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Effects of noise exposure among industrial workers in power plants of the National Electricity Company in N'Djamena, Chad

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Abstract

Background: Noise pollution, unwanted or excessive sound, is one of the most common nuisances in industrial sectors. In the city of N'Djamena, Chad, workers in power plants are exposed to very high levels of noise, which could have deleterious effects on human health. The purpose of the study is to determine the level of noise pollution and its repercussions in a population of power plant workers.

Results: Ninety-two (11.5%) of the 800 workers were included. Their sex ratio was 88 men: 4 women with an outcome of 22. The age range was from 23 to 64 years with an average of 38.7 ± 9.0 years. Forty-seven (51.1%) of the employees had received occupational safety training. The average noise level in the machine rooms was 113.5 ± 4 dB(A). The average duration of exposure to noise was 10.8 ± 8.5 years. Personal protective equipment was worn regularly in 85.9% ($n = 79$). The consequences of noise pollution were auditory fatigue (38%; $n = 35$), tinnitus (32.6%; $n = 30$), hearing loss (15.2%; $n = 14$), nervousness (45.7%; $n = 42$), headache (33.7%; $n = 31$), raised voice (27.1%; $n = 25$), and insomnia (14.1%; $n = 13$).

Conclusions: The level of noise pollution is relatively high in power plants in N'Djamena, Chad. Hearing effects and an altered quality of life are observed among industrial workers. The acquisition of machines with regulated noise levels is desirable. The audiometric test should be integrated into the follow-up assessment of all employees.

Keywords: Effects of noise, Noise nuisance, Measuring device, Power plant workers

Background

Noise is one of the most common occupational hazards worldwide, with several million workers exposed to noise levels above 85 dB(A). Repeated overexposure to noise at or above 85 dB(A) can lead to permanent hearing loss, tinnitus, and difficulties in understanding speech during noise, cardiovascular disease, depression, and loss of balance [1, 2]. In Africa, several authors have reported noise levels above 85 dB(A) [3–5]. For example, in Tanzania, Chadambuka et al. reported excessive noise levels ranging from 94 dB(A) to 103 dB(A). In the industrial sector where noise pollution is present, power plants are among the places with high noise exposure [3].

In N'Djamena, Chad, the employees of power plants are exposed to very high levels of noise, which could have major consequences for their health. This study aimed to determine the level of noise pollution and its repercussions among industrial workers.

This work, the first of its kind in our country, will hopefully contribute to improving the conditions of workers exposed to dangerous levels of noise in the field of occupational safety and health.

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Methods

This is a cross-sectional prospective study carried out in two power plants of the National Electricity Company in N'Djamena, Chad, from 1 August to 30 September 2020.

Every active worker in both of the power plants was included in the study. Employees working outside the power plants and those who refused to participate in the study were excluded.

Each participant was systematically subjected to an interview, a general physical examination, an otoscopy, and an audiometry exam.

The variables studied were socio-professional and safety (age, sex, level of education, function, duration of exposure, daily hourly time, personal protection against noise, information, and training on safety), clinical (medical history, clinical signs), and paraclinical (sonometric and tonal audiometry).

The sound intensity of the two power plants was determined with an integrating sound level meter. The measurement was carried out at the workstations (engine room, control room, mechanical workshop, mechanical office, electrical office, unloading stations) and at the yard of the power plants in Farcha and Djambalbahr while putting the different tasks and their execution times into consideration. The average time measurement was 5 min. The average noise level was calculated as the sum of the decibels found in each site divided by the number of sites.

The clinical and audiometric signs investigated were tinnitus, hearing loss (HL), auditory fatigue, otalgia usually at the end of work, tendency to increase the volume of the radio or telephone, and signs of stress. Stress was defined as a pathological situation that can lead to physical (sleep disorders, headaches, fatigue, anorexia), emotional (irritation, loud speech, anxiety), and behavioral (isolation, addiction to alcohol, tobacco, caffeine) signs.

Linear tone audiometry was performed in the Renaissance University Hospital of N'Djamena using an audiometer in a soundproof booth. The audiometric evaluation of the workers was carried out in groups of 4 persons per day and at least 12 h after their last exposure to noise. An otoscopic examination (using a headlamp) was performed beforehand to exclude the presence of any significant hearing pathology. The average hearing loss (AHL) in each ear was calculated by dividing the sum of the measured deficits (dB(A)) at the frequencies of 500, 1000, 2000, and 4000 Hz by 4. Hearing was normal when the AHL is $\leq$ 25 dB(A); hearing loss is defined by an AHL > 25 dB(A): mild HL, 26–40 dB(A); moderate HL, 41–60 dB(A); and severe HL, 61–80 dB(A). Auditory fatigue was defined as an average hearing loss $\leq$ 25 dB(A) with a high frequency notch (4000 Hz) above 25 dB(A).

Data were entered using Microsoft Office 2019 and analyzed using SPSS (Statistical Package for Social Science IBM) version 26.0. Qualitative data was presented as a percentage. Quantitative variables were summarized as either mean with standard deviation or median with extreme values.

The subjects had been given an informed consent to participate in the study and for the publication of their data. This study had the agreement of the management of the Renaissance University Hospital and the administrative agreement of the power plants.

Results

Of the 800 employees of the National Electricity Company in N'Djamena, 92 workers were included from the two power plants (11.5%) who had agreed to participate in the study. They were 88 men and 4 women with a sex ratio of 22. Their average age was 38.7 $\pm$ 9.0 years. Their median age was 38 years with extremes of 23 to 64 years. Those with a secondary school educational level or higher represented 90.2% (n = 83). A total of 100% (n = 92) of the employees were informed, and 51.1% (n = 47) had received training on safety in the electrical workplace. Their average duration of exposure to noise was 10.8 $\pm$ 8.5 years (median of 8 years with extremes from 1 to 34 years). Exposure was intermittent in 90.2% (n = 83) of cases. Employees who worked more than 8 h a day represented 51.1% (n = 47). The socio-professional characteristics of the workers are summarized in Table 1 below. Workers who regularly wore noise protection equipment accounted for 85.9% (n = 79). Details are shown in Fig. 1. By job position, 44.6% (n = 41) of employees were shift workers, shown in Fig. 2.

The average noise level was 113.5 $\pm$ 4 dB(A) in the machine rooms and 73.5 $\pm$ 12.5 dB(A) in the control rooms.

The clinical and audiometric data are presented in Table 2. Employees with no otological history accounted for 90.3% (n = 83) of the cases. Workers with auditory and extra-auditory signs were 63 (68.5%) altogether. Among these signs, tinnitus was reported in 32.6% of cases (n = 30), self-reported hearing loss in 17.3% of cases (n = 16), nervousness in 45.7% of cases (n = 42), and headaches in 33.7% of cases (n = 31). The audiometric tests were pathological in 53.3% of the cases (n = 49); auditory fatigue was observed in 35 workers (38.0%) and hearing loss in 14 cases (15.2%).

The characteristics of hearing loss are presented in Table 3. Mild hearing loss was found in 79% of cases (n = 11). The distribution of the average hearing loss in both ears according to the duration of exposure to noise is shown in Fig. 3. Table 4 shows the correlation between the duration of exposure and the degree of hearing loss.

Table 1 Socio-professional characteristics of workers

	n	%
Sex		
Male	88	95.7
Female	4	4.3
Total	**92**	**100.0**
Age range (year)		
30–39	40	43.5
40–50	23	25.0
20–29	17	18.5
> 50	12	13.0
Total	**92**	**100.0**
Level of study		
Secondary level or higher	83	90.2
Primary level	5	5.4
Uneducated	4	4.3
Total	**92**	**100.0**
Information on security measures		
Yes	92	100.0
No	0	0.0
Total	**92**	**100.0**
Security training		
Yes	47	51.1
No	45	48.9
Total	**92**	**100.0**
Duration of exposure (year)		
0–5	31	33.7
11–20	27	29.3
6–10	22	23.9
> 20	12	13.0
Total	**92**	**100.0**
Type of exposure		
Intermittent exposure	83	90.2
Continuous exposure	9	9.8
Total	**92**	**100.0**
Daily hourly time		
> 8 h	47	51.1
< 8 h	39	42.4
8 h	6	6.5
Total	**92**	**100.0**

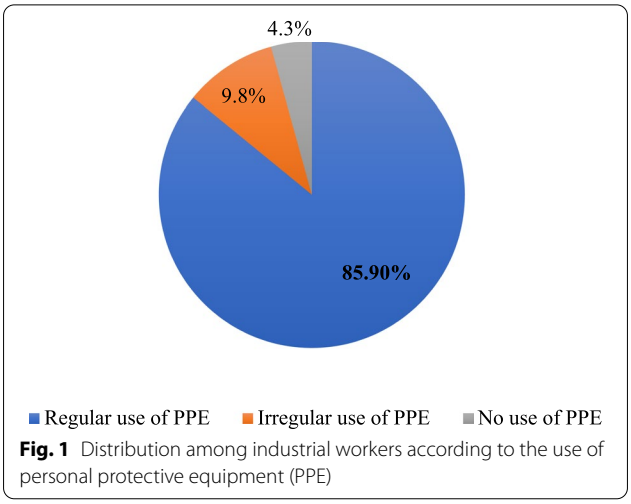

Fig. 1 Distribution among industrial workers according to the use of personal protective equipment (PPE)

Discussion

This is the first study which was done in Chad, to analyze and evaluate noise levels and its effects in a population of workers in an industrial sector. Noise in an industrial environment is potentially dangerous to human health. In this study, the average noise level was 113.5 ± 4 dB(A), which is well above the threshold value of 90 dB(A) [6]. Similar data to ours have been reported in Africa; in Tanzania, Witness et al. found a mean noise exposure level of 96.9 ±5.1 dB(A) in gas-fired power plants [3]. In Ghana, Kitcher et al. sound noise levels ranging from 85.9 to 110.8 dB(A) among mill workers [5]. In a study by Ologe et al. in Nigeria, noise levels recorded in the production section of a bottling plant ranged from 91.5 to 98.7 dB(A) [7].

It is well documented that occupational noise exposure is associated with permanent hearing loss [8–11]. In our study, we found 53.3% of pathological audiograms. This prevalence is similar to that of Witness et al. in Tanzania who reported hearing loss in 53.8% of power plant workers [3]. In Ghana, Kitcherr et al. reported a 43.6% prevalence of noise-induced hearing loss in mill workers [5]. In the Lagos metropolis, Osibogum et al. reported hearing impairment in 79.8% of textile workers [12]. In India, Dube et al. reported a high prevalence of hearing loss (97%) among cotton gin workers [13].

It should be noted that self-reported hearing loss does not reflect the actual rate of hearing loss on audiometric testing, which indicates that individuals may not correctly recognize hearing loss. The earliest signs of hearing loss are audiometric, such as auditory fatigue, which results in an "audiometric notch" usually at 4000 Hz thereafter but can also be observed at 3000 Hz and more variably at 6000 Hz depending on the frequency range of noise exposure [14]. In this study, the prevalence of self-reported hearing loss was only 17.3%, while that of audiometric testing was 53.3%. This finding was also made by Kitcher et al. who found a rate of 23.8% self-reported loss compared to 43.6% on audiometric tests. In the literature, several studies have shown a discrepancy between measured and perceived hearing loss [15–18]. It would be wise to recommend serial audiometry as a means of monitoring the hearing of noise-exposed workers.

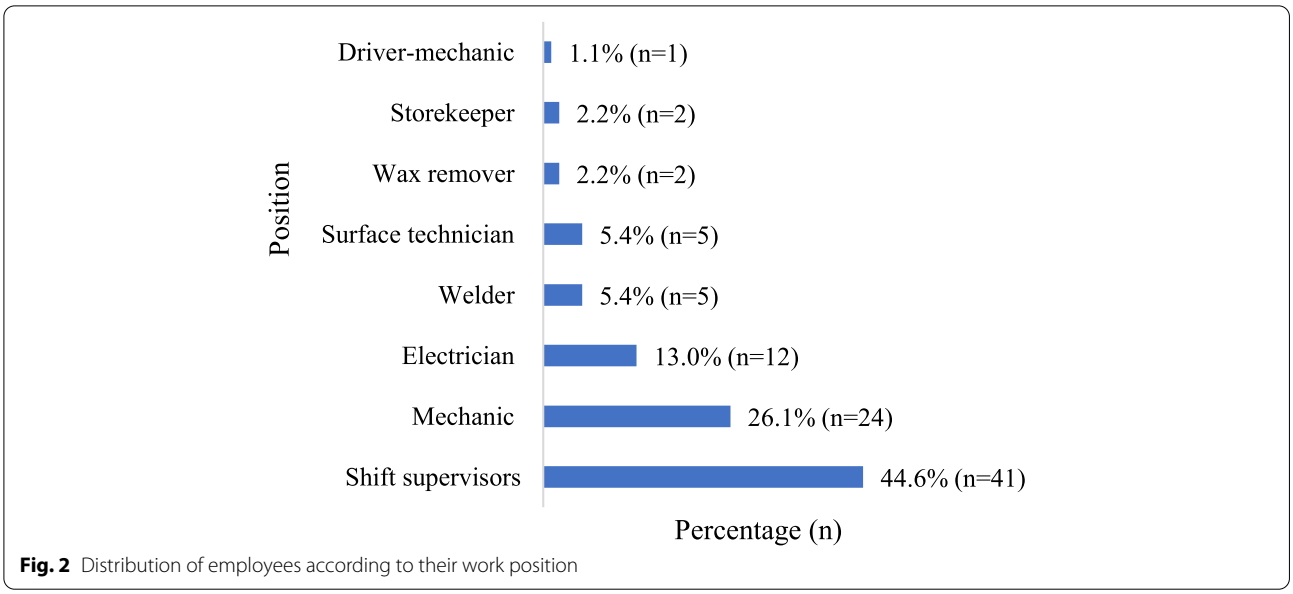

Fig. 2 Distribution of employees according to their work position

Table 2 Clinical and audiometric data of workers

	n	%
Clinical data		
History		
No medical history	83	90.3
Hearing loss	5	5.4
Recurrent otitis	4	4.3
Family history of hearing loss	0	0.0
Auditory signs		
Tinnitus	30	32.6
Hearing loss	16	17.3
Otalgia at the end of labor	8	8.7
Increasing the volume (radio, TV, telephone)	8	8.7
Extra-auditory signs		
Irritability	42	45.7
Headaches	31	33.7
Raising the tone of voice	25	27.1
Insomnia	13	14.1
Audiometric data		
Normal hearing	43	46.7
Auditory fatigue[a]	35	38.0
Sensorineural hearing loss	14	15.2

[a] The audiometric curve is characterized by a hearing loss above 25 dB at 4000 Hz

Table 3 Audiometric characteristics of hearing loss

Characteristics of hearing loss	*n*	%
Bilateral symmetrical (mild)	11	79
Bilateral symmetrical (moderate)	1	7
Bilateral asymmetrical (moderate on the right and mild on the left)	2	14
Total	**14**	**100**

Tinnitus is a significant problem for workers exposed to noise [19]. Tinnitus frequently coexists in people with noise-induced hearing loss [20, 21]. However, it can also serve as a warning sign that hearing loss is at risk [22]. In our study, we found a higher prevalence of tinnitus (32.6%). In Spain, Pelegrin et al. noted tinnitus in 10.7% of noise-exposed workers [23]. In Myanmar, the study by Zaw AK et al., workers who reported tinnitus were 3 times more likely to develop hearing loss than those who did not [19]. This result was in agreement with various studies conducted in Canada by Feder K. et al. that reported a high prevalence of tinnitus in workers exposed to hazardous noise [22].

In this study, 68.5% of the workers had nonauditory signs such as irritability, headaches, tendency to raise their voice when speaking, and insomnia. There is growing evidence of nonauditory effects of noise exposure on public health. Observational and experimental studies have shown that noise exposure causes annoyance, disrupts sleep and causes daytime sleepiness, affects patient outcomes and staff performance in hospitals, increases the occurrence of hypertension and cardiovascular disease, and impairs cognitive performance in school children [24].

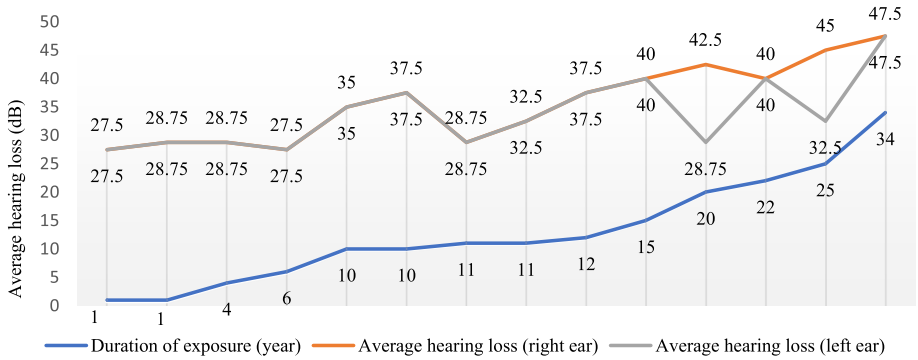

Fig. 3 Distribution of average hearing loss in both ears according to duration of exposure to noise

Table 4 Correlation between duration of exposure and degree of hearing loss

	n	*r*	*P*	**< 0.05***
Duration of exposure				
• Degree of hearing loss (right ear)	14	0.919	$< 10^{-3}$	**
• Degree of hearing loss (left ear)	14	0.704	0.005	**

*There is a link between the duration of exposure to noise and the degree of hearing loss: when the duration of exposure is long enough, the hearing loss is significant

**Significant correlation at the 0.01 level (two tailed)

Conclusion

Workers in the N'Djamena power plant stations are exposed to a very high level of noise pollution that is dangerous for human health; they are subjected to real hearing impairment. The self-reported hearing loss underrepresented the incidence of hearing loss actually found in an audiometry. Moreover, other nonauditory effects (nervousness, headaches, sleep disorders) were reported by workers.

For better safety, the acquisition of machines with regulated noise levels is desirable. The audiometric test should be integrated into the follow-up assessment of all employees working in a hazardous noise environment.

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Authors' contributions
All authors contributed to the design and development of this work. AAT was responsible for analyzing the data and writing the manuscript. The preparation of the material and data collection were carried out by AAY, MSMM, TF, and YAA. CA was responsible for correcting the form and content. All authors have read and approved the final manuscript.

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

Declarations

Ethics approval and consent to participate
The study had been authorized by the ethics committee of the Renaissance University Hospital (reference no. 207/MSP/DGHR/DM/DAF/20). The study had been complied with the 2013 Declaration of Helsinki. All the patients were consented to participate in the study.

Consent for publication
A verbal consent was obtained from participants for the publication of the data.

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

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