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To cite this article: Özge Gedik Toker & Elif Kuru (24 Jan 2024): The effect of occupational exposure to noise and chemical agents on hearing abilities, Archives of Environmental & Occupational Health, DOI: [10.1080/19338244.2024.2305803](https://doi.org/10.1080/19338244.2024.2305803)

To link to this article: <https://doi.org/10.1080/19338244.2024.2305803>



Published online: 24 Jan 2024.



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# The effect of occupational exposure to noise and chemical agents on hearing abilities

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## ABSTRACT

Exposure to loud noise or chemical agents may cause hearing disorders such as tinnitus and recruitment, known as an increase in the perception of loudness in addition to hearing loss. Our study aims to evaluate the hearing abilities of hairdressers exposed to noise and chemical agents in the working environment. The study included one hundred hairdressers and one hundred participants who do not work as hairdressers or are nonworkers. The participants' demographic characteristics, working conditions, and auditory complaints were questioned, and each participant completed the Speech, Spatial, and Qualities of Hearing Scale (SSQ). A statistically significant difference was found between the two groups in speech perception, spatial perception, hearing quality, and general SSQ scores. Hairdressers' SSQ scores were significantly lower in all sub-dimensions and general scale scores ( $p < 0.001$ ). The auditory complaints of the hairdressers and the low SSQ scores indicate that exposure to noise and chemical agents affects the hairdressers' hearing system.

## ARTICLE HISTORY

Received 31 July 2023  
Accepted 9 January 2024

## KEYWORDS

Chemical exposure;  
hairdressers and hearing;  
noise-induced hearing loss;  
ototoxicity; SSQ

## Introduction

The second most common and health-threatening risk factor in the working environment is noise exposure, constituting 22% of occupational health problems.<sup>1</sup> Many studies show that occupational noise exposure directly causes hearing loss.<sup>2</sup> Occupational noise is an important risk factor for hearing loss in workers of all ages, and it is thought that 7–21% of adult-onset hearing loss worldwide is caused by exposure to occupational noise.<sup>1,3</sup> The National Institute for Occupational Safety and Health (NIOSH) estimates that the number of workers exposed to dangerous noise levels with or without ototoxic agents is 30 million.<sup>4,5</sup>

Noise causes inner and outer hair cell loss in the cochlea, decreased blood flow in the basal region, rupture of cell connections, excitotoxicity and loss of VIII nerve fibers, and cochlear synaptopathy.<sup>6–8</sup> Exposure to loud noise may cause hearing disorders such as tinnitus and recruitment in addition to hearing loss.<sup>6</sup> While noise accounts for the majority of occupational hearing loss, occupational chemical agent exposure is also a risk factor for hearing loss.<sup>4</sup> Among the many

chemicals found in the environment, the chemicals most known to cause ototoxicity are organic solvents such as toluene, styrene, xylene, and ethyl benzene, and exposure to these chemicals can significantly impair the auditory system.<sup>6,9,10</sup>

Millions of workers are exposed to noise at work every day, and uncontrolled noise exposure can cause permanent hearing loss.<sup>11</sup> Hairdressers are also among the occupational groups routinely exposed to these risk factors. Hair dryers used frequently and in large numbers in hairdressing salons can produce unwanted sounds between 60 and 95 dB.<sup>12,13</sup> Noise from hair dryers can harm human health, especially auditory function, as it is usually used very close to the ear.<sup>12</sup> However, it has been reported in the literature that chemical agents in hairdressers' working environments also cause adverse health effects. High concentrations of chemicals have been discovered, especially in some hairdressing salons.<sup>14</sup> It has been reported that these chemicals found in hairdressing salons contain volatile solvents, cetrimonium chloride, toluene, ethyl benzene, betaine monohydrate, ammonia compounds, cyanoacrylates, formaldehyde, methacrylate,

nitrosamines, etc.<sup>15-17</sup> Exposure to these chemicals, which are found in hair dyes, lightening agents, permanent wave solutions, shampoos, conditioners, and hair styling products, can have acute or chronic health effects.<sup>16</sup> Some studies have reported that hairdressers are at increased risk for certain health problems, including asthma, rhinitis, hypersensitivity pneumonia, and decreased lung function.<sup>18,19</sup> There are also studies reporting that chemicals in hair products are potentially carcinogenic and that hairdressers are more likely to develop lung, larynx, and bladder cancer.<sup>14,20</sup>

When the literature was reviewed, many studies were found in which occupational diseases in hairdressers were investigated. However, no study has been found that primarily aims to evaluate the hearing function of hairdressers, who are often exposed to noise and chemical agents that may threaten hearing health in their working environments. For this reason, we aim to evaluate the possible effects of noise and chemical agents on the auditory system of hairdressers.

## Materials and methods

This research was conducted in the Audiology Clinic of Bezmialem Vakıf University. The Bezmialem Vakıf University Non-Interventional Research Ethics Committee approved the study on 07 February 2023 (decision number: 2022/407).

Voluntary consent of the participants was obtained via Google Forms, and individuals who volunteered were included in the study. We reached the heads of hairdresser associations, and they helped us with data collection by communicating with hairdressers on their social media accounts. For the control group, we reached participants via the researchers' social media accounts. Participants in the control group included teachers, bankers, students, nurses and people who were not working. Their common feature is that none of them were exposed to noise in the work environment. In the study group, 109 people filled out the form, but nine people were excluded from the study due to hearing loss onset before the hairdressing profession and working in another occupation where noise/chemical agents were present before the hairdressing profession. In the control group, 135 people filled out the form, but 35

were excluded from the study due to noise/chemical agent exposure in their current and/or previous working life. From the study group, 100 participants whose age range was 25-57 (mean  $\pm$  SD: 40.96  $\pm$  7.76) and from the control group, 100 participants whose age range was 25-56 (mean  $\pm$  SD: 39.29  $\pm$  7.99) were included in the study. The questions, including demographic information, auditory complaints, exposure to noise outside of work, and information about the working environment, and the Speech, Spatial, and Qualities of Hearing Scale (SSQ) transmitted to women's hairdressers (study group), and non-hairdresser or non-worker individuals (control group) via Google Forms. SSQ scale was developed by Noble and Gatehouse in 2004 at MRC Institute of Hearing Research, Glasgow, UK, to evaluate the sub-components of hearing and hearing quality in detail and to determine the level of disability caused by the current hearing problem.<sup>21</sup> It was adapted to Turkish, and its validity and reliability study was conducted by Kılıç et al. (2021).<sup>22</sup> The SSQ scale evaluates the reality of hearing in daily life in a wide range. The SSQ consists of the sub-headings of speech perception, spatial perception, and hearing quality and is a 10-point Likert scale with 14, 17, and 18 questions, respectively, with a total of 49 questions. It aims to evaluate the parameters of hearing speech sounds in various conditions, direction, distance, and movement components of spatial perception, distinguishing sounds in simultaneous speech, ease of listening, the naturalness of voice, clarity and identifying different speakers, different musical pieces and instruments, different everyday sounds.<sup>21</sup>

According to data received from the Ministry of Commerce of the Republic of Turkey, the total number of women's hairdressers in Turkey was determined to be 32.067.<sup>23</sup> With a population size of 50.000, the sample size was calculated as 96 with a sampling error of 0.10 and a significance level of 0.05.<sup>24</sup>

A descriptive statistical analysis was performed to determine the characteristics of the study and control groups. Exploratory factor analysis (EFA) was performed to determine the reliability of the SSQ scale. Cronbach's alpha reliability coefficient was determined. Kolmogorov-Smirnov (K-S) test was performed using SPSS 25 to determine

whether the data set is normally distributed. As a result of this test, since the Z value of scale and dimensions was  $p < 0.05$ , it was decided that the data were not normally distributed, and therefore, the Mann-Whitney U difference test was performed. To evaluate the effect of working time, the study group was divided into two groups: more than ten years working time and ten years or less working time in the hairdressing profession. Mann-Whitney-U test was used to measure the difference in SSQ scores between these two groups. The results were evaluated at the  $p < 0.05$  significance level.

Additionally, the Pearson Chi-Square test was used to determine the relationship between length of working time and difficulty understanding noise. The results were evaluated at the  $p < 0.05$  significance level. In addition, Cross-tabulation was performed to show the percentage relationship between working time and tinnitus and between working time and hearing loss.

## Results

Demographic data of the study and control groups are shown in Table 1. There was no significant difference between the groups regarding age and gender.

Transactions performed by hairdressers in the hair salons, the average daily exposure to noise/chemical agents, the questions about the work environment, such as at least how many hair dryers are

working at the same time, and hairdressers' complaints after working hours are shown in Table 2.

It was stated by 54% of the hairdressers who participated in our study that they had difficulty communicating with others when there was noise in the working environment. In addition, after leaving work, 41% of hairdressers reported that they felt tinnitus/buzzing, and 22% reported that they felt a decrease in their hearing. The auditory complaints of the study and control groups were questioned. The auditory complaints of the participants in the study group according to their working time and the percentage values of the answers are shown in Table 3.

Before starting the EFA, Kaiser-Meyer-Olkin (KMO) and Bartlett's sphericity test were performed to determine whether the scale items were suitable for analysis. The KMO result was 0.948, and Bartlett's sphericity test result was significant ( $\chi^2=7556,209$ ;  $p < 0.001$ ). Items with a factor load below 0.40 or gathered under other factors as a result of EFA (Speech 2, Speech 13, Spatial 3, Spatial 14, Spatial 15, Spatial 16, Qualities of Hearing 2, Qualities of Hearing 7, Qualities of Hearing 11, Qualities of Hearing 14, Qualities of Hearing 15, Qualities of Hearing 18) were excluded from the analysis. In the repeated analysis, the scale was consistent with the original, and the items were grouped under three factors. The variance and Cronbach's alpha reliability coefficient explained by each dimension and scale in the final form of the scale are shown in Table 4.

**Table 1.** Demographic data of groups.

Demographic data	Study group		Control group	
Age (Mean $\pm$ SD)	40.96 $\pm$ 7.76		39.29 $\pm$ 7.99	
Range	25–57		25–56	
Gender	52F/48M		58F/42M	
Working time (year)	Year	n/%	Year	n/%
	1–2	10	1–2	27
	3–4	3	3–4	18
	5–10	5	5–10	16
	>10	82	>10	29
Weekly working time (day/week)			Non-worker	10
	Day	n/%	Day	n/%
	5–6 days	83	1–2 Day	2
	7 days	17	3–4 Day	6
Daily working time (hour/day)			5–6 Day	82
	Hour	n/%	0 Day	10
	5–8 Hour	11	Hour	n/%
	>8 Hour	89	0–4 Hour	2
			5–8 Hour	58
Exposure to non-working noise (listening to loud music)	Yes (n/%)	No (n/%)	Yes (n/%)	No (n/%)
	17	83	45	55
			0 Hour	10
		>8 Hour	30	

**Table 2.** Work environment status and after-hours complaints of the study group.

Transactions	Transaction								n/%
	Hair dyeing								17
	Hair drying								5
	Hair dyeing + permanent hair styling								3
	Hair drying + permanent hair styling								1
	Hair drying + hair dyeing								2
	Hair drying + hair dyeing + permanent hair styling								72
Minimum number of hair dryers working simultaneously	Number	1	2	3	4	5	6	7	
	n/%	33	39	13	8	1	3	3	
Average daily exposure to hair dryer (hours/day)	hour	<1h	1–2h	3–4h	5–6h	7–8h	>8h		
	n/%	1	11	33	32	11	12		
Average daily exposure to chemical agents (hours/day)	hour	<1h	1–2h	3–4h	5–6h	7–8h	>8h		
	n/%	5	12	28	29	10	16		
Do you find it difficult to communicate with others when there is noise in the work environment?		Undecided						20%	
		Yes						54%	
		No						26%	
Do you feel tinnitus/buzzing after work?		Yes (n/%)						No (n/%)	
		41						59	
Do you feel a decrease in your hearing after leaving work?		22						78	

**Table 3.** Auditory complaints of the study and control group.

Complaints		Study group (n/%)		Control group (n/%)	
Tinnitus	Bilateral	20	≤10 Years working time: 11.2 %	Bilateral	4
	Right	5	>10 Years working time: 31.8 %	Right	1
	Left	3		Left	2
	No complaints	72	≤10 Years working time: 88.9 % >10 Years working time: 68.3 %	No complaints	93
Hearing loss	Bilateral	12	≤10 Years working time: 5.6 %	No hearing loss	
	Right	6	>10 Years working time: 29.2 %		
	Left	7			
	No hearing loss	75	≤10 Years working time: 94.4 % >10 Years working time: 70.7 %		
Difficulty understanding speech in noise	Yes	63	≤10 Years working time: 38.9 % >10 Years working time: 68.3 %	Yes	24
	No	37	≤10 Years working time: 61.1 % >10 Years working time: 31.7 %	No	76

When the results of the study and control groups were compared, a statistically significant difference was found between the two groups in speech perception, spatial perception, hearing quality, and general SSQ scores. The scores of the study group were found to be significantly lower in all sub-dimensions and general scale scores ( $p < 0.001$ ). The value of the scale dimensions of both groups is shown in Table 5. To evaluate the effect of working time, the SSQ scores of hairdressers with more than ten years of working time and those with ten years or less were compared. Spatial, qualities of hearing, and general SSQ scores of hairdressers with more than ten years of experience were found to have significantly decreased, and the results are shown in Table 6.

## Discussion

Our study evaluated the effect of exposure to noise and chemical agents on the auditory system

in hairdressers with the SSQ scale. As a result of the study, it was determined that speech perception, spatial perception, and hearing quality were significantly lower in hairdressers than in the control group.

While OSHA allows up to 8 h of exposure to 90 dB(A) noise,<sup>25</sup> NIOSH allows 85 dB(A),<sup>26</sup> and WHO allows 75 dB(A);<sup>27</sup> however, it is estimated that 22 million workers are exposed to potentially damaging noise in the workplace each year.<sup>28,29</sup> According to OSHA, if we have to speak louder to talk to someone one meter away, the noise level in our environment can be over 85 dB. Also, if we experience tinnitus, buzzing, or temporary hearing loss when we leave work and shout to be heard by a colleague an arm's length away, we may have a noise problem in our workplace.<sup>30</sup> The data we obtained supports OSHA's warning and shows that noise is a problem in the working environments of hairdressers.

**Table 4.** The results of the exploratory factor analysis of the SSQ scale.

Items	Speech	Spatial	Qualities of hearing	Variance (%)	Cronbach alpha
Speech 1	0.749				
Speech 3	0.600				
Speech 4	0.793				
Speech 5	0.786				
Speech 6	0.775				
Speech 7	0.756				
Speech 8	0.716			24.788	0.957
Speech 9	0.716				
Speech 10	0.712				
Speech 11	0.748				
Speech 12	0.683				
Speech 14	0.690				
Spatial 1		0.626			
Spatial 2		0.637			
Spatial 4		0.638			
Spatial 5		0.713			
Spatial 6		0.715			
Spatial 7		0.719		24.341	0.972
Spatial 8		0.765			
Spatial 9		0.788			
Spatial 10		0.741			
Spatial 11		0.764			
Spatial 12		0.687			
Spatial 13		0.664			
Spatial 17		0.654			
Qualities of Hearing 1			0.800		
Qualities of Hearing 3			0.698		
Qualities of Hearing 4			0.813		
Qualities of Hearing 5			0.647		
Qualities of Hearing 6			0.752		
Qualities of Hearing 8			0.758	23.668	0.958
Qualities of Hearing 9			0.726		
Qualities of Hearing 10			0.725		
Qualities of Hearing 12			0.622		
Qualities of Hearing 13			0.592		
Qualities of Hearing 16			0.645		
Qualities of Hearing 17			0.718		
SSQ total				72.797	0.981
KMO					0.948
Bartlett's Test of sphericity			Chi-square		7556,209
			df		666
			p		<0.001

**Table 5.** Comparison of SSQ sub-dimensions and general score by groups\*.

Dimension	Group	n	Mean ± SD	p Value
Speech	Study	96	6.242 ± 2.269	<0.001
	Control	97	8.012 ± 1.377	
Spatial	Study	87	6.843 ± 2.371	<0.001
	Control	99	8.609 ± 1.178	
Qualities of hearing	Study	90	7.970 ± 1.889	<0.001
	Control	94	9.229 ± 0.868	
SSQ	Study	81	7.020 ± 1.964	<0.001
	Control	90	8.626 ± 1.000	

\*Increase in the SSQ score indicates better hearing performance.

**Table 6.** Comparison of SSQ scores of participants in the study group according to working times

Dimension	Group	n	Mean ± SD	p Value
Speech	≤10 Years	17	6.955 ± 2.455	0.155
	>10 Years	79	6.088 ± 2.214	
Spatial	≤10 Years	12	8.109 ± 2.144	0.032
	>10 Years	75	6.641 ± 2.356	
Qualities of Hearing	≤10 Years	15	8.944 ± 1.084	0.033
	>10 Years	75	7.775 ± 1.958	
SSQ	≤10 Years	11	8.174 ± 1.950	0.018
	>10 Years	70	6.839 ± 1.917	

Most of the equipment used in the hairdressing and cosmetics industry can typically generate noise above the permissible limit in the workplace. Since hairdressers from a total of 80 different women's hair salons from each of the seven regions in Turkey were included in our study, it was impossible to measure the noise level of hair salons. However, we questioned how many hair dryers are working simultaneously. It was reported by 39% of hairdressers that at least two hair dryers were working simultaneously daily. Hair dryers produce sound in the 60–95dB range, and such high noise levels can potentially lead to noise-induced hearing loss (NIHL).<sup>31</sup> In addition, when more than one noise source works simultaneously, this effect on the environment is multiplied. For example, when two sound sources producing 90 dB work together, the sound level

will increase to 93 dB, and when three sound sources work together, the sound level will increase to 95 dB.<sup>25</sup> Also, 88% of the hairdressers reported that the average daily hair dryer exposure was 3–4 h or more, and 12% reported exposure to hair dryer noise for more than 8 h a day. Considering that NIOSH allows 85 dB(A) noise exposure for a maximum of 8 h and 88 dB(A) noise for a maximum of 4 h, it is inevitable to observe the adverse effects of noise in hairdressers.<sup>26</sup> In addition, proximity to the noise source is also known to increase the damaging effect, and for individual use, the hair dryer is usually operated at a distance of 1–6 inches.<sup>31</sup>

Noise is present in most occupational environments therefore, hearing impairments observed among workers are often referred to as NIHL. However, in addition to noise, ototoxicity is one of the important factors that cause hearing loss in hairdressers.<sup>32</sup> Research shows that exposure to certain chemicals, called ototoxic, can adversely affect the functioning of the ear independently of noise exposure, causing hearing loss and/or balance problems.<sup>33,34</sup> Chemical agents have been reported to damage cochlear hair cells and peripheral nerve endings, and their effects are not limited to the cochlea.<sup>32</sup> Reports have shown that retrocochlear and central effects may also be associated with these exposures.<sup>35,36</sup> Since chemical agents can affect the central auditory system, frequency, temporal and spatial resolution, and speech discrimination function may be affected. This can make it difficult to work in noisy environments and increase the risk of workplace injury due to the inability to hear coworkers, environmental sounds, and warning signals.<sup>11</sup> Compared to other disability questionnaires, the SSQ focuses specifically on perceiving speech sounds in various competing contexts and on the direction, distance, and movement components of spatial hearing. In addition, the SSQ evaluates the separation of sounds, participation in simultaneous speech flows, recognition of different sounds, and ease of listening. Central auditory attention and cognitive factors get involved in these hearing-speech abilities.<sup>21</sup> Banh et al. (2012) compared SSQ scores in different age groups with normal hearing and observed that SSQ scores decreased with aging.<sup>37</sup> In another study, Demeester et al.

(2012) observed a decrease in SSQ scores in the age-related hearing loss group compared to age-matched normal hearing individuals.<sup>38</sup> The results of these two studies show that the SSQ is affected by cochlear and retrocochlear disorders and aging. In this context, our study findings suggest that chemical agents and noise exposure affect auditory performance *via* a significant decrease in SSQ scores.

Studies show that exposure to chemical agents is a risk factor for hearing loss.<sup>11,39</sup> Cosmetic products are indispensable products for hairdressing salons. They can contain up to nine thousand different ingredients, and hundreds of them are used in hairdressing salons.<sup>40</sup> These products include shampoos, conditioners, hair dyes, and various sprays, which often contain a mixture of several different chemicals.<sup>41</sup> Hairdressers are in contact with hair care products daily and are exposed to potentially hazardous chemicals through inhalation and/or skin contact.<sup>42</sup> Potassium or sodium bromate and thioglycolates are also routinely used in hairdressing salons as perm lotion and hair neutralizers in permanent hair styling processes.<sup>33</sup> Reported toxic effects of potassium and sodium bromate include diarrhea, hearing loss, peripheral neuropathy, hemolytic anemia, vomiting, and acute renal failure. The most common symptom of bromate poisoning is hearing loss.<sup>34,43</sup> In our study, 82% of the hairdressers stated that they have been practicing this occupation for over ten years, and 83% reported that the average daily exposure to chemical agents is 3–4 h or more. The literature has reported that long-term exposure to low-intensity noise<sup>44,45</sup> and chemical agents<sup>46,47</sup> may cause auditory problems. In our study, low SSQ scores and an increase in auditory complaints were observed in people who have been hairdressers for more than ten years, and these results support the literature. However, the type of chemical agents that the hairdressers in our study were exposed to was not questioned. This is one of the limitations of our research.

The hearing system is vulnerable to various chemicals, including organic solvents.<sup>48</sup> Although its effects can be observed independently from noise exposure, studies report that exposure to chemical agents and noise together increase the ototoxic effect.<sup>5,49,50</sup> In our study, 72% of the hairdressers reported that they applied all of the hair

drying, dyeing, and permanent hair styling processes in their daily work routine, which is thought to increase auditory exposure. It will not be possible to independently evaluate the effects of noise and chemical agents on the auditory system since these physical and chemical factors are generally found together in work environments. In addition, there is not yet a gold standard auditory test battery that can evaluate the situation caused by both factors separately for workers exposed to chemical agents only with chemical agents or noise.<sup>51,52</sup> The most important element in diagnosing hearing loss due to noise or chemicals is exposure history, usually obtained through anamnesis or questionnaires.<sup>32</sup> Pure tone audiometry, the gold standard test in the diagnosis of hearing loss, also does not provide information about sound perception and hearing quality, so it does not provide a complete evaluation of hearing function.<sup>53</sup> It also requires special equipment and a soundproof booth, making it a costly test for use in field studies.<sup>54</sup> Questionnaires based on daily listening performance reported by individuals are important in this point and can be used as a hearing screening.<sup>53</sup> For these reasons, in our study, the exposure history of hairdressers was questioned, and speech perception, spatial perception, and hearing quality were evaluated with the SSQ scale. Since the clinical audiological evaluation method was not used in our study, we could not obtain information about the location of the damage that may have been caused by exposure to noise and chemical agents in the auditory system. Although this is a limitation of our study, the absence of any study evaluating the auditory status of hairdressers in the literature and the statistically significant low SSQ scores in hairdressers, this study will pioneer further studies.

According to the literature, acquired hearing loss caused by noise and chemical agents usually progresses slowly and, in the long term, can cause a decline in quality of life and productivity, cognitive decline, depression, difficulties in education and social integration, and significant economic burden.<sup>3,6</sup> In our study, hairdressers reported auditory complaints such as hearing loss, tinnitus, and difficulty in understanding speech in noise, and these complaints emerged after starting the hairdressing profession in all of the hairdressers.

However, it is impossible to answer which part of the auditory system is affected by these data.

Since hairdressing salons are closed areas, indoor air quality and ventilation conditions are important. As a result of insufficient ventilation, pollutants and chemical agents accumulate in hairdressing salons. It has been reported in the literature that improvements such as the establishment and use of appropriate ventilation systems should be made to reduce the effects of exposure in hairdressers who are frequently exposed to noise and chemical agents in the working environment.<sup>55</sup> Another limitation of our study is that the ventilation and filtration conditions in hairdressing salons were not questioned. Also, the socioeconomic, educational status and annual income of the participants in both groups were not questioned in our study. This cross-sectional study was conducted online via a google form, so the participation rate is unknown. The individuals included in the study are convenience participants and do not represent all hairdressers. In addition, the participants' full occupational and environmental history could not be obtained, so the existence of other factors that may affect hearing is unknown. Furthermore, another limitation of our study is that the participants were not questioned about alcohol, cigarette and drug use.

To summarize, hairdressers are generally exposed to noise and chemical agents for a long time in their working environments. It was determined in our study that hairdressers had auditory complaints and adverse effects on their auditory performance however, it is important to evaluate the auditory systems of hairdressers with a broader test battery in future studies. In addition, improvements such as the use of protective equipment, working hours regulation, and ambient ventilation may be beneficial in terms of eliminating the factors that may threaten the hearing health of hairdressers.

### Acknowledgments

The authors thank Kerem Toker, Associate Professor, for control of statistical analysis and manuscript. The authors report that there was no funding source for the work that resulted in the article or the preparation of the article.

## Ethical approval

Bezmiâlem Vakıf University, Non-Interventional Ethics Committee with the decision number 2022/407 on 07/02/2023. The participants were included in the study on a voluntary basis and each participant signed a voluntary consent form.

## Author contributions

Özge Gedik Toker; conception or design of the work; drafting the work or revising it critically for important intellectual content; the acquisition, analysis, or interpretation of data for the work; writing manuscript and final approval of the version to be published; agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. Elif Kuru; the acquisition, analysis, or interpretation of data for the work; drafting the work or revising it critically for important intellectual content; agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.



## Disclosure statement

No potential conflict of interest was reported by the author(s).

## Funding

The author(s) reported there is no funding associated with the work featured in this article.

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