean HTL at 9, 10, 11.2, 12.5, 14 and 16 kHz > 20 dB HL) was found in 38.3% (95% CI: 27.1−51.0%) of analysed ears. For comparison, the high-frequency notches (mainly at 4 or 3 kHz) were noted in the 11.7% (95% CI: 5.5–22.6%) of the examined ears. Thus, the prevalence of notched audiograms was close to that observed in the general population[22].

Our hearing test results are in line with the results of some earlier studies analysing audiometric hearing thresholds in call centre operators. For instance, earlier Mazlan et al.[23] examined the hearing status among young Malaysian call centre operators and found that the prevalence of NIHL among this professional staff was comparable to prevalence in normal subjects.

More recently, Ayugi et al.[24] carried out a descriptive cross-sectional study in 1351 call centre operators (aged 19−55 years) to study the prevalence of symptoms of acoustic shock syndrome. However, despite the numerous symptoms of acoustic shock syndrome among 13% of the examined subjects, they noted NIHL only in case of 21 (i.e.

1.6% of 1351) workers. Twelve females had mild hearing loss while only one man had severe hearing loss.

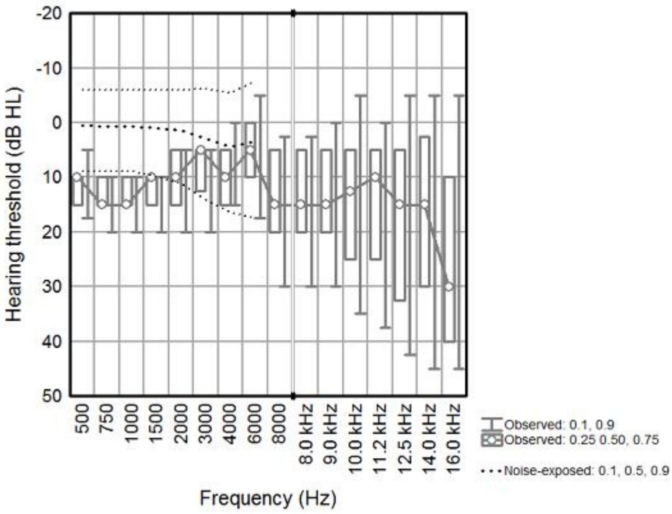

Figure 4: Distribution of hearing threshold levels in call centre operators compared to expected hearing threshold levels according to ISO 1999:2013 from noise exposure

4. CONCLUSIONS

The results of noise measurements under communication headsets indicated that military aviation personnel, transcribers and call centre operators are usually exposed to noise at the diffuse-field-related equivalent continuous A-weighted sound pressure level of 68−88 dB (10−90th percentile) for 1.5–8 hours per day (10−90th percentile). Furthermore, a part of the headset users, especially those working in noisy environment such as military aviation personnel, are likely to be exposed to harmful noise levels exceeding 85 dB.

Exposures to noise from headsets for 40 years of employment might cause the risk of hearing loss (expressed as the average hearing threshold at frequencies of 2, 3 and 4 kHz exceeding 25 dB) reaching values up to 29–35%.

Although, over a half of the examined call centre operators had normal hearing within standard frequency range, comparison of them to the highly screened otologically normal non-noise-exposed population (as specified in ISO 7029:2017[10]) revealed that their hearing threshold levels in the frequency of 0.25−11.2 kHz were higher (worse) than the expected median values for the reference age-related highly screened (otologically normal) non-noise exposed population specified in ISO 7029:2017. Furthermore, the actual hearing thresholds in call center operators were proved to be higher than predicted due to noise exposure for 500-4000 Hz according to ISO 1999:2013, while close to predictions at 6000 Hz.

The findings presented in this paper confirm the need to implement a hearing conservation program for headsets users. However, further studies are needed, comprising a greater number of workers of various industries and longer time of employment before firm conclusions concerning the risk of NIHL due to the usage of communication headsets are drawn.

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