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Original Research Article

Prevention of noise-induced hearing loss by rational appointment algorithm in periodontal, restorative and prosthetic treatments: A method study

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ABSTRACT

Dentists are at risk of noise-induced hearing loss (NIHL). Dental treatment equipment has high-intensity noise levels. Occupational noise levels of multi-unit dental clinic are higher than private clinic and are at further increased risk of NIHL. This study aims to develop a noise-reducing appointment system in multi-unit dental clinics using treatment duration and steps noisemap. Restorative, periodontal, and prosthetic dental procedure noise levels were measured in a multi-unit dental clinic. A procedure noise map was created by measuring the amount of noise in the treatment time interval and the silent treatment period. The appointment algorithm was created according to this noise map. Control and 7 test simulation appointment algorithms were tested. The control group was simulated in six units simultaneously with conventional hour-based appointment algorithm. Test groups were simulated according to the appointment algorithm based on the treatment steps noisemap. Six-unit dental clinic was simulated under the dBmap system. While 2 of the 6 units in the test groups are in noise producing treatment steps, the other 4 seats are planned to operate without noise. According to treatment steps noisemap, test groups operated two-unit simultaneously at different timings. The distribution of noise producing units in the clinic was simulated in 7 groups (T1-T7). The mean noise measurements in all tested groups were significantly lower than in the control group. Periodontal treatment mean occupational noise level (68 dB) was higher than restorative (61 dB) and prosthetic treatment (59 dB). Control room mean occupational noise measurement was 68,54 dB, and test groups mean occupational noise measurements were between 57,19 –63,98 dB. The difference between control and tested groups was significantly different(p=0,0009). Occupational noise was significantly reduced with the noise reduction-based appointment method. Further studies are needed with different treatment procedures and validation studies in clinical settings.

1. Introduction

Noise is defined as unwanted sound occurring in an environment. Occupational noise-induced hearing problems are an important problem for employees. Sound-reducing barriers, silent devices, earplugs are recommended for protection.[1] Dentists may be exposed to loud noise, various infectious diseases, radiation exposure, skin burns, neuropathies, musculoskeletal diseases, eye diseases, and other physiological occupational diseases.[2] Many studies have been conducted on Occupational Noise-Induced Hearing Loss (NIHL), and it has been accepted as an occupational disease.[3–7] The noise levels of instruments such as aerator, micromotor, saliva ejector, laboratory equipment, amalgamator was measured.[8–11] The noise range of these devices is 60-100 dB[1,8,12,13].

NIHL occurs due to prolonged exposure to noise levels in these ranges.[13] NIHL is defined as slowly developing

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hearing loss resulting from exposure to loud noise for a period of time.[14] According to OSHA, 8 hours of exposure to noise above 85 decibels is a reason for NIHL.[15] It has been reported that hearing problems will occur when exposed to noise at lower levels than the OSHA for a long time,[6,16] Various studies have investigated the effects of occupational noise on hearing. In these studies, dentists and other occupational groups were compared, and occupational noise-related hearing loss was detected in dentists.[5,17,18] In order to be protected from NIHL, studies such as sound isolation, low-noise instruments, replacement of old instruments, and the use of ear protection have been carried out.[17,18] In addition to reducing occupational noise, exposure time is also important.[14] To increase productivity, the issues of patient admission and the organization of the staff's working hours were studied. However, these studies did not consider occupational noise levels.[19,20] Efforts have been made to reduce the time spent outside the clinic, such as waiting times for patients, time to reach the dentist, etc., to admit more patients to the clinic.[21–24] These studies aimed to admit more patients with the same number of dentists and nurses. The disadvantage was that dentists and their staff were exposed to higher levels of occupational noise. Occupational noise can be reduced by using noise sources rationally instead of using protective equipment, device renewals, or sound barriers. This study aims to calculate the total occupational noise level in the appointments according to the treatment duration and occupational noise timing and develop an appointment system according to the total occupational noise.

2. Materials and Methods

The noise levels of treatment procedures on phantom jaws were measured at the Mersin University Faculty of Dentistry clinic. Six dental units (Planmeca, Finland) were used in the multi-unit dental clinic to measure occupational noise levels. Dental units were divided by 1,5-meter-high screens. During dental treatment procedures, noise levels at a distance of 30 cm from the sound source and the total noise levels in the middle of the clinic were recorded.[2] Noise levels were measured using a sound level meter (Uni-T UT353BT Mini Sound Level Meter; Uni-Trend Technology Co., LTD, China). The maximum sound (Lmax), the average sound (Lav) noises were recorded in dB, and the procedures' durations were logged. Restorative dental treatment, periodontal treatment, and prosthetic dental treatment duration and noise levels were recorded. Average noise and usage times of noise sources are mapped in Table 2 in chronological order.

A simulated multi-unit dental clinic was prepared with dBmap software. Sound level meter device measurements and dBmap measurements were compared and verified. The data obtained by measuring noise source instruments were used as test parameters in this simulation. Six dental unit were placed at equal distances, 3 in the north and 3 in the south as Table 3. Noise generating devices was introduced to the simulation with a height of 1 meter from the ground and a noise level of 90 dB. A screen as a sound barrier with a height of 1.5 m was defined between the dental units. Measuring devices were placed at the midpoints of the clinic and 30 cm from the noise sources. The height of the measurement points from the ground was determined as 1 m in the simulation software.

Two simulations were evaluated. The first simulation algorithm was the timing of the noisy equipment used in multi-unit clinic setups. The second simulation aims to simultaneously reduce the total used noisy equipment in multi-unit clinic setups.

In the first simulation, simple graphical data was created with excel (MS Office 365) tables. The treatment steps-based noise map data table used to calculate room occupational noise levels. Two groups were tested in this simulation. The first one was an hourly-based appointment system algorithm, and the second was based on the duration of noisy equipment usage timings described in Table 2.

The second simulation system aimed to control inducted noise of the treatment procedures in multi-unit clinic's unit positions and sound screens' locations. In the simulated clinic setup, the dBmap (noisetools.net) application was used to calculate the amount of occupational noise.

The scenario in which all instruments worked simultaneously was measured in the control group. In the test groups, simulation measurements were made of the dental units operating and silent times following the appointment algorithm developed in this study to prevent NIHL(Table 4). Noise levels were measured as maximum and average for each step of the treatment procedures, as presented in Table 1. Processing time, total treatment time, and elapsed times for each step measured are presented in Table 2. All statistical analyses were performed using GraphPad Prism software version 9.3.1. Sound levels of test and control groups were evaluated with one-way ANOVA. Tukey and Dunnett's multiple comparison tests were used when necessary.

3. Results

The maximum and average noise levels of the treatment procedures are as shown in Table 1.

The noise map is the measurement of the noise levels of the treatment steps in chronological order. It is aimed to calculate occupational noise and noise-free minutes in the clinic. The measured operating durations and silent durations are described in Table 2. Maximum noise level and the longest operation duration were measured in periodontal treatment procedures.

In the control group, all procedures were performed on an hourly schedule in the simulation. The procedures were scheduled to the clinic at different times in the test

Table 1: Treatment noise levels

	Maximum/ (Lmax)/dB	Mean/ (Lav) /dB	Operation Duration /min
Restorative treatment procedure	85	61	45
Periodontal treatment procedure	92	68	68
Prosthetic treatment procedure	89	59	65

Table 2: Treatment steps-related noise measurements and duration of dental treatment procedures

	The Treatment Steps-based Noise Map (step durations and mean noise measurements)				
Restorative treatment procedure	Preparation, Anamnesis, Anesthesia 10 min 50 dB	Access cavity preparation 10 min 90 dB	Endodontic enlargement /Restorative cement application 5 min 75 dB	Root filling/ Matrix band application/ 5 min 70 dB	Filling material application / Occlusal correction/10 min 75 dB
Periodontal treatment procedure	Preparation, Anamnesis, anesthesia, index 25 min 60 dB	Cavitron application 20 min 90 dB	Subgingival curettage 10 min 70 dB	Polishing 5 min 70 dB	Postoperative instructions 3 min 60 dB
Prosthetic treatment procedure	Preparation, Anamnesis, anesthesia 10 min 50 dB	Tooth preparation 15 min 90 dB	Impression + CADCAM preparation 20 min/ 50 dB	CADCAM crown correction 5 min / 60 dB	Cementing and Occlusal correction 5 min 75 dB

Table 3: Distribution of dental units and measurement points

Noise source and measurement points			
North	A/1	B/2	C/3
Mid	4	5	6
South	D/7	E/8	F/9

*ABCDEF dental unit noise source **123456789 noise measurement points

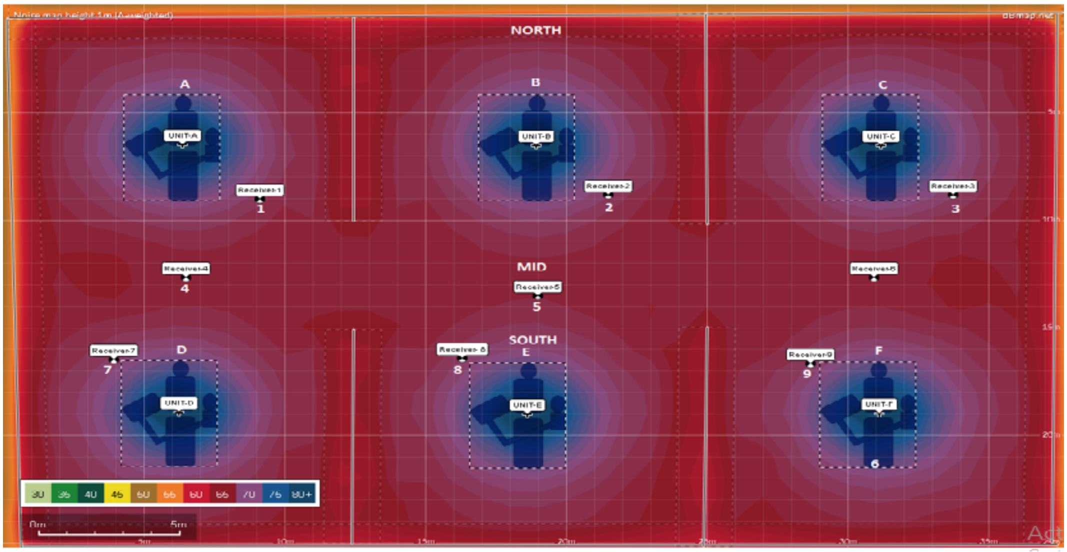

Fig. 1: Distribution of dental units and measurement points. *ABCDEF dental unit noise source **123456789 noise measurement points

group to keep the noise levels low, as described before. The maximum occupational noise level was measured in the control group, and the minimum occupational noise level was measured in Test-3 and Test-5 groups. The occupational noise levels differed significantly in the control and test groups(p=0,0009) Table 5. Occupational noise recordings of the test and control groups are presented in Table 4.

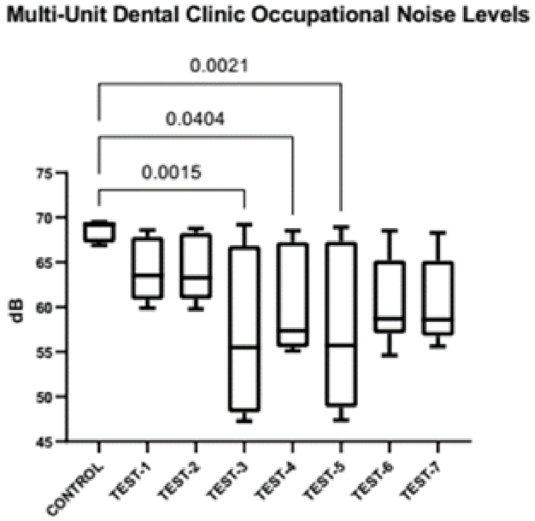

Fig. 2: Multi-unit clinic occupational noise levels graph.

In the simulation, mean room occupational noise, operating unit noise, silent unit noise, and mid-clinic unit noises were measured for both test and control rooms. Significant differences were measured between control room mean noise levels and test room mean noise levels (p=0,0009), test room silent unit(p=0,0003), and test room mid-clinic(p=0,0007) noise levels (Figure 3). There was no significant difference between mean control room noise level and test room operating unit noise levels (Table 7).

There were significant differences between Test group noise measurements. Mean room noise level was different with operating unit(p=0.0011), silent unit(p=0.0230) measurements (Table 9). The operating unit was different with mid-clinic noise(p=0.0004) and silent unit (p<0.0001) noise measurements (Figure 4).

In this appointment algorithm, all patients were given an appointment on the hour (Figure 5). In this way, two noisy operations are performed simultaneously in the 10th minute in the dental units. Our study aims to prevent the simultaneous use of noise-containing procedures in multi-unit dental clinics.

According to the noise mapping algorithm, at the end of the 90 dB noisy step of the restorative procedure, the prosthetic treatment starts at 90 dB, and at the end of this, the periodontal treatment starts at 90 dB (Figure 6). With this algorithm, the noise level of the occupational environment is reduced. Occupational noise

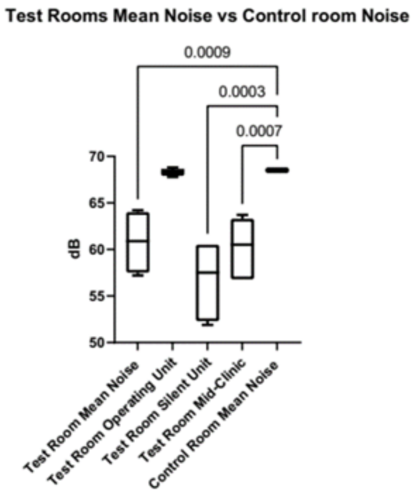

Fig. 3: All test rooms noise levels compared to control room noise level graph.

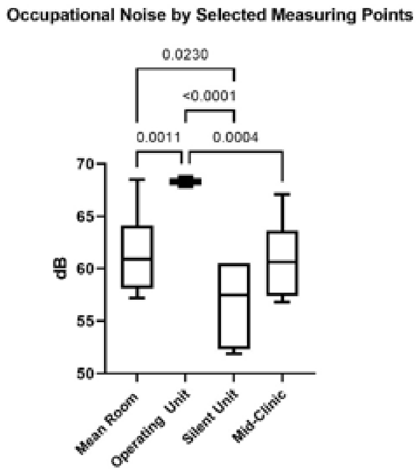

Fig. 4: Test group noise levels graph.

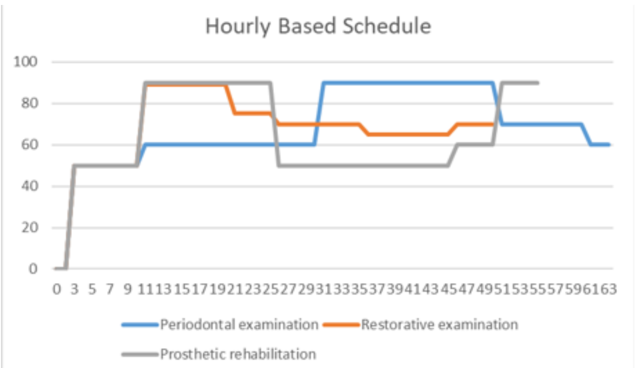

Fig. 5: Hourly based scheduling algorithm table (dB/min)

Table 4: Control and test groups simulated occupational noise levels.

Group	Nouse sources active	passive	Noise Measurements/dB* 1/A	2/B	3/C	4	5	6	7/D	8/E	9/F	Control Mean Room Noise	Operating Unit	Silent Unit	Mid Clinic
Control	ABCDEF	-	68,7	69,4	69,3	66,9	67,5	66,9	69,5	69,3	69,4	68,5	68,5	N/A	67,1
Test-1	ABC	DEF	67,5	68,2	68,6	63,5	62,9	63,5	59,9	61,3	60,4	64,0	68,1	60,5	63,3
Test-2	ABC	DEF	60,7	61,1	59,8	63,3	64,5	63,2	68,8	68,1	68,4	64,2	68,5	60,5	63,7
Test-3	AD	BCEF	67,8	55	47,3	65,9	55,5	48,9	69,2	57,5	47,6	57,2	68,5	51,9	56,8
Test-4	BE	ADCF	57,7	68,5	55,1	56,1	66,1	55,8	55,2	68,4	57,4	60,0	68,5	56,4	59,3
Test-5	CF	ABDE	48,9	57,6	68,9	48,8	55,7	65,9	47,4	55,2	68,7	57,5	68,8	52,3	56,8
Test-6	AC	BDEF	67,3	54,6	68,5	63	56,3	63,1	58,7	57,9	58,6	60,9	67,9	57,5	60,8
Test-7	AF	BCDE	67,3	56,8	58,5	63	55,6	62,9	58,6	56,8	68,3	60,9	67,8	57,7	60,5

*Values are mean noise levels in Decibel(dB).

Table 5: Mean and standard deviations of control and test groups occupational noise levels.

	Control	Test-1	Test-2	Test-3	Test-4	Test-5	Test-6	Test-7	p-value
Mean (dB)	68,54	63,98	64,21	57,19	60,03	57,46	60,89	60,87	0,0009*
Std. deviation	1,120	3,351	3,484	8,653	5,831	8,560	4,847	4,702	

*One way ANOVA

Table 6: Mean occupational noise levels comparison Table

Tukey's multiple comparisons test	Summary	p-value
Control vs. Test-1	ns	0,6713
Control vs. Test-2	ns	0,7265
Control vs. Test-3	**	0,0015
Control vs. Test-4	*	0,0404
Control vs. Test-5	**	0,0021
Control vs. Test-6	ns	0,0914
Control vs. Test-7	ns	0,0896

*Multiple comparisons of noise levels, Tukey posthoc test, ns not significant Mean occupational noise levels were significantly different in Control and Test-3, (p=0,0015), Control and Test-4 (p=0,0404), Control and Test-5(p=0,0021) groups (Figure 2).

Table 7: Post hoc test results for control and test groups noise measurements.

Dunnett's multiple comparisons test	Summary	p-value
Control Room Mean Noise vs. Test Room Mean Noise	***	0,0009
Control Room Mean Noise vs. Test Room Operating Unit	ns	0,4750
Control Room Mean Noise vs. Test Room Silent Unit	***	0,0003
Control Room Mean Noise vs. Test Room Mid-Clinic	***	0,0007

*Dunnett's posthoc test

Table 8: Test groups noise measurements.

	Test Rooms Mean Noise	Test Rooms Operating Unit	Test Room Silent Unit	Test Rooms Mid-Clinic	Control Room Mean Noise	p-value
Mean	60,67	68,30	56,69	60,17	68,50	0,0002*
Std. Deviation	2,775	0,3697	3,488	2,776	0,000	

*One way ANOVA There were significant differences in test groups noise measurements(p=0.0002).

Table 9: Post hoc test results for test groups noise measurements.

Tukey's multiple comparisons test	Summary	P
Mean Room vs. Operating Unit	**	0,0011
Mean Room vs. Silent Unit	*	0,0230
Mean Room vs. Mid-Clinic	ns	0,9789
Operating Unit vs. Silent Unit	****	<0,0001
Operating Unit vs. Mid-Clinic	***	0,0004
Silent Unit vs. Mid-Clinic	ns	0,0542

*Tukey's posthoc test.

was calculated to be the highest when performing noise-containing operations in the control group measurements. The average of all measurements is 68.5 dB (Figure 7). In the control group, the duration of noisy operations in all dental units simultaneously was 30 minutes per hour on average. In a clinic working from 8.00 in the morning to 17.00 in the evening, the exposure time to this noise level is 4 hours a day.

In the test group, the patients were admitted to the clinic by changing the starting time of the procedures involving noise. Occupational noise data in which noise-containing operations started at different times in the test group are as follows.

Test-1 Operations involving noise in ABC units, while the noiseless operations were performed in DEF units, the occupational noise was as Figure 8.

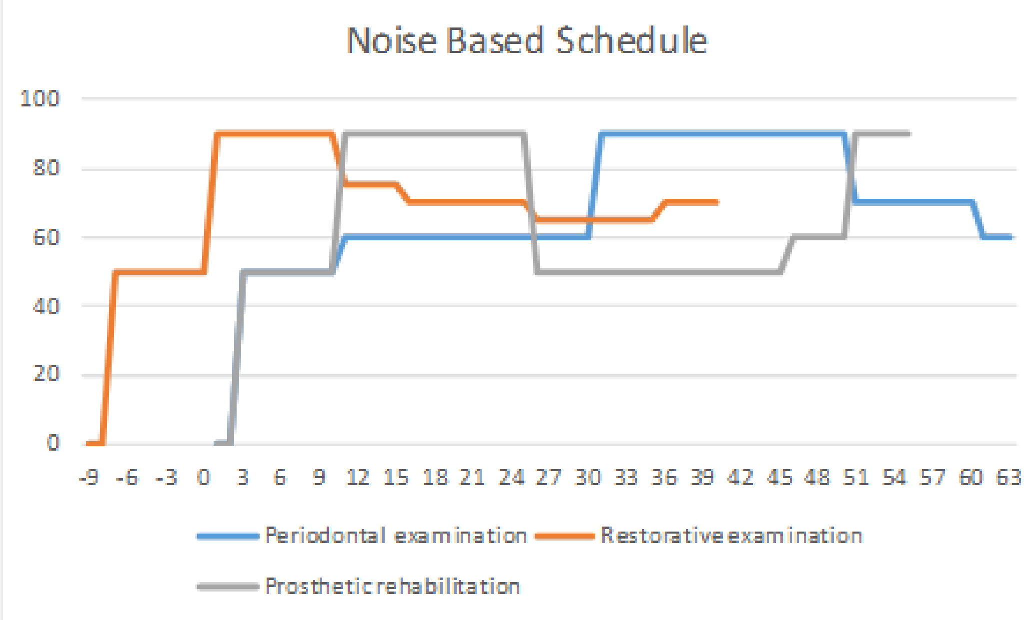

Fig. 6: Noise based scheduling algorithm table (dB/min).

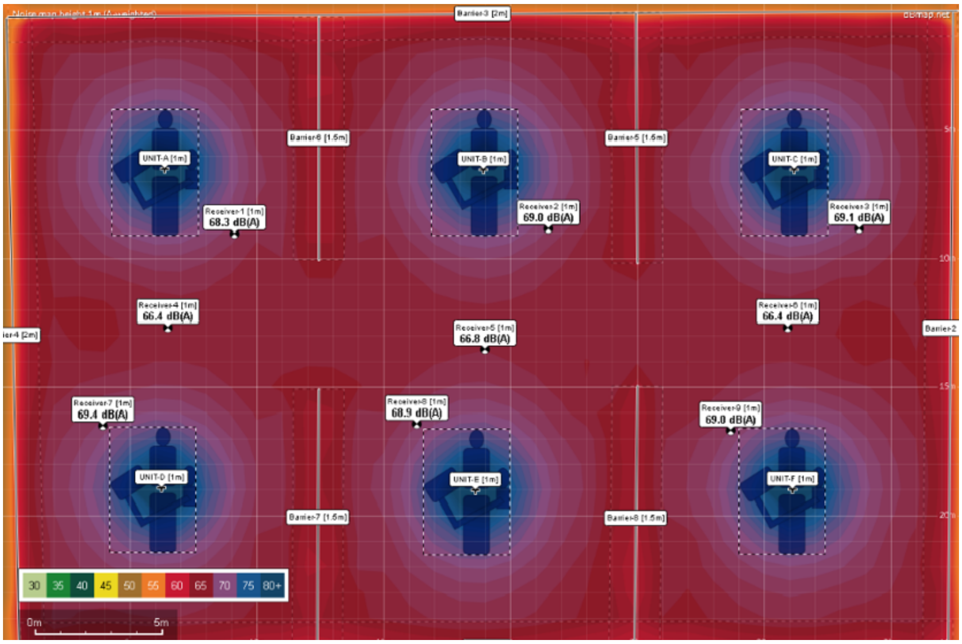

Fig. 7: Occupational noise measurements in ABCDEF units in the processing period of noise containing operations (Control Group).

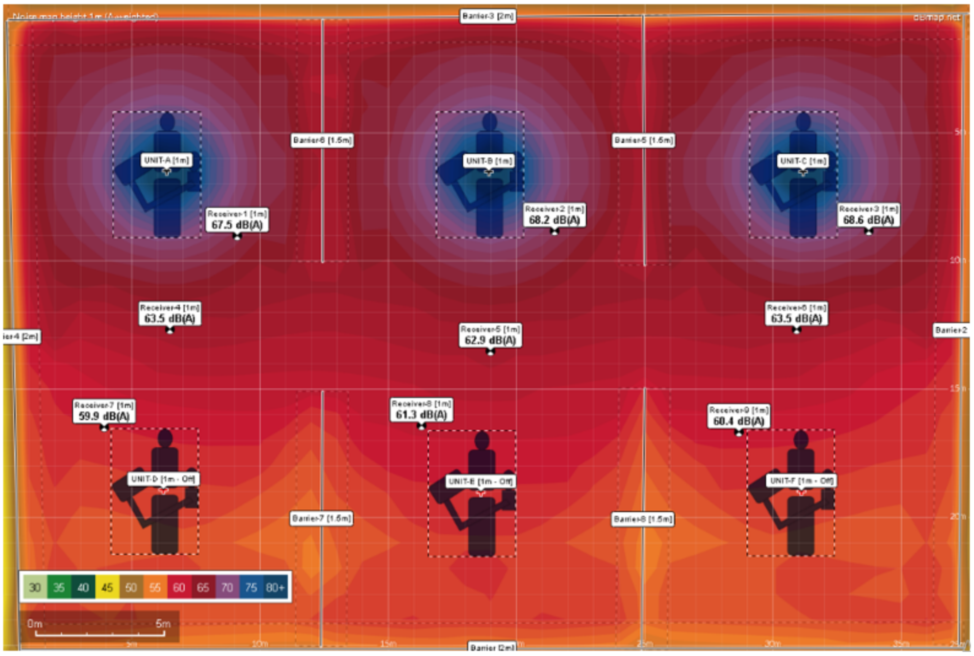

Fig. 8: Occupational noise measurements during noise containing operations in ABC units (Test-1)

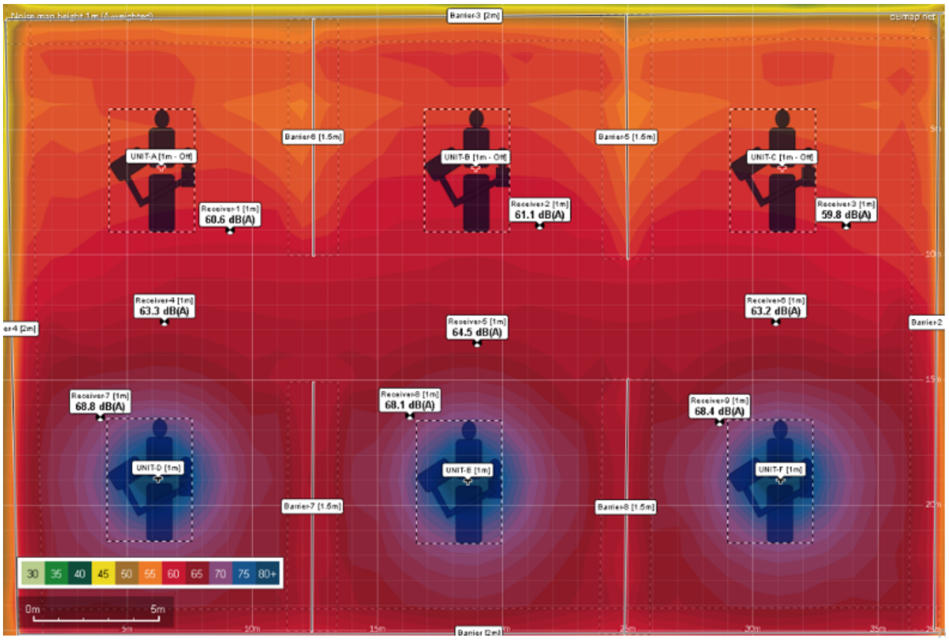

Fig. 9: Occupational noise measurements during noise containing operations in DEF units (Test-2).

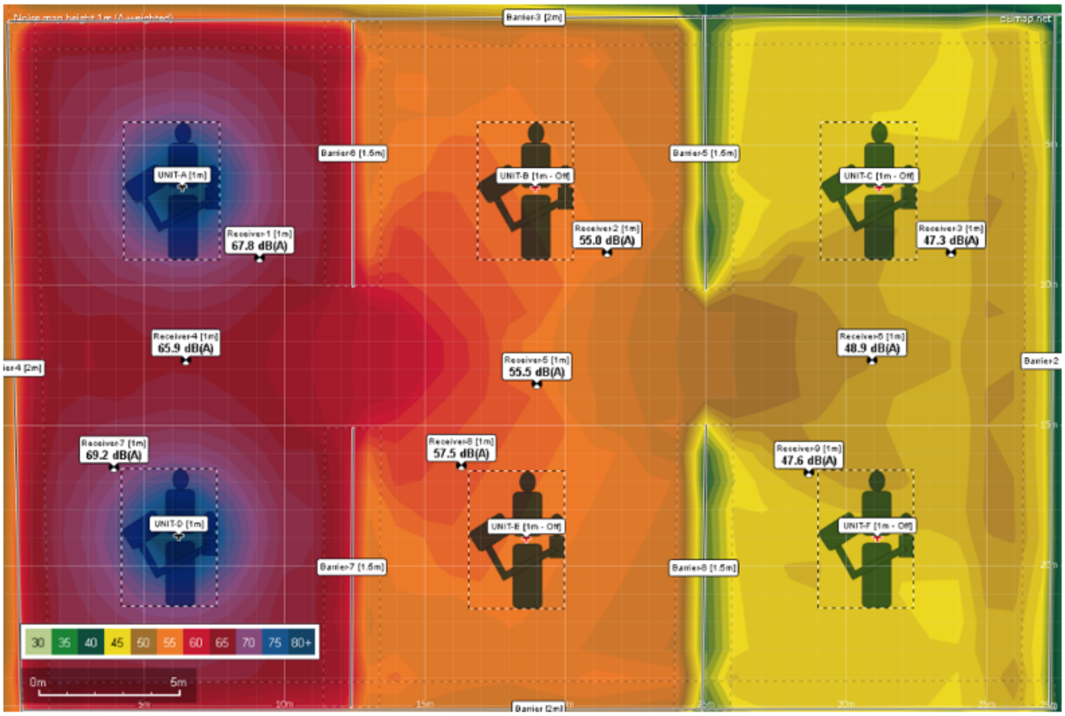

Fig. 10: Occupational noise measurements during noise containing operations in AD units (Test-3).

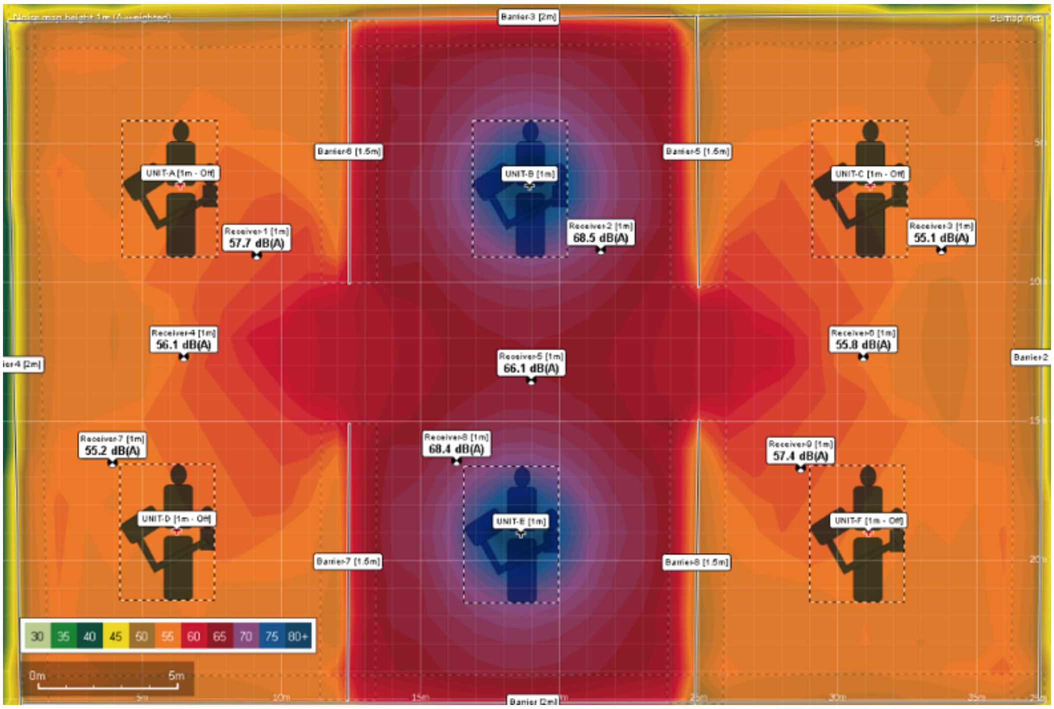

Fig. 11: Occupational noise measurements during noise containing operations in BE units (Test-4).

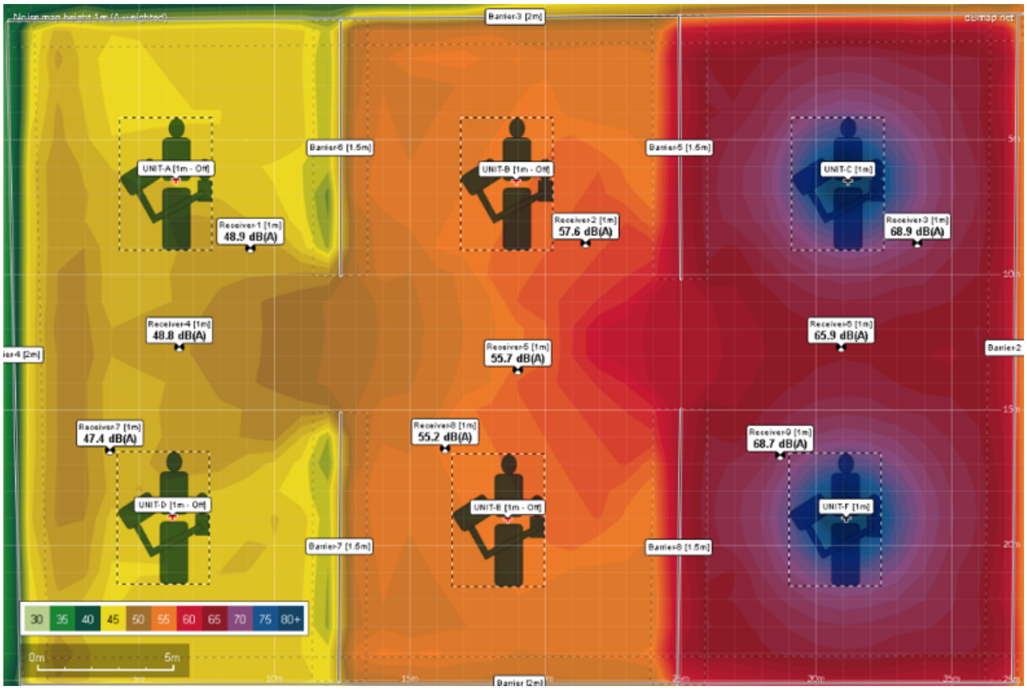

Fig. 12: Occupational noise measurements during noise containing operations in CF units (Test-5).

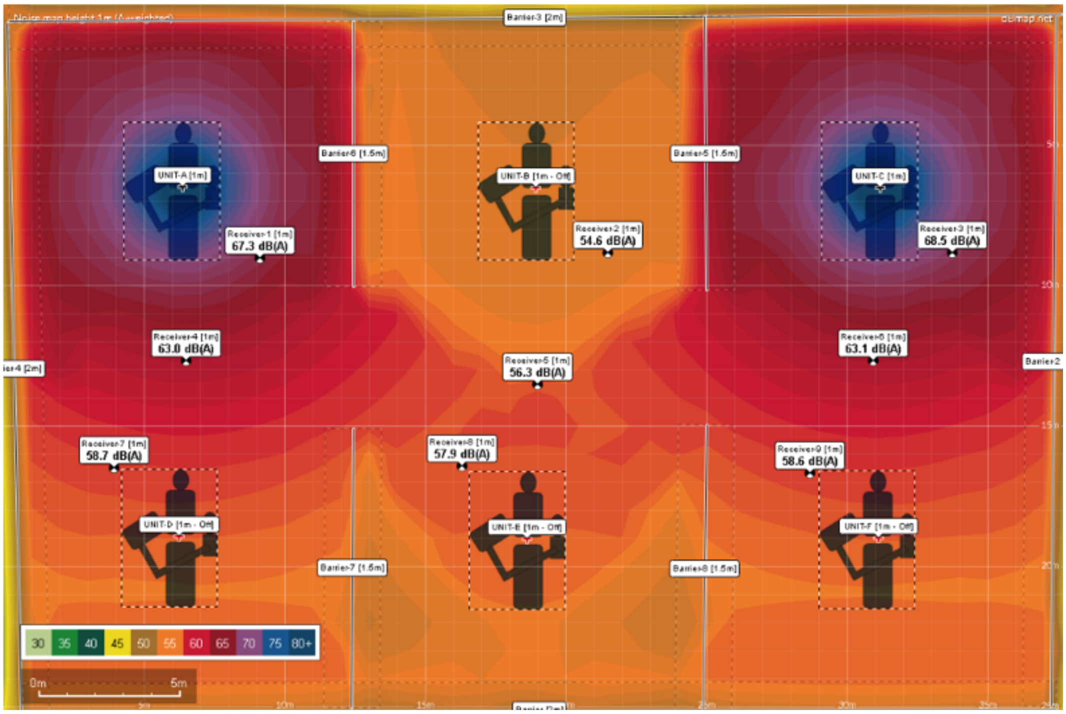

Fig. 13: Occupational noise measurements during noise containing operations in AC units (Test-6).

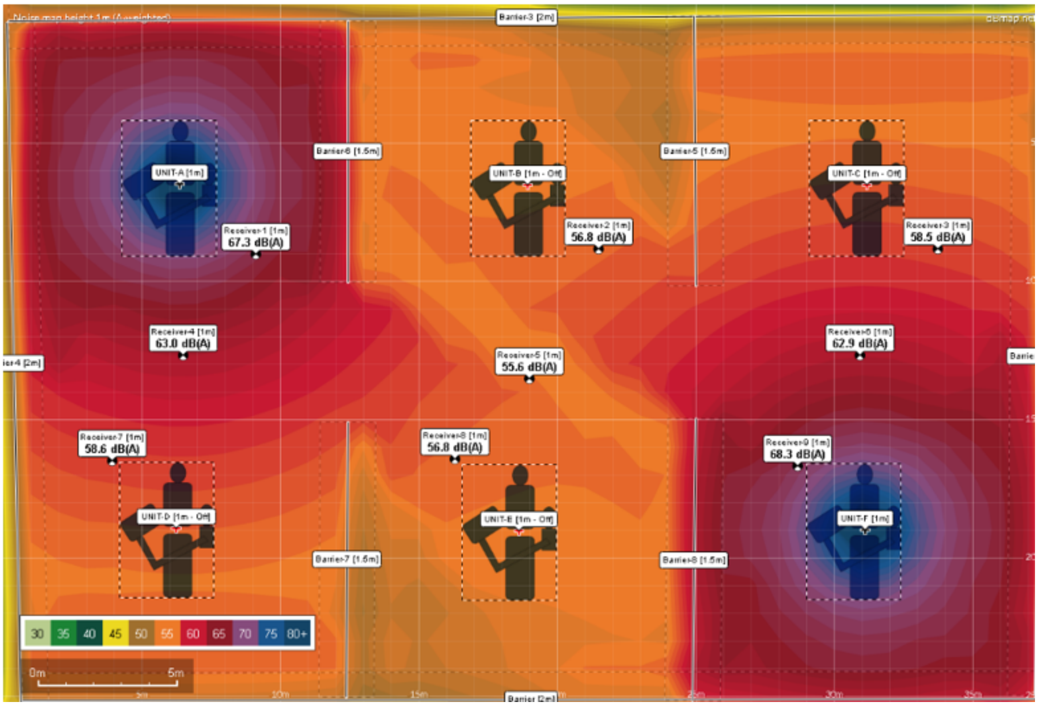

Fig. 14: Occupational noise measurements during noise containing operations in AF units (Test-7).

Test-2 Operations involving noise in DEF units, while the noiseless operations were performed in ABC units, the occupational noise was as Figure 9.

Test-3 Operations involving noise in AD units, while the noiseless operations were performed in BCEF units, the occupational noise was as Figure 10.

Test-4 Operations involving noise in BE units, while the noiseless operations were performed in ACDF units, the occupational noise was as Figure 11.

Test-5 Operations involving noise in CF units, while the noiseless operations were performed in ABDE units, the occupational noise was as Figure 12.

Test-6 Operations involving noise in AF units, while the noiseless operations were performed in BDEF units, the occupational noise was as Figure 13.

Test-7 Operations involving noise in AF units, while the noiseless operations were performed in BCDE units, the occupational noise was as Figure 14.

4. Discussion

Annual total exposure dose follow-up is performed for occupational diseases such as radiation, where side effects are seen in a short time.[25] Annual screening has been recommended for NIHL, but its use has not been widely accepted[6,26–28] Various studies have been carried out in clinics for more efficient patient admission, less waiting time, or more patient satisfaction.[19,20] In these studies, dentists and their staff work harder and are exposed to more occupational noise. In addition, occupational noise can cause people with dental anxiety to delay their treatment.[29] Artificial intelligence algorithms studies have been carried out for patients to spend minimum time in the waiting room.[24] The aim of these studies was efficiency and fast service. There are various applications such as wall paints, screens, ceiling tiles, anti-noise devices to reduce occupational noise.[30–33] In addition, studies on the production of tools that produce low noise were made.[34–36] Studies show that old tools produce high noise.[37,38] For this reason, it is recommended to replace old tools for noise reduction[38] However, this process may not be possible due to the cost of new equipment. It has been reported that the simultaneous continuous use of two or more noisy devices in a room should not be longer than 10 minutes.[1] This study hypothesized that the rational use of noise-making tools might reduce the occupational noise level in a multi-unit dental clinic.

In this study, measurements were taken from the center of the clinic as mid-clinic noise measurements at 4,5,6 named points and 30 cm from the sound source named as 1,2,3,7,8,9. The distance of 30 cm was calculated as the distance between the dentist's ear and the instruments making noise.[31]

Simulation of control and test group average noise levels and the test parameters are presented in Table 4. Noise-producing devices (aerator, scaler, etc.) application points are A, B, C, D, E, F. Different sound-producing devices' operation timings are evaluated in test groups. All sound-producing devices operated simultaneously in the control group and measured occupational noise compared with test groups. In test groups, all the sound-producing devices operated by the rational scheduling algorithm as described in this study (Figures 5 and 6).

In this study, the maximum mean occupational noise was measured in the control group. There was a significant difference in control and test groups (p=0,0009) (Table 5). According to post hoc test results, Control group with Test-3 (p=0,0015), Test-4 (p=0,0404) and Test-5(p=0,0021) are significantly different (Table 6). In the Test-3 group, A and D units were operating the noise-producing equipment, and the other units were in silent steps of the treatments. In the Test-4 group, the operating units were BE, and the silent ones were ACDF. In the Test-5 group, the operating units were CF, and the silent ones were ABDE. Test-3 mean room noise was 57,19, and Test-5 was 57,46 dB in this simulation. These noise levels were the lowest measurements in this study. Test-3, Test-4, and Test-5 operating units' algorithms differed from Test-1, Test-2, Test-6, and Test-7.

In Test-3, Test-4, and Test-5, the operating two units were opposite seats simultaneously. The sound barriers between units have a sound confinement effect. The gap between the units acts as a sound leveling apparatus and helps to cancel the noise produced by the devices. In Test-1 and Test-2, all three operating units' opposite units were in silent treatment steps (Figure 8). In this scheduling algorithm the mean room occupational noise level was 63,98 dB for Test-1, 64,21 dB for Test-2 and 68,54 dB for control. There was no significant difference between these groups. In Test-6 and Test-7, the mean room occupational noise levels were 60,89 and 60,87 dB, and the difference with the control group was not significant. These two test groups have two units operating at the corner of the room simultaneously, and the other units operate the silent steps of the treatment procedures. In this scheduling algorithm, the devices' sound waves distributing from the gap of the barriers and the mean room occupational noise level increases compared to Test-3, Test-4, and Test-5.

The control room scheduling algorithm has a mean room occupational noise of 68,54 dB. Since all units were operating in the clinic, there were no silent units to be compared with test groups in this group. The comparison of the control room mean noise with the test room was described in Figure 3 and Table 7. The mean noise level of all tested groups was 60,67 dB, which was statistically significant(p=0,0009), different from the control group. According to this result, the rational occupational noise-reducing appointment system reduces the mean room noise levels. The test room operating units noise level was not statistically different from the control group. This result was expected due to operating devices' occupational noises being the same at all time points of the simulation. The test room silent units and mid clinic noise measurement were below the test room mean noise, and the difference between control room was statistically significant also. (Table 7)

This study has also evaluated the difference in each other's noise in test groups (Table 8). The compared measurements were mean room noise, operating unit noise, mid-clinic and silent unit mean measurement as calculated for all tested simulations. There was a significant difference in measurements grouped with procedure steps (p=0,0002). According to the post hoc test, there were significant differences in the mean room and operating unit noises(p=0,0011), mean room and silent unit noises(p=0,0230), operating unit, and silent unit(p<0,0001), and operating unit with mid-clinic noise measurements(p=0,0004). There was no significant difference between the silent unit with mid-clinic and the mean room with mid-clinic. This insignificant difference was important because the reduction system has a good performance at noise reduction system, and there is no difference in silent, mid-clinic, and mean room noise levels measurements (Table 9).

According to this study, occupational noise can be effectively reduced by scheduling noisy instruments and tools. The mean room occupational noise level was 68,54 dB. The noise levels in this study were within the confidence interval of OSHA. According to OSHA, 8 hours of noise above 85 dB per day is a factor for hearing loss.[2] Although 68,54 dB noise level was below 85 dB of OSHA, it has produced NIHL.[15,39] In this study, the noise-producing instrument measurements are comparable to noise levels in the study of Al-Omoush et al.[4] These data were used for calibration purposes in the dBmap simulation program. The data obtained from this study were the data obtained in the simulation environment.

The simulation program used in this study was the dBmap web application (noisetools.net). The study was carried out as a simulation because different equipment, different clinic setup, and other factors that may affect the sound level may differ in the measurements in each clinic setup. The fact that different dentists use different devices in each clinic and the use of different techniques will also affect the occupational noise level. The sound level produced by a dentist who performs root canal treatment with an electric micromotor and a dentist who performs canal treatment with manual instruments will not be the same.[40] The noise level produced by the dentist using a cavitron or a sonic scaler will not be the same[11,14] In comparing each group's noise levels, there may be a standardization problem due to these problems. In a simulation system, all the environmental factors can be standardized, and results will be more reliable to compare within groups. The shortcoming of this study is that few treatment methods have been evaluated, and the appointment algorithm has not been evaluated in a real clinical setting. It is necessary to study with dentists in real clinical setups and different treatment methods.

This study simulated two different algorithms. The first algorithm was to reduce the total amount of noise by changing the usage timing of the devices that produce noise in treatment duration. In this algorithm, the treatment procedures were evaluated by hourly-based scheduling versus an algorithm to reduce the simultaneous use of the noisy instruments simultaneously. The data graph of occupational noise according to the treatment steps in a clinic with an hourly appointment was in Figure 5. In this simulation graph, the noisy steps occurring in prosthetic and restorative procedures were overlapping. The steps-based noise graph for restorative, prosthetic, and periodontal treatments in the test group simulation was as in Figure 6. In Figure 6, the instruments that produce noise do not operate simultaneously in three patient appointments at any time interval. When two patients are given an appointment simultaneously for the same treatment procedure, it will be protective for occupational noise-induced hearing loss in a six multi-unit clinic setup. The algorithm described in Figure 6 reduces the simultaneous usage of devices like aerator, ultrasonics, etc., and reduces the mean room occupational noise levels.

The second algorithm was scheduling the timings of noise-producing treatment procedures according to the location of the operating unit in multi-unit clinic setups.

The effects of clinical settings on occupational noise in multi-unit clinics were evaluated in this study. According to the results, Test-3 and Test-5 simulation measurements were at the lowest multi-unit clinical occupational noise levels. Significant protection was detected with treatment in opposite units as described in Test-3, Test-4 and Test-5 (Figures 10, 11 and 12).

Appointment simulation studies were conducted to reduce the patients' waiting time and reach the maximum number of patients treated per day.[19] In order to create a simulation, information about treatment types and times, patients' arrival patterns to the clinic, general treatment needs of patients, and the time required for these are needed.[19] These studies evaluated the average number of treated patients and average patient waiting time.[19] With this information, arrangements can be made, such as arranging the hours of admission of patients to the clinic, arranging the starting time of the doctor and assistant personnel, and arranging full-time staff who start work at different times.[19] In addition to these data, occupational noise can be reduced by including the noise maps obtained in this study into used appointment system. Piezotome noise and high-speed handpiece noise were compared in molar tooth extraction, and no significant difference was found. However, while the high-speed handpiece is 77-88 dB, the piezotome has been reported to generate 68 dB noise.[41] The background noise level has been reported as 60.8 dB.[2] This study showed that the type of noise-producing device was ineffective on the noise level, but the average appointment noise was higher than the ambient noise during the treatment process. During the procedure, the dentist and staff are exposed to cumulative aggregation of dental equipment noise.[42] It has been reported that this cumulative effect may cause hearing loss.[42] With the scheduling application designed using artificial neural network software and patients' specifications, clinical efficiency has been increased, and patient waiting times have been reduced.[24] An appointment system should be developed by evaluating the treatment noise data as described in this study.

Patients' anxiety with dental fear may increase due to hearing aerator and scaler sounds.[29,43] In an appointment system, giving appointments to dental anxiety patients during the quiet times of the clinic may increase the comfort of the patients. With the noise mapping of clinic treatment processes, noise-induced hearing loss should be prevented, and customer satisfaction should be increased. Numerous studies have been conducted on occupational noise. A study evaluating classical periodontal treatment appointments calculated that an average of 1 hour and 16 minutes was required for treatment. The treatment phase, in which sound-producing instruments were used, was 29 minutes. No noise was produced for an average of 47 minutes during treatment.[44] In these 47 minutes, the noisy operation of other treatment procedures or the examination patient should be taken, and the rational management of the noise level in multi-unit dental treatment clinics should be possible. In this study, the sound-producing treatment phase was 20 minutes, and the total treatment duration was 68 minutes in periodontal treatment (Table 2). Forty-eight minutes of the silent zone should be used for other appointments' noisy procedures.

Occupational noise-related hearing impairment can be reduced with the rational appointment algorithm described in this study. In private clinics, setups with one unit per room can be built. However, multi-unit clinics can be found in state and academic clinics due to financial inadequacies and staff limitations. Most occupational noises were detected in academic clinics.[29] Wallcoverings, ceiling fixtures, screens, low-noise devices are used to reduce occupational noise in these clinics. When an hour-based appointment system was used in a clinic working from 8.00 am to 5.00 pm, exposure to noise should be 4 hours a day. Although these noises are below 85 dB as described by OSHA, their effects on NIHL are well known.[15,39] In this study, it has been shown that scheduling appointments at variable hours can reduce the total amount of occupational noise produced in multi-unit clinics.

5. Conclusions

A protocol for scheduling patients in multi-unit clinics was developed according to the treatment noise map. According to this study, the cost for reducing occupational noise may decrease by scheduling patients by treatment noise map-based scheduling applications. This appointment system may positively reduce the occupational noise-induced stress levels of patients with dental anxiety. A limited number of dental procedures and a small multi-unit clinic setup were considered in this study. Further studies are required with more treatment procedures and measurements in real dental clinics.

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None.

7. Conflict of Interest

None.

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