Workplace noise exposure and audiometric thresholds in dental technicians

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ABSTRACT

Noise is a well-known risk factor in occupational medicine. Several studies have been performed in workplaces with noise sources, especially in the industrial field; on the contrary, only a few studies have been carried to evaluate the noise exposure effects in non-industrial workplaces such as small factories, handicraft laboratories, and dental laboratories. The aims of this study were to evaluate workplace noise exposure and hearing thresholds in dental technicians. Four laboratories and 51 dental technicians were included in the study. Noise exposure levels during a nominal eight-hour working day (LEX, 8 h) were assessed in the included laboratories. Audiometric thresholds with pure tone audiometry were performed in 51 dental technicians, and results were compared with those expected in subjects not exposed to noise. The environmental noise measures showed moderate differences of the LEX, 8 h among the four laboratories (range 71.4 to 76.2); average LEX, 8 h was 73.9 ± 2.2 dB(A). The audiometric results showed a progressive increase of hearing threshold values at the frequencies mostly involved in noise-induced hearing loss (3, 4 and 6 kHz) and a correlation with age and working seniority especially in males (p<0.005). Nevertheless, in the 92.1% of subjects the threshold increases were in line with those expected in subjects of the same age and sex not exposed to noise and in the remaining 7.8% were not statistically significant (p>0.05). In 3.9% of the cases the increases were bilateral, typical of noise-induced hearing loss, and only 1.9% showed involvement of several frequencies with worsening of expected thresholds >25 dB. In conclusion, our study showed that exposure to noise in dental laboratories was not sufficient to represent a hazard to hearing, as demonstrated by the LEX, 8 h, which were below 80 dB(A) and therefore below the European exposure limit values and exposure action values for workers.

Keywords: Noise-induced hearing loss, environmental noise, dental laboratory, dental technicians.
INTRODUCTION
Noise is a well-known risk factor in occupational medicine; it is considered the most widespread pollutant in the workplace and there are many international organizations involved in its management. Specific effects on the auditory system, as well as specific and nonspecific effects on other organs, can be attributed to noise. While non-specific effects are still under discussion, specific effects on the auditory system especially following oxidative stress - are well known and have been widely described in the literature, as well as possible interferences between noise and ototoxic substances. Noise-induced hearing loss is typically a bilateral and symmetrical non-reversible sensorineural hearing loss that initially affects the 3-6 kHz frequencies and then extends to mid and low frequencies. Several studies have been performed in workplaces with noise sources, especially in the industrial field. On the contrary, only a few studies have been carried out to evaluate the noise exposure effects in non-industrial workplaces such as small factories, handicraft laboratories, and medical facilities. Dental technicians are a population subject to several occupational risks, such as skin allergy to acrylics (chemicals widely used in dental techniques) respiratory irritation and infections and accidents. In this field, exposure to noise produced by turbine drills, micromotors, compressors, sandblasters, model trimmers, circular saws for plaster has been mainly studied in dentists and dental hygienists; however, there is a lack on specific studies that demonstrate unequivocally the presence or absence of auditory effects in dental technicians that have a peculiar role in dental practice. Furthermore, studies on hearing thresholds at different frequencies in this population are lacking. The purpose of this study is to explore the effects of noise exposure in dental technicians through observations conducted in dental laboratories, aiming at (a) assessing the environmental noise levels in dental laboratories and (b) identifying alterations compatible with occupational noise exposure in the audiometric profile of dental technicians, even at an early stage.

MATERIALS AND METHODS
This study included 52 subjects, 29 males (55.8%) and 23 females (44.2%) working in four different dental laboratories (laboratory 1-4). Inclusion criteria were age between 18 and 68 years working as dental technicians. Exclusion criteria were subjects with history of unrelated noise exposure, ipsilateral or contralateral middle ear pathology, retrocochlear pathology, previous ear surgery. The study was performed in accordance with the Helsinki declaration and its amendments. Informed consent was obtained from all the participants.

Environmental Noise Level Assessment: An environmental noise level assessment was performed in four dental laboratories in the city of Rome, Italy, using an integrated sound level meter (Cel Instrument Ltd, Type 573.CIT, version 98.0) and an acoustic calibrator (Cel Instrument Ltd, Model 284/2) class 1, according to IEC standards. Three measurements were performed in each workplace with several noise sources, placing the microphone at ear height of workers and at a distance of 10 cm. The ‘daily noise exposure levels’ (LEX, 8 h) were used as specific indicators of occupational risk, according to the European legislation on minimum safety and health requirements for workers exposed to noise (Directive 2003/10/EC on the minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents). These levels are defined by the International Standard Organization (ISO 1999/1990) and are substantially time-weighted average values, representing the average level of noise exposure during a nominal 8 hour working day. The LEX, 8 h detected in the dental facilities were compared with the exposure limit values and exposure action values (upper and lower) established by the European Union.

Audiological Evaluation: Dental technicians working in each of the four dental laboratories underwent full otolaryngologic examination, Pure Tone Audiometry (PTA) and auditory immittance testing. PTA was performed in a soundproof room after an acoustic rest of at least 16 h. The audiometer was calibrated according to 389-1979 ISO and PTA was performed according to 6198 ISO. The air and bone-conducted hearing thresholds were measured at the 0.25, 0.5, 1, 2, 3, 4, 6 and 8 kHz frequencies in both ears. The hearing thresholds were compared with those expected in normal subjects of the same age not exposed to work-related noise and without otological diseases, corresponding to the mean values of the group A of the international standard ISO 1999/1990. The reference frequencies were 3, 4 and 6 kHz.

Interview: All subjects were interviewed by an occupational medicine physician on individual clinical history, noise exposure and otolaryngologic symptoms. In details, the interview investigated systemic pathologies (arterial hypertension, diabetes, dyslipidemia, cranial trauma, intracranial hypertension), otorhinolaryngologic conditions (acoustic neuroma, neuritis), use of ototoxic drugs (salicylates, Nonsteroidal anti-inflammatory drugs, loop diuretics, antibiotics), infectious diseases (meningitis, herpes zoster, cytomegalovirus). The interview also investigated previous history of specific leisure activities, such as hunting and playing a musical instrument, and work history, with particular attention to the tools used, the length and frequency of daily exposure, duration of current work, and previous jobs.

Statistical Analysis: The data were processed statistically using SPSS (Statistical Package for Social Science) 17.0 software. The analysis of possible associations between increases of auditory thresholds compared to those
Table 2: The results of the comparison of the results of the survey for the psychosocial consequences of tinnitus with the parameters of the loudness of tinnitus.

| Tinnitus Acceptability | No (n=65) | Yes (n=57) |
|-------------------------|-----------|------------|
| **Loudness tinnitus (VAS; mm)** | Mean | SEM | Mean | SEM | P-value |
| Mean | 68.8 | 3.4 | 57 | 3.4 | 0.016 Sign. |
| Minimal | 45.5 | 4.3 | 41.7 | 3.5 | 0.493 |
| Maximal | 84.3 | 3.1 | 73 | 2.9 | 0.004 Sign. |
| Difference Maximal and Minimal | 32.7 | 3.3 | 40.2 | 4.1 | 0.155 |

Concentration Disturbed

| **Loudness tinnitus (VAS; mm)** | Mean | SEM | Mean | SEM | P-value |
|---------------------------------|------|-----|------|-----|---------|
| Mean | 65.3 | 3.6 | 59.2 | 3.8 | 0.224 |
| Minimal | 42.5 | 3.6 | 44.2 | 4.3 | 0.765 |
| Maximal | 83.6 | 2.3 | 71.3 | 3.3 | 0.003 Sign. |
| Difference Maximal and Minimal | 43.3 | 3.5 | 27.4 | 3.6 | 0.002 Sign. |

Can resist their tinnitus

| **Loudness tinnitus (VAS; mm)** | Mean | SEM | Mean | SEM | P-value |
|---------------------------------|------|-----|------|-----|---------|
| Mean | 69.3 | 3.6 | 56.4 | 3.3 | 0.010 Sign. |
| Minimal | 45.7 | 4.4 | 40.2 | 3.5 | 0.332 |
| Maximal | 88.2 | 1.5 | 70.5 | 3.1 | 0.000 Sign. |
| Difference Maximal and Minimal | 44 | 4.1 | 31.3 | 3.4 | 0.020 Sign. |

Feeling Depressed

| **Loudness tinnitus (VAS; mm)** | Mean | SEM | Mean | SEM | P-value |
|---------------------------------|------|-----|------|-----|---------|
| Mean | 65 | 3.7 | 60.7 | 3.3 | 0.39 |
| Minimal | 39.0 | 4.0 | 45.4 | 3.7 | 0.243 |
| Maximal | 85.0 | 2.4 | 73.8 | 2.9 | 0.003 Sign. |
| Difference Maximal and Minimal | 48.5 | 3.9 | 28.7 | 3.2 | 0.000 Sign. |

Table 3: The levels of the maximal loudness of the tinnitus and the results of the survey for the psychosocial consequences of tinnitus.

| Maximal loudness tinnitus (VAS; mm) | Less than 73 | 73 - 77 | 78 - 83 | More than 83 | P-value |
|-------------------------------------|-------------|--------|--------|-------------|---------|
| Not acceptable | 31% | 60% | 33% | 65% | 0.009 Sign. |
| Concentration disturbed | 34% | 60% | 60% | 77% | 0.001 Sign. |
| Feeling depressed | 28% | 40% | 27% | 58% | 0.026 Sign. |
| Cannot resist their tinnitus | 16% | 40% | 40% | 64% | 0.000 Sign. |
| Having Fear | 19% | 40% | 20% | 43% | 0.070 |
| Having Anger | 6% | 20% | 20% | 23% | - |

dB: decibel; Hz: Hertz; KHz Kilohertz; SEM: Standard Error of the Mean; Sign: Significant; Prev: Prevalence; VAS: Visual Analogue Scale; mm: millimetre
expected was tested using the Chi-square test. The analysis of possible correlation between audiometric thresholds, the age and work seniority was tested using the r coefficient of Spearman. The level of significance was assumed at p<0.05.

RESULTS

The noise sources and daily noise exposure levels, measured in the four investigated laboratories, are summarized in Table 1. The average LEX, 8 h was 75.6 ± 0.5 dB in laboratory 1, 75.8 ± 0.8 dB in laboratory 2, 72.2 ± 0.6 dB in laboratory 3 and 71.9 ± 0.5 dB in laboratory 4. Fifty-two dental technicians were included in the study and underwent clinical interview and audio logical evaluation. One woman had a previous pharmacological-induced hearing loss and was excluded from the study. The general characteristics of the subjects are summarized in Table 2. In details, 29 subjects were males (55.8%) and 22 were females (42.3%). Mean age was 39.1 years (range: 20-68 years). Mean age of male subjects was 41.4 years (range: 20-68 years), mean age of female subjects was 36 years (range: 27-50 years). Mean working seniority was 15.4 years (range: 2-40 years); 16.8 years for males (range: 2-40) and 13.5 years for females (range: 7-23 years). Audiometric thresholds are detailed in Table 3. Measurements were taken in both ears and were classified into groups of values above or below 25 dB, which is internationally recognized as the limit for hearing "disability"\(^5\)\(^4\)\(^5\). Table 4 and Table 5 detail the mean values of the audiometric thresholds at 3, 4 and 6 kHz, classified according to sex, age and working seniority of the enrolled subjects. The comparison between the audiometric thresholds at 3, 4 and 6 kHz with those expected in same age subjects without otological diseases and not exposed to work-related noise, according to ISO 1999/1990, showed exceedance in four dental technicians. The

Table 1: Noise sources and daily workplace noise exposure levels (LEX, 8 h).

| Laboratory no. 1 | Laboratory no. 2 | Laboratory no. 3 | Laboratory no. 4 |
|-------------------|-------------------|-------------------|-------------------|
| Model trimmers    | Model trimmers    | Model trimmers    | Model trimmers    |
| Polishing lathe with (dust) extraction | Polishing lathe with (dust) extraction | Polishing lathe with (dust) extraction | Polishing lathe with (dust) extraction |
| Centrifugal casting machine | Centrifugal casting machine | - | - |
| VapoKlein | VapoKlein | VapoKlein | VapoKlein |
| Air gun | Air gun | - | Air gun |
| Sandblaster | Sandblaster | Sandblaster | Sandblaster |
| Vacuum mixer | Vacuum mixer | - | - |
| Vibrator | Vibrator | Vibrator | Vibrator |
| - | - | - | - |
| - | - | - | - |
| - | - | - | - |
| Micromotor with extraction | Micromotor with extraction | Micromotor with extraction | Micromotor with extraction |
| Micromotor | Micromotor | Micromotor | Micromotor |
| Curing unit | - | - | - |
| Work bench | Work bench | Work bench | Work bench |
| - | Extractor fan | Extractor fan | Extractor fan |
| - | Ultrasonic unit | - | - |
| - | Porcelaine furnace | - | - |
| - | Plaster box with (dust) extraction | - | - |

LEX,8H=75.6 ± 0.5 LEX,8H=75.8 ± 0.8 LEX,8H=72.2 ± 0.6 LEX,8H=71.9 ± 0.5

Table 2: Demographic characteristics of subjects included in the study.

| Subjects | Total | 52 |
|----------|-------|----|
| Excluded | 1     |    |
| Enrolled | 51    |    |
| Males    | 29    |    |
| Females  | 22    |    |
| Range (years) | 20 – 68 |    |
| Mean and SD (years) | 39.1 ± 8.2 |    |
| Range males (years) | 20 – 68 |    |
| Age (years) | 41.4 ± 11 |    |
| Mean and SD males (years) | 27 – 50 |    |
| Range females (years) | 36 ± 11.3 |    |
| Mean and SD females (years) | 2 – 40 |    |
| Working seniority (years) | 15.4 ± 9.2 |    |
| Range males (years) | 2 – 40 |    |
| Mean and SD males (years) | 16.8 ± 3 |    |
| Range females (years) | 7 – 23 |    |
| Mean and SD females (years) | 13.5 ± 7.8 |    |
The analysis of noise exposure in the four laboratories included in the study showed moderate differences of the LEX,8 h values (range 71.4 to 76.2); average LEX,8 h was 73.9 ± 2.2 dB(A). The observed differences are attributable to the heterogeneity of the instruments available in the laboratory based on the type of processes and materials used. The noise levels are consistent with other studies and are below the exposure limit values and the exposure action values provided by Art. 3 of the European Directive n. 2003/10/EC that establishes the minimum requirements to protect workers’ health and safety against damage due to noise exposure. The results of the audiometric thresholds in the subjects included in the study revealed that hearing loss was worse in the 3-8 kHz frequency range. At these frequencies, hearing loss over 25 dB in both ears were observed in a proportion of cases between 9.8% and 15.7%. Examining the data as a whole, it emerged that there were slight differences between the right and left ear, the latter being more affected by hearing loss over 25 dB even at 250 Hz-1 kHz (present in 2-3.9% of cases). The differences decreased progressively with frequency increase up to 3 kHz and disappear completely at higher frequencies. This is consistent with other studies and is below the exposure limit values and the exposure action values provided by Art. 3 of the European Directive n. 2003/10/EC that establishes the minimum requirements to protect workers’ health and safety against damage due to noise exposure.

**DISCUSSION**

The analysis of noise exposure in the four laboratories included in the study showed moderate differences of the LEX,8 h values (range 71.4 to 76.2); average LEX,8 h was 73.9 ± 2.2 dB(A). The observed differences are attributable to the heterogeneity of the instruments available in the laboratory based on the type of processes and materials used. The noise levels are consistent with other studies and are below the exposure limit values and the exposure action values provided by Art. 3 of the European Directive n. 2003/10/EC that establishes the minimum requirements to protect workers’ health and safety against damage due to noise exposure. The results of the audiometric thresholds in the subjects included in the study revealed that hearing loss was worse in the 3-8 kHz frequency range. At these frequencies, hearing loss over 25 dB in both ears were observed in a proportion of cases between 9.8% and 15.7%. Examining the data as a whole, it emerged that there were slight differences between the right and left ear, the latter being more affected by hearing loss over 25 dB even at 250 Hz-1 kHz (present in 2-3.9% of cases). The differences decreased progressively with frequency increase up to 3 kHz and disappear completely at higher frequencies. This is consistent with other studies and is below the exposure limit values and the exposure action values provided by Art. 3 of the European Directive n. 2003/10/EC that establishes the minimum requirements to protect workers’ health and safety against damage due to noise exposure.

**Table 3**: Distribution of audiometric thresholds measured by frequency.

| Frequency (Hz) | Right >25 | Right <25 | N° Subjects (%) | Left >25 | Left <25 | N° Subjects (%) |
|---------------|-----------|-----------|-----------------|----------|----------|-----------------|
| 250           | 10 - 25   | -         | 51 (100)        | 2 (3.92) | 49 (96.07) |
| 500           | 10 - 25   | -         | 51 (100)        | 2 (3.92) | 49 (96.07) |
| 1000          | 10 - 20   | -         | 51 (100)        | 1 (1.96) | 50 (98.03) |
| 2000          | 10 - 50   | 1 (1.96)  | 50 (98.03)      | 3 (5.88) | 48 (94.11) |
| 3000          | 10 - 55   | 5 (9.80)  | 46 (90.19)      | 6 (11.76)| 45 (88.23) |
| 4000          | 10 - 55   | 7 (13.72) | 44 (86.27)      | 7 (13.72)| 44 (86.27) |
| 6000          | 10 - 55   | 7 (13.72) | 44 (86.27)      | 7 (13.72)| 44 (86.27) |
| 8000          | 10 - 55   | 8 (15.68) | 43 (84.31)      | 8 (15.68)| 43 (84.31) |
| Total         | 10 - 55   | -         | 51 (100%)       |          |           |                 |

**Table 4**: Mean audiometric thresholds’ distribution by sex and age.

| Age class (years) | Males | Females |
|-------------------|-------|---------|
|                   | N° subjects (%) | N° subjects (%) |
|                   | 3 kHz | 4 kHz | 6 kHz | 3 kHz | 4 kHz | 6 kHz |
| 20 – 30           | 5 (17.2) | 10.0 | 10.0 | 10.0 | 8 (36.4) | 12.5 | 12.5 | 11.2 |
| 30.1 – 40         | 10 (34.5) | 14.2 | 14.9 | 15.7 | 4 (18.2) | 10.0 | 10.0 | 10.0 |
| 40.1 – 50         | 7 (24.1) | 17.6 | 18.2 | 19.6 | 10 (45.4) | 12.5 | 16.2 | 15.0 |
| 50.1 – 60         | 6 (20.7) | 22.1 | 26.7 | 30.0 | 1 (1.96) | - | - | - |
| > 60              | 1 (3.4) | 42.5 | 42.5 | 65 | - | - | - |
| Total             | 29 (100) | 17.1 | 19.4 | 20.5 | 22 (100) | 12.0 | 12.3 | 11.4 |

**Table 5**: Mean audiometric threshold distribution by sex and working seniority.

| Working seniority class (years) | Males | Females |
|---------------------------------|-------|---------|
|                                 | N° subjects (%) | N° subjects (%) |
|                                 | 3 kHz | 4 kHz | 6 kHz | 3 kHz | 4 kHz | 6 kHz |
| <5                              | 3 (10.3) | 10.0 | 10.0 | 10.0 | 1 (1.96) | - | - | - |
| 5.1–10                          | 7 (24.1) | 12.1 | 13.6 | 13.6 | 8 (36.4) | 12.5 | 12.5 | 11.2 |
| 10.1–15                         | 3 (10.3) | 17.6 | 18.2 | 19.6 | 4 (18.2) | 10.0 | 10.0 | 10.0 |
| 15.1–20                         | 4 (13.8) | 15.0 | 15.8 | 17.5 | 8 (36.4) | 13.1 | 13.7 | 12.5 |
| 20.1–25                         | 7 (29.1) | 14.3 | 15.7 | 12.5 | 2 (9.1) | 10.0 | 10.0 | 10.0 |
| >25                             | 5 (17.2) | 29.5 | 33.0 | 41.5 | 1 (1.96) | - | - | - |
| Total                           | 29 (100) | 17.1 | 19.4 | 20.5 | 22 (100) | 12.0 | 12.3 | 11.4 |
system, with involvement of the protective role of the efferent pathways to cochlea\[a\]. Analysis of the audiometric results at 3, 4 and 6 kHz, classified according to age and working seniority, revealed differences between males and females. In male subjects there was a progressive increase in the audiometric thresholds as age and working seniority increased, reaching its peak in the age >60 years and in the working seniority >25 years. On the contrary, there was no evidence of a relationship between audiometric thresholds and age group (from 20-30 to 40.1-50 years old) or working seniority (from 5.1-10 to 20-25 years) in females. In this regard, the history of women showed work discontinuity in the years and inhomogeneity in the working day. The data are confirmed by statistical analysis, which showed correlation between audiometric thresholds at 3, 4 and 6 kHz with age and work seniority statistically significant (p<0.05) in males and not significant (p>0.05) in females. The comparison between the mean thresholds at 3, 4 and 6 kHz and those expected according to the ISO international standard 1999/1990 reveal a limited number of cases (7.8% of total subjects) over the expected thresholds, including 1 female (4.5% of females) and 3 males (10.3% of males). Moreover, no differences were found statistically significant (p>0.05) between the 4 subjects' mean audiometric thresholds at 3, 4 and 6 kHz with those expected in same sex and age subjects without otological diseases and not exposed to work-related noise. Recent research studies have demonstrated that prolonged exposures to lower intensity noise may damage the inner ear, in particular outer hair cells. In a paper from 60 in rats, the authors showed that noise may damage the inner ear, in particular outer hair cell function with otoacoustic emissions, and the limited sample of subjects included, the absence of previous hearing exams, the absence of evaluation of outer hair cell function with otoacoustic emissions, and the lack of a control group.

CONCLUSION

The present study shows that exposure to noise in dental laboratories was not sufficient to represent an hazard to hearing of dental technicians, as demonstrated by the LEX,8 h, which were below 80 dB(A) and therefore below the European exposure limit values and exposure action values for workers exposed to noise. The audiometric results showed a progressive rise in the auditory threshold values at the frequencies mostly involved in noise-induced deafness and a correlation with age and working seniority in the males. Nevertheless, in the majority of the subjects auditory thresholds were in line with those expected in subjects of the same age and sex not exposed to noise. Further studies on larger samples with more detailed analysis of the outer hair cell function are necessary to confirm our results.

CONFLICT OF INTEREST

The author declares no conflict of interest.

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