

## PROLONGED WORK IN KINDERGARTEN AND THE RISK OF HEARING PROBLEMS

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**Abstract:** Excessive noise exposure is one of the main causes of hearing loss. There are numerous researches that prove high noise levels in kindergartens. Therefore, teachers and their assistants are at risk of developing hearing problems like tinnitus, hearing loss, difficulties to understand speech in noise which negatively affect their quality of life. The prolonged working period of the staff in the kindergarten increases the risk of developing hearing problems. The problem of noise in the workplace could be overcome by implementing various prevention measures such as periodic assessment of hearing and hearing skills. The study aims to investigate whether noise and years of experience in kindergarten negatively affect the hearing of teachers and their assistants. To achieve the objectives of the study, a questionnaire was developed with questions about auditory skills in everyday life. All participants had an otoscope examination, audiological assessment with pure tone audiometer and an original author's speech-in-noise test with a set of 80 words (40 one-syllable words and 40 two-syllable words). The study involved 20 kindergarten teachers aged from 30 to 60, with an average age of 44. The participants were divided into two groups depending on the length of work experience in the kindergarten. The analysis of the obtained data revealed that teachers with less experience in kindergartens (up to 10 years) have normal hearing, and 60% of teachers with prolonged work experience that is more than 11 years have hearing loss. The results collected from the assessment were described and analyzed with Statistical Package for the Social Sciences software. A statistically significant difference was found in the results between the two groups of the audiological examination of high frequencies (3000 Hz, 4000 Hz and 8000 Hz). Most of the teachers and assistants who are working over eleven years at the kindergarten demonstrated difficulties in perception of high frequency sound signals from the audiological assessment. The younger employees with less working experience in the kindergarten showed better results at understanding words in noise. Long-term exposure to noise in kindergarten leads to progressive hearing loss, which ultimately affects the understanding of speech and more specifically when it has to be perceived in the presence of background noise. This has a negative impact on the quality of life of the individual. It is necessary to take actions for prevention and early assessment of hearing disorders in risk groups for occupational noise-induced hearing loss like teachers and their assistants in kindergartens, working toward to reduce noise in the kindergarten building.

**Keywords:** hearing impairment, noise, speech intelligibility, background noise speech, kindergarten teacher, kindergarten

### 1. INTRODUCTION

In recent years, the World Health Organization (WHO) has paid attention to the persistent exposure to loud noise that cause health problem such as acquired hearing disorders (Portnuff & Claycomb, 2020). Excessive noise exposure is one of the main causes of hearing loss. Single exposure to loud sound usually causes temporary hearing impairment and tinnitus, but the prolonged exposure to loud noise leads to permanent hearing loss. Noise with a traumatic effect on the human body depends on the intensity, duration and spectrum (Wattman, 2019). Noise induced hearing loss is a result of prolonged and persistent loud noise exposure that permanently injured or destroyed the cochlear hair cells. This process is irreversible. Therefore, it means that once the cochlear hair cells are dead, then hearing loss becomes permanent (Brice, 2021). Noise induced hearing loss can be a result of loud noise at work, the environment (traffic, subway etc.) or even of leisure activities like listening to loud music and going to night clubs. Working prolonged period in an environment with loud noise can lead to negative effect on health and well-being – stress, (Grebennikov & Wiggins, 2006), sleep disturbance, fatigue, annoyance (Hong, et al., 2013), tinnitus (Kang et al., 2021) and hearing problem known as noise induced hearing loss in the work place (Behar, 2021). The meta-analysis conducted by Livingston et al. (2020) found that risk factor with high prevalence (31,7%) in midlife that can contribute to increased dementia risk in later life is hearing loss.

Often, people working in noisy environments do not realize how much noise damages their hearing. In fact, most of them do not know how to protect themselves. Hearing loss occurs gradually over time and is difficult for them to notice. People often realize that they have hearing loss by the reactions of others in communication situations. Generally, in cases of noise induced hearing loss are typical the “V notch” audiograms that occur first in the range of audible frequencies from 3000 Hz to 6000 Hz and after that the hearing loss spreads to other frequencies – higher and lower (Brice, 2021). Patients with noise induced hearing loss demonstrate difficulties in speech comprehension, especially with background noise (Behar, 2021). In particular, identification of high-frequency speech sounds is

affected (Brice, 2021; Kwon & Lee, 2021). Certain sounds in Bulgarian language including high-frequency sounds are the consonants [f, s, ʃ, tʃ, z] and the vowels [e, i] (Padareva-Ilieva, 2015).

The research on occupational noise induced hearing loss is most often related to factory workers, miners, construction workers and other professions where workplace noise is above 85 dB(A) for most of the working day. In fact, less attention is paid to teachers and their assistants who are exposed to noise in the kindergarten. There are numerous researches that prove high noise levels in kindergartens (Martins et al. 2007; Sarantopoulos et al., 2014; Aguilar & Tilano, 2019). The study by Mealings (2016) investigated the literature for typical noise levels in classrooms worldwide. The values of noise level in classrooms vary from 28 dB(A) when the room is unoccupied to 75 dB(A) in occupied room. The levels of background noise are higher in the kindergartens compared to schools. She provided recommendations for overall acoustic levels for classrooms in kindergartens where good values for noise levels are from < 30 dB(A) to < 50 dB(A) and the values for bad noise levels are from > 40 dB(A) to > 55 dB(A) (Mealings, 2016). For example, a study conducted by Martins et al. (2007) registered background noise in kindergarten's classrooms ranging from 59.8 dB(A) to 89 dB(A). Therefore, teachers and their assistants are at risk of developing voice problems (Remacle, Morsomme & Finck, 2014), hearing problems (Martins et al., 2007) like tinnitus, hearing loss, difficulties to understand speech in noise which negatively affect their quality of life (Fredriksson, Kim, Torén, Magnusson, Kähäri, Söderberg, Wayne, 2019). The prolonged working period of the staff in kindergarten increases the risk of developing hearing problems. During the COVID-19 pandemic the furniture made of soft materials such as armchairs or sofas, poufs and carpets were removed from kindergarten classrooms that participated in the study to facilitate cleaning and disinfection. The lack of sound absorption materials in rooms produces excessive reverberation. As a consequence of this, the ambient noise increases and degrades speech intelligibility in classrooms (Aguilar & Tilano, 2019).

The occupational noise induced hearing loss is preventable and can be early identified with proper healthcare actions in order to reduce the negative effects on hearing (Leensen & Dreschler, 2013; Frederiksen et al. 2017; Sethunga et al., 2022). The problem of noise in the workplace could be overcome by implementing various prevention measures such as periodic assessment of hearing and hearing skills. Some of the recommendations for identification and assessment of this type of hearing loss are: pure-tone audiometry to measure the hearing sensitivity (Kwon & Lee, 2021) and speech recognition in noise (Akeroyd et al., 2015; Liberman, Epstein, Cleveland, Wang, & Maison, 2016).

The study aims to investigate whether noise and years of experience in kindergarten negatively affect the hearing of teachers and their assistants.

## 2. MATERIALS AND METHODS

To achieve the objectives of the study, a screening questionnaire was developed. It consisted of questions about auditory skills in everyday life that directed the researcher's attention to the presence of symptoms of hearing problems. The questions were Likert-type with 3 items: 1 – never, 2 – sometimes and 3 – always.

The research was conducted in a quiet room in the kindergarten building away from the classrooms. All participants had an otoscope examination to exclude cases with otitis externa and otitis media, or those with earwax. Those who passed the screening with the otoscope were included in the study. They were 20 female kindergarten teachers and assistants aged from 30 to 60, with an average age of 44. The participants were divided into two groups depending on the length of work experience in the kindergarten. All of them underwent audiological assessment with pure tone screening audiometer – air-conduction measures. Following the American Speech-Language-Hearing Association (2005) guidelines, threshold assessment was made at 250, 500, 1000, 2000, 3000, 4000, 6000, and 8000 Hz. Normal hearing ranged from -10 to 15 dB. The slight hearing loss ranged from 16 to 25 dB, then the mild hearing loss ranged from 26 to 40 dB, from 41 – 55 dB is moderate hearing loss, from 56 – 70 dB is defined as moderately severe, the ranged from 71 to 90 dB is indicated as severe hearing loss and 91 + dB is defined as profound hearing loss (Kramer & Brown, 2019).

There are two tests for speech audiometry in Bulgaria. The first one was published by L. Shishkov in 1963 and it consisted of list with one-syllable words. The second one was published by the same author in 1966 and it was with 200 two-syllable words (Frengov, 2011). There is not a scientific publication with an updated version of these tests for speech audiometry in Bulgaria. Last years the speech in noise test became very popular. For the purposes of the research the author of the current study designed and developed an original speech-in-noise test with a set of 80 words (40 one-syllable words and 40 two-syllable words). The set of words is divided in two groups – 40 words with predominant low-frequency speech sounds and 40 words with predominant high-frequency speech sounds. The assessment with the speech-in-noise test was conducted in free field. The participants were sitting in front of two speakers placed in one meter distance. The recording of the set of words was played from a personal computer with an intensity of 55 – 65 dB. Each participant had to repeat the word she heard.

The data from the assessment was analyzed with Statistical Package for the Social Sciences software. Descriptive statistics was used for the answers from the screening questionnaire. The Mann-Whitney U test was applied to examine the hypothesis that the audiological results and speech-in-noise comprehension test results would be different for the participants in the two groups. The Rank correlation of Spearman's was conducted to study if there was a correlation between the length of work experience in kindergarten and the results from the audiological assessment and the speech-in-noise test.

### 3. RESULTS AND DISCUSSION

Description of the results from the screening questionnaire is presented in Table 1. Positive answers of these questions are "red flags" for hearing problems. More positive answers suggest hearing loss.

*Table 1 Results from the screening questionnaire.*

№	Questions	Participants with work experience up to 10 years			Participants with work experience more than 11 years		
		Never	Sometimes	Always	Never	Sometimes	Always
1.	Do you listen to loud music?	50%	40%	10%	100%	0	0
2.	Do you have a headache at the end of the workday?	40%	30%	30%	30%	20%	50%
3.	Do you ask people to repeat what they have said?	40%	40%	20%	70%	0	30%
4.	Do you ask your interlocutor to speak more slowly and clearly?	60%	30%	10%	80%	0	20%
5.	Do you say "Huh?" or "What?" five or more times a day?	60%	10%	30%	90%	10%	0
6.	Do you find it difficult to understand your communication partner when it is noisy?	30%	40%	30%	40%	10%	50%
7.	Do you speak in a loud voice?	0	50%	50%	30%	10%	60%
8.	Do you often increase the TV volume?	50%	30%	20%	40%	20%	40%
9.	Do you understand your communication partner better if you watch his/her mouth when speaking?	60%	20%	20%	60%	10%	30%
10.	Do you feel pain in your ear(s) at the end of the workday?	100%	0	0	90%	0	10%
11.	Do you have tinnitus after the end of the workday?	80%	10%	10%	80%	0	20%
12.	Do you find it difficult to understand what your communication partner is saying on the phone?	80%	10%	10%	70%	10%	20%

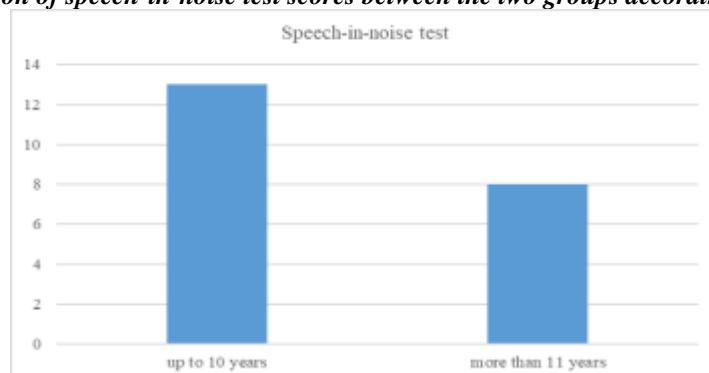
According to the answers of the first question from the survey younger teachers and assistants liked to listen to loud music. All participants from the second group gave negative answers to the first question. One of them commented that children were very noisy in the classroom and usually after work she got home, turned off all devices (TV, radio, equipment in the kitchen) and asked the family to keep quiet for at least 1-2 hours so she could relax. Most of the personnel with prolonged work experience reported headache at the end of the workday. Two of them felt this discomfort sometimes and half of the group had indicated as an answer – "always". Three of the younger participants also strongly stated that they always had headache after work and the same amount are the "sometimes" answers. The headache is a common symptom of noise-induced hearing loss and 80% of the interviewed individuals indicated this complaint. Actually, when the participants were asked the next 3 questions related to communication situations, many of them said that they never thought about it or paid attention to it. More respondents from the prolonged work experience group answered that in a conversation they never asked their interlocutor to repeat what was said. Four from the other group gave the same answers. In fact, less experienced kindergarten personnel felt some difficulties in communication situations and sometimes (4 respondents) or always (2 respondents) asked for

repetition of the communication partner's words. The answers to the next question were more definite. Many individuals declared that they never asked their interlocutor to speak more slowly and clearly. Six people with work experience shorter than 10 years and eight people from the other group gave negative answers. Similar were the answers of the fifth question. It investigated how often during the day kindergarten's personnel did not hear well what their communication partner said and prompts him/ her to repeat what was said. Most teachers and assistants declared difficulties in understanding speech with background noise. This was reported as one of the symptoms typical for noise-induced hearing loss (Akeroyd et al., 2015; Liberman et al., 2016; Fredriksson et al., 2019; Brice, 2021; Hatzopoulos et al., 2021). Working at noisy environment like kindergarten often leads to voice problems (Remacle et al., 2014; Fredriksson et al., 2019). Teachers speak in education hours and during the children play time when they scream, laugh, make noise with the toys. These facts explained the answers of the seventh question. The participants with work experience up to 10 years sometimes (50%) or always (50%) use excessive voice. Interesting were the responses of the participants with work experience more than 11 years. Three of them never used loud voice. They added that they had a voice disorder in the past and had to stop working for a period of time because of it. In fact, since then they tried to use appropriate voice loudness when speaking. One of them underwent speech therapy to change her vocal behavior. Half of the younger and less experienced respondents never increased the TV volume. The positive answers from the other group of the participants were more – four of them always and two of them sometimes had problems to hear what was said on the TV when watching it with the family. These were the teachers and assistants with detected hearing loss from the pure-tone audiometry. It was another symptom related to hearing loss and proved with the audiological examination. Only one participant felt pain in the ears and tinnitus at the end of the workday and this was an individual with ascertained hearing loss from the audiological assessment. She found it difficult to understand what was said when talking on the phone. She is the only respondent with predominant positive answers in the survey. There weren't many cases with prevailing "red flags" after completing the questionnaire. Hence, it could be assumed that a greater proportion of the studied individuals would have normal hearing. But in fact, the audiological examination showed different results than expected.

The summary of the pure-tone audiometry was done by calculating a pure tone average for each ear over a particular frequency range. Most of the studies calculated a pure tone average using values obtained at 500, 1000, 2000, and 4000 Hz (Hatzopoulos, 2021). The results from the pure-tone audiometry showed that all teachers and assistants at kindergarten with less work experience (up to 10 years) have normal hearing. But the audiological assessment is totally different for the personnel with prolonged work experience that is more than 11 years. It identified hearing loss in 60% of the assessed individuals. All of them were with slight hearing loss on both ears. The difference between the two groups was statistically significant  $p < 0.05$ , when the Mann-Whitney U test was applied. Pure tone average using the values obtained at 3000, 4000 and 6000 Hz was calculated too. It was reported high prevalence of hearing loss at high-frequency values in individuals with noise induced hearing loss (Brice, 2021; Kwon & Lee, 2021). A statistically significant difference was found in the results between the two groups of the audiological examination of high frequencies ( $p < 0.05$ ). Most of the teachers and assistants who are working over eleven years at the kindergarten demonstrated difficulties in perception of high-frequency sound signals from the pure-tone audiometry. 80% of the personnel with prolonged work experience were with hearing loss (4 individuals with slight and 4 with mild hearing loss). There was an interesting finding in the group of personnel with work experience up to 10 years. There was one individual with slight hearing loss at high-frequency values. This was the teacher who liked to listen to loud music in her spare time.

The study of kindergarten's personnel auditory skills was completed by an assessment with the speech-in-noise test in Bulgarian language. A comparison of test scores between the two groups is illustrated in Figure 1.

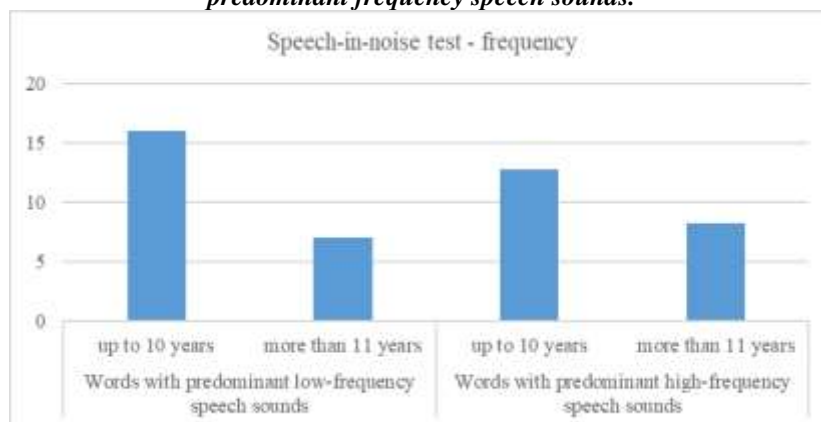
**Figure 1** A comparison of speech-in-noise test scores between the two groups according to work experience.



A Mann-Whitney U test was conducted for the statistical analyses. There was a statistically significant difference in the scores in speech-in-noise test showed from the two groups  $U = 20$ ,  $p = .049$ ,  $r = .44$ . The participants with work experience up to 10 years could repeat correctly more words heard in background noise compared to the personnel who were exposed longer to the excessive noise in kindergarten. These findings corresponded with the conclusions of (Akeroyd et al., 2015; Liberman, Epstein, Cleveland, Wang, & Maison, 2016; Fredriksson et al., 2019). It proved that people with noise-induced hearing loss had difficulties to understand speech when accompanied with background noise.

It was interesting to look at more detailed data. The comparison of the results from the speech-in-noise test between the two study groups according to the predominant low- or high-frequency speech sounds is presented in Figure 2. The statistical analysis with Mann-Whitney U test showed significant difference between the two groups in comprehension of words with predominant low-frequency speech sound  $U = 20$ ,  $p = .017$ ,  $r = .55$  and not so big difference in understanding of words with predominant high-frequency speech sound played with background noise  $U = 20$ ,  $p = .080$ ,  $r = .4$ . The younger employees had less working experience in the kindergarten and less exposure to loud noise. This explained their better results at understanding speech-in-noise test. Participants with work experience more than 11 years registered lower scores in both subgroups of words. As it was mentioned above the identification of high-frequency speech sounds is affected in cases of noise induced hearing loss (Brice, 2021; Kwon & Lee, 2021). This could be the explanation of statistically insignificant difference in results for comprehension of words with predominant high-frequency speech sounds. All participants were exposed to excessive noise at kindergarten but the duration of work experience was different.

**Figure 2** A comparison of speech-in-noise test scores between the two groups according to work experience and predominant frequency speech sounds.



The correlation between the speech-in-noise test and the duration of work experience at kindergarten was examined with Spearman rank-order correlations test. A significant negative correlation was observed, where  $p < 0.05$ . This meant that the longer exposure to excessive noise at kindergarten would result in worse performance at speech-in-noise test. With the applied statistical analysis, the hypothesis set at the beginning of the study was proved.

Different health professionals should work for prevention, early detection and intervention of individuals with noise-induced hearing loss. For example, changes in furniture and the buildings design could be done to reduce the noise in kindergartens. Health professionals should work to increase public awareness of the harmful impact of noise on health. Regular audiological and speech therapy examinations should be conducted with the kindergarten's personnel. It is also necessary to continue the research and to expand it with comparison of audiological abilities and speech perception in different communication situations between individuals who are exposed to excessive noise and others, who work in quiet environment.

#### 4. CONCLUSIONS

Long-term exposure to noise in kindergarten leads to progressive hearing loss. This ultimately affects the health. More specific are hearing problems such as understanding of speech when it has to be perceived in the presence of background noise. It is necessary to take actions for prevention and early assessment of hearing disorders in risk groups for occupational noise-induced hearing loss. It is recommended that teachers and their assistants in kindergartens undergo audiological examinations annually. Professionals should be working toward to reduce noise in the kindergarten building.

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