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Otologic symptoms and hearing thresholds among a cohort of call center operators in Lagos

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Abstract

Background: The call center operation jobs are becoming a global phenomenon. The use of headphones for 7 to 9 h daily with varying noise level exposure is quite common among call center operators. This can cause structural and/or functional changes in the auditory system. Researchers have arrived at different conclusions regarding the risks associated with prolonged headphone usage. This study aimed to evaluate the risk of hearing changes and the range of otologic symptoms among call center operators in Lagos State, Nigeria.

Methods: This is a prospective cross-sectional study carried out on 90 call center operators (customer service staff) and 90 administrative staff (controls) aged 18 to 40 years working in two call centers affiliated to different private establishments in Lagos State. Their biographic data, work information, and otologic/non-otologic symptoms developed with the commencement of the job were obtained with a self-administered structured questionnaire. After otoscopic examination, diagnostic pure tone audiometry (PTA) was carried out before and after the work shift.

Results: The most commonly reported symptoms among the call center operators were headache, tinnitus, and vertigo. Symptoms were noted as early as 3 months into the job in 20 (24.7%) call center operators. The pre-shift and post-shift mean PTA of the call center operators were normal bilaterally and comparable to the controls. There was an elevation of low frequency (500 Hz) mean PTA of > 30 dB in both the call center operators and the controls. The mean PTA average for the call center operators' pre-shift and post-shift were 25.4 ± 8.2 and 25.6 ± 8.1 in the right ear, 24.8 ± 8.5 and 24.7 ± 8.9 in the left ear, 25.9 ± 7.8 and 24.7 ± 7.8 right and left ears for the control. There were no statistically significant differences between the call center operators' pre-shift and the controls' hearing thresholds, and the pre-shift and post-shift hearing thresholds of the call center operators at all frequencies and in both ears.

Conclusion: Otologic and non-otologic symptoms arise from prolonged headphones usage among call center operators. No hearing damage or headphone noise-induced hearing loss was recorded in the call center operators in this study.

Keywords: Call center operators, Hearing threshold, Otologic symptoms, Headphones

Background

At the turn of the millennium, the advent of the telecommunications industry has led organizations such as banks, telecommunication companies, online retail stores, and radio stations among others to create call center operation jobs to facilitate the marketing of their products. A study from Sweden estimated that 1.3 – 4.0% of the working population in the country are employed in call centers [1]. Typically, call center operators must wear headphones to do their jobs. Although most of the headsets have adjustable volume controls, environmental factors such as background noise in the workplace or from the callers' locations may make call center operators increase their headset volumes which in turn can increase the sound levels transmitted into their ears.

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The use of headphones at work has been estimated to put 25% of the UK workforce at risk of noise-induced hearing loss (NIHL) [2]. Similar findings have been reported by a study conducted in Egypt [3]. Worldwide estimates of work-related hearing impairment were 16 to 24% [4].

Occupational noise-induced hearing loss (NIHL) is defined as a partial or complete hearing loss in one or both ears as a result of one's employment; it is a function of exposure to continuous high levels of noise or intermittent short bursts of loud noise over several years [5]. The noise exposure leads to cochlear hair cell injury and injury to the inner ear surrounding supporting cells resulting in the degeneration of auditory nerve fiber [6]. Noise exposure can also have an effect on other structures in the cochlea such as the stria vascularis and spiral lamina [7]. There is also the metabolic production of reactive oxygen species which plays a significant role in NIHL [8, 9].

The intensity and duration of noise exposure correlate with inner ear cell injury and associated hearing loss [10, 11]. The permissible exposure limit of 85 dBA and 90 dBA for an 8-h time-weighted average with a 3 dB and 5 dB exchange rate (increase or decrease in decibel corresponding to doubling or halving the noise dose) has been recommended by the National Institute for Occupational Safety and Health (NIOSH) [12] and the Occupational Safety and Health Administration (OSHA) [13] respectively.

Most call center operators are young adults who commonly use headphones for 7 to 9 h daily with varying noise level exposure. This can cause damage to the ear, resulting in noise-induced hearing loss, and the acceleration of the process of age-related hearing loss later in life [14, 15]. Symptoms associated with headphone usage and acoustic shock events in call center operators can be otologic and non-otologic, and they include tinnitus, headache, hypersensitivity to sound, vertigo, otalgia, numbness/soreness/tenderness around the ear/and neck, headache, "fatigue", and many others [16].

Little is known about the risk of hearing changes and symptoms experienced by call center operators, especially in developing countries. This study aimed to evaluate the risk of hearing changes and the range of otologic symptoms among call center operators in Lagos State, Nigeria.

Methods

This is a prospective cross-sectional study carried out on call center operators (customer service staff) working in call centers affiliated with different private establishments in Lagos State. Various call centers are located together in the same venue in different parts of Lagos. Two of such venues were randomly selected. The population of call operators working in the centers located in the selected venues was 600. Subjects were selected using a systematic sampling technique. Adults aged between 18 and 40 years who had been call center operators for at least 12 months were recruited as study subjects. Administrative staff at the centers who have never worked as call operators were recruited as controls. Written permission to enrol subjects in this study was obtained from the Human Resources (HR) managers of the selected call centers. Written informed consent was obtained from the prospective subjects before enrolment into the study. All participants completed the following procedures: a questionnaire designed for this study was used to obtain biographical data and information about the length of shift, ear on which earphone/headphone is worn most frequently (left/right/both), the average number of working days per week, history of exposure to loud noise acutely or on a chronic basis, otologic symptoms such as otalgia, tinnitus, loss of balance, aural fullness, hyperacusis, autophony, and hearing loss among others were obtained. Otoscopy was carried out and cerumen and debris were managed as needed.

Diagnostic pure tone audiometry (PTA) was performed using a Kamplex As7 audiometer applying the modified Hughson-Westlake method. Thresholds were measured at 0.5, 1, 2, 3, 4, 6, and 8 kHz pure tone frequencies. The Pure Tone Average was then calculated and used to determine the degree of hearing loss according to the World Health Organization (WHO) classification. PTA was carried out for each call operator before the commencement of the shift and at the end of the work shift. The controls had their PTA done just once.

Sound meter ST-85C was used to measure the noise level of where PTA was carried out before commencement and call operation halls at peak periods of randomly selected shifts.

The headphones used by the call operators were Plantronics ™ Supra Plus Professional Series (Monaural and Binaural headsets) with ultra-noise canceling microphones. These were coupled to Vista Plus ™ Audio Processors. These devices were manufactured in England by Plantronics Ltd., Interface Business Park, Bincknoll Lane, Wootton Bassett, and Wiltshire SN4 8QQ.

Statistical analysis

The data was collated and analyzed using Statistical Product and Service Solution (SPSS 23.0.0) for Windows. Discrete variables such as call operators' work history and symptoms experienced after the commencement of the call center job were presented as percentages while the continuous variables including the pre and post-shift hearing threshold of call center operators and hearing

threshold of the control were expressed as means and standard deviation. The means of the hearing threshold were compared using independent *t* test for both call center operators and the control. For all comparisons, $p < 0.05$ was adopted as the criterion for establishing statistical significance. The correlation between the onset of the symptoms and the duration of exposure to headphones was analyzed using Spearman correlation.

Results

Two hundred and fifty-six subjects were recruited for the study (166 call center operators in the study group and 90 subjects in the control group). One hundred and eighty subjects, 90 call center operators, and 90 controls were studied. The attrition rate was 45.8%, consisting of 76 call center operators who did not complete the study.

The study population comprised adults aged 18–40 years. The peak age range was 25–29 years accounting for 38.3% of the total number of participants in the study. The mean ages in this study were 27.5 ± 4.8 years for the call center operators and 27.5 ± 5.4 years for the controls. The male: female ratio was 1.65:1 in the call center operators and 1.2:1 in the controls. Overall, there was a male preponderance of 1.4:1.

It was noted that only 8 (8.9%) of the call center operators had documented pre-employment audiologic assessment done and their results were normal. Three (3.3%) of the call center operators had worked as call operators for 1 to 2 years prior to taking up this present job, and 13 (14.4%) had been exposed to a high level of noise in their previous employment (12 as factory workers, 1 as airport worker) but only 3 of them worked for 1 to 3 years. The average noise level of the assessment rooms was 59.6 dB while that of the call center halls was 62.8 dB.

Table 1 shows a summary of the work history of the call center operators. Sixty-eight (75.6%) of the call center operators have worked for 1 to 3 years, binaural headsets were used by 81 (90%) of the operators. Sixty-six (83.3%) of the call center operators work 8 h or less per shift with a mean of work hours of 8.42 ± 1.0, and 84 (93.3%) work for 5 days or less per week with a mean of 5.07 ± 0.3.

Symptoms were classified as otologic symptoms, non-otologic symptoms, or no symptoms. Eighty-one (90%) of the call center operators had either otologic and/or non-otologic symptoms while only 9 (10%) had no symptoms. Forty-six (57.8%) call center operators' had 1–2 symptoms, 30 (37.0%) had 3–4 symptoms while 5 (6.2%) had 5–8 symptoms and the mean number of symptoms was 2.2. Twenty (24.7%) of the call center operators developed their first symptoms within 3 months of the commencement of work, while 40 (49.4%) and 61 (75.3%) developed their first symptoms by 6 months and 12 months respectively. Symptoms experienced by call center operators are shown in Table 2. The most commonly reported otologic symptoms were otalgia (33.3%), tinnitus (31.3%), ear tingling (25.6%), autophony (23%), and hearing loss (17.8%) and the least frequent was burning sensation in the ear. Headache was the most frequently experienced symptom though non-otologic. All these symptoms were mostly transient lasting for a few minutes after work in 62 (76.5%), 1–3 h in 8 (9.9%), and more than 3 h in 11 (13.6%) of call center operators. The onset of symptoms was positively and statistically significantly correlated to

Table 1 Call center operators' work history

Variable	Frequency ($n = 90$) *n* (%)
Duration of working with headphones (years)	
1–3	68 (75.6)
> 3–10	19 (21.1)
> 10	3 (3.3)
Type of headphones	
Monaural	9 (10.0)
Right ear	5 (5.6)
Left ear	4 (4.4)
Binaural	81 (90.0)
Length of a work shift (h)	
≤ 8	66 (73.3)
9–12	24 (26.7)
Mean ± SD	8.42 ± 1.0
Number of days per week spent working with headphones	
≤ 5	84 (93.3)
> 5	6 (6.7)
Mean ± SD	5.07 ± 0.3

Table 2 Symptoms experienced by subjects call center operators after the onset of use of headphone

Symptom	Frequency *n* (%)
Headache	44 (48.9)
Otalgia	30 (33.3)
Tinnitus	28 (31.3)
Ear tingling	23 (25.6)
Autophony	20 (23.0)
Hearing loss	16 (17.8)
Hyperacusis	13 (14.4)
Aural fullness	11 (12.1)
Ear numbness	6 (6.7)
Loss of balance	5 (5.6)
Head fullness	5 (5.6)
Burning sensation in the ears	4 (4.4)

the duration of exposure to headphones as call center operators (rs = 0.492**, P <0.001). However, there was no statistically significant correlation between the duration of the job and the number of symptoms (rs = −0.023, P = 0.827).

Table 3 shows a summary of the comparisons of the call center operators' pre-shift hearing thresholds and the controls' hearing thresholds. Both groups recorded mild elevation of the hearing threshold at the lowest frequency (500 Hz) bilaterally. No statistically significant differences existed between the call center operators' pre-shift hearing thresholds and the controls' hearing thresholds for both right (p = 0.679) and left (p = 0.967) ears.

The impact of work shift on the hearing threshold was tested by comparing pre-shift and post-shift hearing thresholds in the call center operators. There was no high-frequency notch in the post-shift assessment. There were no statistically significant differences between pre-shift and post-shift hearing thresholds among the call center operators in the right (p = 0.748) and left (p = 0.919) ears (Table 4).

Discussion

This study aimed to evaluate the risk of hearing changes and the range of otologic symptoms among call center operators in Lagos State. The 18–40 years age range and peak age range of 25–29 years of call center operators in this study are similar to other studies [14, 15]. A high rate of resignation and turnover among the call center operators during the study resulted in a high attrition rate of 45.8%. Call center operators are mostly fresh graduates taking on this available job while seeking better jobs. A similar study in Australia reported a higher annual attrition and turnover rate among call centers operators than in the general industry, which was attributed to poor working conditions, health and safety issues, and work stress [17].

Table 3 Comparison of the pre-shift hearing thresholds of study subjects with the hearing thresholds of the control subjects

Hearing threshold (dB)			
Frequency (kHz)	**Study group Mean ± SD**	**Control group Mean ± SD**	**Significance (2-tailed)**
2-tailed	**Right ear**		
0.5	35.0 ± 11.0	34.9 ± 13.5	
1	22.4 ± 8.4	22.9 ± 7.3	
2	18.3 ± 9.1	19.3 ± 6.3	
3	17.3 ± 8.6	18.4 ± 7.0	
4	17.3 ± 9.4	18.1 ± 7.1	
6	17.9 ± 10.2	22.5 ± 9.8	
8	13.7 ± 8.4	16.2 ± 11.4	
PTA average	**25.4 ± 8.2**	**25.9 ± 7.8**	**0.679**
	Left ear		
0.5	33.6 ± 10.8	32.4 ± 13.3	
1	21.9 ± 8.6	23.2 ± 8.3	
2	18.2 ± 9.0	18.4 ± 7.6	
3	16.9 ± 8.2	18.6 ± 7.4	
4	16.3 ± 8.8	18.4 ± 7.6	
6	18.9 ± 8.4	22.2 ± 9.9	
8	13.9 ± 9.0	15.7 ± 11.4	
PTA average	**24.8 ± 8.5**	**24.7 ± 7.8**	**0.967**

Table 4 Comparison of pre-shift and post-shift hearing thresholds of the study subjects

Hearing threshold (dB)			
Frequency (kHz)	**Pre-shift Mean ± SD**	**Post-shift Mean ± SD**	**Significance (2-tailed)**
Right ear			
0.5	35.0 ± 11.0	35.6 ± 10.7	
1	22.4 ± 8.4	22.7 ± 9.6	
2	18.3 ± 9.1	18.5 ± 8.0	
3	17.3 ± 8.6	17.2 ± 8.1	
4	17.3 ± 9.4	16.6 ± 9.2	
6	17.9 ± 10.2	17.6 ± 10.5	
8	13.7 ± 8.4	11.3 ± 8.8	
PTA average	**25.4 ± 8.2**	**25.6 ± 8.1**	**0.748**
Left ear			
0.5	33.6 ± 10.8	33.4 ± 11.7	
1	21.9 ± 8.6	22.6 ± 10.0	
2	18.2 ± 9.0	18.3 ± 10.0	
3	16.9 ± 8.2	17.6 ± 8.0	
4	16.3 ± 8.8	16.1 ± 8.0	
6	18.9 ± 8.4	19.3 ± 9.8	
8	13.9 ± 9.0	12.8 ± 9.2	
PTA average	**24.8 ± 8.5**	**24.7 ± 8.9**	**0.919**

Hearing threshold changes

The pre-shift mean PTA of the call center operators and the mean PTA of the controls were both normal and had no statistically significant difference. A low-frequency elevation of the hearing threshold was noted in both call center operators and controls. Preponderant low-frequency elevation of the hearing threshold was similarly noted by Mazlan's study [18]. This can be attributed to the environmental noise in the assessment room, which was an average of 59.6 dB noise level in our study, or to the low energy of sound transmission at these frequencies resulting in difficulty hearing low-frequency tones as reported in Mazlan's study [18].

The non-audiometrically corroborated hearing loss reported by the call center operators in this study might be attributed to the effect of the fluctuation of the

headset noise levels during phone calls. The A-weighted sound pressure levels of the headphones are usually between 50 and 88 dB depending on the type of headset [19–21]. Exposure to higher noise levels may cause subjective hearing loss and/or permanent hearing loss [19]. Exposure to higher noise levels for a short duration or daily noise exposure levels exceeding the admissible level (85 dB) at 10% of workstations was shown to have a significant effect on the operator's overall noise exposure [19, 22]. The headset noise was not measured in this study due to the non-availability of the Knowles Electronics manikin for Acoustic Research (KEMAR) used for this purpose.

There was no statistically significant difference between the pre-shift and post-shift PTA among call center operators. The average noise level of 62.8 dB in the call operation halls during the day shift in this study was lower than what has been reported in other studies and in normal offices, which is above 62.8 dB [16, 17, 23]. It was also lower than the permissible noise exposure limit of 85 dB, the threshold above which prolonged exposure of 8 h or more may cause permanent hearing loss [12]. Our findings are consistent with what has been reported in the literature [17, 24]. The lack of elevated hearing thresholds in call center operators is not an unexpected finding given the duration of work history (1 to 3 years) among the studied "young" call center operators in this study, as well as the noise exposure level which did not exceed the permissible level. However, because of the consistent exposure to background noise induced by environmental settings and exposure to acoustical shock induced by headsets, call operators remain at risk of developing SNHL [3].

Range of otologic/non-otologic symptoms

The most frequently experienced otologic symptoms include otalgia (33.3%), tinnitus (31.1%), ear tingling (25.6%), and autophony (23.0%). Hearing loss was reported by only 17.8% of the call center operators. The least frequently experienced symptom was a burning sensation in the ear (4.4%). Headache (48.9%) was the most frequently experienced symptom though non-otologic. The range of symptoms reported in this study is consistent with the other studies [16, 25].

While the main cause of these symptoms is not part of the study design, the high frequency of headaches can be attributed to work stress [14]. Further, the frequency of reported tinnitus in this study is higher than what has been reported in the literature [26–28]. The potential explanation could be an acoustic shock [28]. Occasionally, call center telephone operators experience acoustic incidents such as a sudden loud shriek or piercing tone through their headsets, which cause symptoms like hyperacusis, tingling, dizziness and nausea, headaches, fullness of hearing, or tinnitus [28]. The longer the call center operators were on the job the more likely they were to develop symptoms. However, the duration on the job was not statistically related to the number of symptoms. The mean number of symptoms experienced by the call center operators was 2.2.

Only 8.9% of call center operators had documented pre-employment hearing assessment. The reason for the non-pre-employment hearing assessment for 91.1% of the call center operators is not clear. It, however, points to poor compliance on the part of the management of the call centers to the industry regulations and poor supervision by the supervising agencies.

Limitations

Limitations of this study include the non-use of extended high-frequency audiometry which is helpful in detecting noise-induced hearing loss. Also, the lack of objective hearing assessment such as otoacoustic emissions test (OAEs) which could potentially detect early cochlear damage before it shows up on the audiogram, and auditory brainstem response test (ABR) in which reduced wave 1 could signify cochlear synaptopathy (explaining the disconnect between the self-report of hearing loss and normal hearing sensitivity on audiogram). Lastly is the high attrition rate of 45.8% that was recorded in the study subjects.

Conclusion

The hearing ability of call center operators in this study was normal, comparable to that of the control, and was not affected even in the immediate post-shift. However, because of the consistent exposure to background noise induced by environmental settings and exposure to acoustical shock induced by headsets, call operators remain at risk of developing SNHL. Headache, otalgia, tinnitus, and other symptoms related to hearing are common among call center operators. Periodic hearing evaluation in addition to healthcare services to prevent or minimize these symptoms in this population should be provided due to its debilitating effects on health- and work-related outcomes.

Abbreviations

PTA: Pure tone audiometry; SNHL: Sensorineural hearing loss; dB: Decibel; Hz: Hertz; OAE: Otoacoustic emissions; ABR: Auditory brainstem response.

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Authors' contributions
DOOO contributed to the conceptualization, carrying out the research and literature review and data analysis. CNA contributed to the conceptualization, supervision of data collection, drafting, and revision of the manuscript. AOS contributed to the conceptualization and supervision of data collection, and revision of manuscript. CCN revised draft substantively and approved submitted version. All authors read and approved the final manuscript.

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Availability of data and materials
The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate
Ethics approval was obtained from Health Research and Ethics Committee of the Lagos University Teaching Hospital (LUTH) ADM/DCST/HREC/809. Written informed consent was obtained from the prospective subjects before enrolment into the study.

Consent for publication
Not applicable.

Competing interests
The authors declare that they have no competing interests.

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