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Evaluation of Hazardous Noise Exposure in US Army Dental Treatment Facilities

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Evaluation of Hazardous Noise Exposure in US Army Dental Treatment Facilities

Anita M. Kimbrough, DDS; Sheteka Ross-Goodlett, DDS; Robert Masterson, DDS, MS

ABSTRACT

Background. Hearing loss, including tinnitus, remains a concern for the dental professional. To the author's knowledge there has not been any documented studies within a United States Army Dental Treatment Facility (DTF) which evaluate the noise exposure of dental practitioners during an eight-hour day utilizing a personal noise level meter. This study was undertaken to measure and evaluate the level of noise using a wearable noise level meter during an eight-hour day and to compare these measurements to assessments done via the Army's Industrial Hygiene Program using a sound level meter.

Methods. The author measured the continuous noise levels experienced during eight-hour clinical workdays. The noise measuring device was set to record noise in the range minimum of 70.0 decibel (dB) (A) to a maximum of 140.0 dB (A). Noise levels were recorded from the first clinical or laboratory procedure to the last procedure of the day using the calibrated SL400 noise level meter by EXTECH®. The five-week study took place in two Dental Treatment Facilities (DTFs) located at Fort Hood, Texas. This data was then compared to the results obtained from the Industrial Hygiene Department of Public Health, Carl R. Darnall Army Medical Center (CRDAMC) for a general area noise dosimetry measurement conducted on October 6, 2020, using the 3M™ Sound Level Meter, Model #SE401IS10271.

Results. Average levels of noise (Leq) ranged from 79.0 to 83.3 dB(A). Department of Defense (DoD) standards recommend the decibel level not exceed a time weighted average (TWA) of 85 dB(A) for an eight-hour work period. Basic levels of noise measured in the DTF did not exceed NIOSH/OSHA/DoD standards for the eight-hour time weighted average.

Conclusion. The EXTECH® SL400 personal noise dosimeter measurements were higher than those collected utilizing the 3M™ Sound Level Meter conducted by Industrial Hygiene Department, CRDAMC, but the TWA for an eight-hour day did not exceed the permissible DoD standard of 85 dB(A). Future studies are recommended to compare measurements with the sound level meter and the personal noise dosimeter incorporating additional clinical environments during full patient treatment capacity such as the schedules prior to the COVID-19 Pandemic.

Practical Implications. Hearing conservation is important to incorporate into daily practice for the dental professional. The impact of work-related injuries, such as hearing loss, may have a profound effect on the quality of life. Dentists that operate within the DoD especially need to preserve their hearing as a crucial component of combat readiness [6].

Key Words. Noise Exposure: Noise Induced Hearing Loss (NIHL); Tinnitus

Noise-Induced Hearing Loss (NIHL), according to the National Institute for Health and Occupational Safety (NIOSH), is the most common work-related injury in the United States and is more prevalent than cancer or diabetes [1]. It is understood that exposure to noise at work can lead to permanent sensorineural hearing loss [2]. Noise exposure and hearing loss has been a concern for the dental practitioner for decades since the introduction of the high-speed dental handpiece.

Noise surveys are routinely conducted at dental clinics to assess exposure to potentially hazardous noise in the workplace because, according to OSHA standards (29 CFR 1910.95 Occupational Noise Exposure), protection against noise exposure must be provided when the sound levels exceed those mandated within the published guidelines.

Regardless of technological advances in the manufacturing process for the high-speed handpiece, many cross-sectional and longitudinal studies demonstrate that dentists suffer from rates of hearing loss and tinnitus which are twice that of the general population [3]. Hearing loss can develop over a long span of time and through cumulative exposure to hazardous noise. The hearing loss that dentists are susceptible to can be considered a silent hearing killer. The effects are not often realized until symptoms such as tinnitus occur.

A new analysis from a nationally representative health interview and examination survey found that nearly one in four (24 percent) of United States adults aged 20 to 69 years has features of his or her hearing test in one or both ears that suggest noise induced hearing loss (NIHL) [4]. These statistics may explain the concern over the impact of hazardous noise from equipment utilized in the dental profession.

Hearing acuity is especially important for Active Duty military dental Officers who must maintain physical readiness to deploy into combat environments. One study from the United Kingdom (UK) investigated noise-induced hearing loss in a military setting using a wearable noise dosimeter. The UK study postulated that it is possible for military dentists to have at least three occupational exposures to hearing loss [5]. These exposures include the use of weapons for combat training and the noise levels in the dental clinic environment.

Sound discrimination, in particular, is imperative in the Army operational environment. Higher-pitched frequencies are the first to be affected by overexposure to noise like the dental handpiece. High frequency sound range is responsible for 95% of speech discrimination. As a result, even a modest degree of damage in this frequency region may lead to strained communication, more so in noisy environments [1]. This can be very important, for example, if someone says “No”, but it is heard as “Go”.

Previous studies on noise exposure within the dental office have recorded measure-ments using a sound level meter. The sound level meter is a device that is typically placed on a stationary surface to measure sound pressure levels within a room or an area. The sound level meter is usually not intended to be worn by the user. Most protocols utilizing the sound level meter record noise measurements within a single area of the clinic. Measurements with the sound level meter are typically captured for a timespan of four hours.

The noise level meter, on the other hand, is a personal wearable device. Very few studies have incorporated the wearable personal noise level meter in the dental environment. A noise level meter can be worn by the person either on the collar or a pocket close to the ear. This will theoretically allow for a more accurate estimation of the noise being captured by the ear, and therefore, it is possible the noise level meter may be better suited to categorize the actual risk level to noise exposure for the dental professional.

The rationale for testing using noise measurement devices close to the source rather than on a countertop a few feet away is based on the law of inverse square level for sound. The inverse square level law for sound/noise states: as the distance between the noise source and the ear is halved, the intensity of the noise is doubled. Therefore, if one is basing dB levels on recording instruments placed 2-3 feet away (or more) on a tabletop, per the law of inverse square level for sound, it is possible that the dB levels will show a greater than 50% reduction as compared to those recordings captured via the SL400® which is half the distance (if not closer) to the noise source.

The purpose of this study was to measure and evaluate noise exposure within a military dental clinic using a personal noise dosimeter to determine if it would record a higher noise exposure than the sound level meter traditionally used during OSHA mandated IH surveys. The protocol for the current study also sought to capture the clinician's noise exposure in his/her comprehensive work environment (not just one location within the DTF like standard IH surveys) for a full eight-hour clinical day.

Furthermore, the intent of this study is not to measure the noise generated for individual pieces of equipment in the dental clinic, rather the intent is *to evaluate the cumulative daily exposure* of individuals to potentially hazardous noise within U S Army DTFs.

To the author’s knowledge, no studies exist that have evaluated continuous noise exposure using a wearable noise level meter within a United States Army DTF.

Null Hypothesis: The noise level recordings via the EXTECH® SL400 will not provide a higher time weighted average (TWA) than the sound level meter which is typically used during annual Army Industrial Health Service noise survey testing.

MATERIALS AND METHODS

Testing model, continuous noise level recording

This study used a brand new EXTECH SL400® (Figure 1) noise level meter/sound dosimeter to record noise. The instrument was calibrated according to American National Standards Institute (ANSI) standards by the manufacturer prior to utilization and is certified for one year of use following calibration. The EXTECH SL400® has a microphone which is attached via a USB cable to the recording device (Figure 2). Noise measurements were collected with the EXTECH SL400® Noise Level Meter with a ½” microphone. The EXTECH SL400® is lightweight (weighing

Figure 1. EXTECH SL400® Personal Noise Dosimeter with USB Interface. Provides Noise Surveys for compliance with OSHA, MSHA, DOD, ACGIH and ISO standards.

only 10 ounces) which makes it discrete and easy to attach to the wearer. The manufacturer has built-in, pre-set options from which to choose the type of noise measurement being recorded. The device was set to the OSHA industry standards for measuring noise level utilizing the TWA measuring mode. At the start of the clinical day, the operator attached the microphone of the noise dosimeter to the collar to capture noise within 12 inches from the source. The microphone was positioned at 6” from the operator’s ear. The device was secured to the waistband throughout the noise recording.

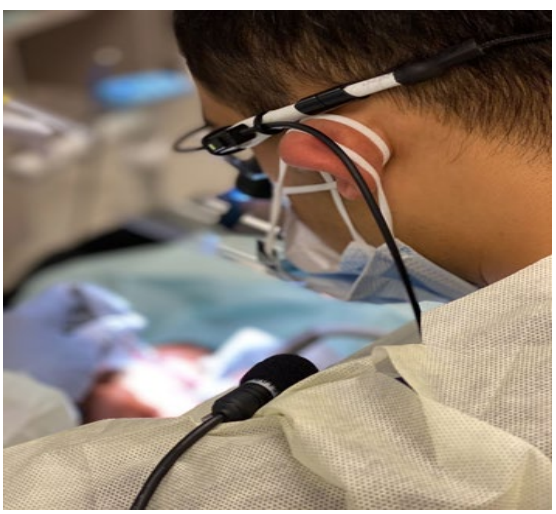

Figure 2. Operator wearing noise dosimeter during clinical procedure

Upon the start of the first procedure of the day the recording device was turned on for continuous readings. The device was set to pause during the operator's lunch break and re-started upon return to clinical procedures.

Various types of clinical and laboratory procedures were completed during an eight-hour day. The appointments included procedures such as surgical extraction of third molars, tooth preparation for restorations, hygiene appointments for teeth cleanings with hand scalers, ultrasonic scalers, polishers, and endodontic procedures as well as various laboratory procedures. These procedures involved the use of the high-speed handpiece, high speed handpiece for surgical procedures, ultrasonic suction, ultrasonic scalers, ultrasonic handpiece for endodontic procedures, and a HEPA air filtration unit where available. The operator wore the noise level meter in closed door and open bay clinical settings.

The Army DTF commonly has an open bay setting which has multiple dental chairs positioned adjacent to each other. Some DTFs within the United States Army have individual treatment rooms that have a door which can be closed to perform dental procedures. For this study, noise was measured in both environments. To mitigate the spread of aerosol- generated COVID-19 particles a portable Omniaire 600V HEPA air filtration machine was utilized during most dental procedures.

All measurements are reported in a dBA scale with slow response time-weighting.

The A-weighted scale of sound measurement best simulates the sound that is heard by the human ear. The A- weighted scale is most commonly used and covers the full frequency range of 20Hz all the way up to high frequency 20 kHz and accounts for the fact that the human ear is slightly less sensitive to lower frequencies [7].

RESULTS

A noise survey conducted by the Industrial Hygiene (IH) Department at CRDAMC on October 6, 2020, was used as the comparison study for this project. The complete study is available upon request

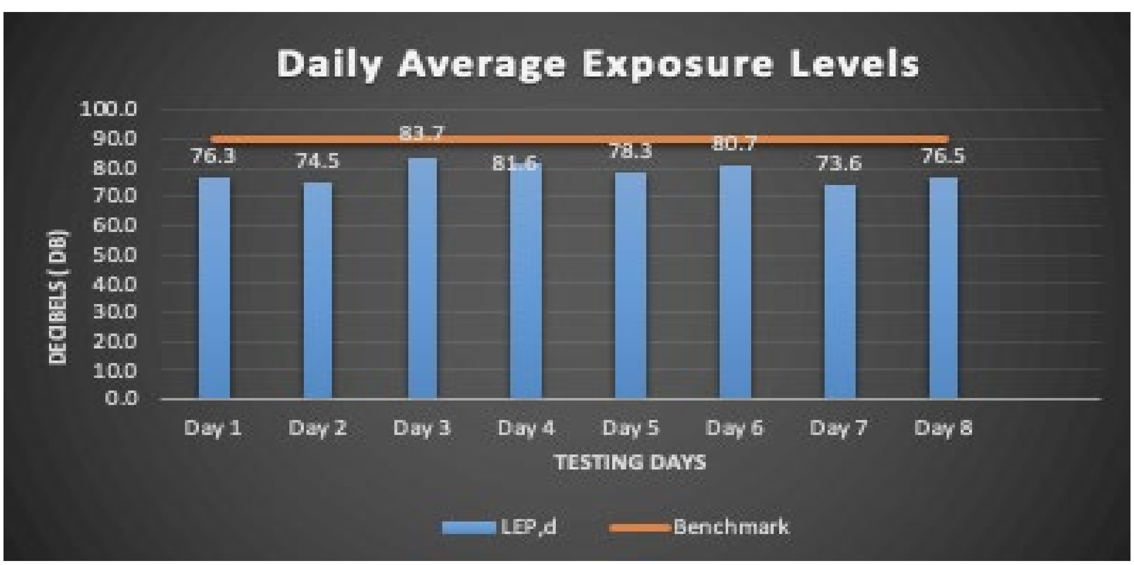

Table 1. Daily Average Exposure Levels using EXTECH® SL400 noise dosimeter reported in dB(A).

from the Department of Industrial Hygiene, Fort Hood, TX. In that survey, the highest noise level occurred during laboratory procedures with the peak at 92.5 dBA.

For the wearable noise dosimeter study, noise recordings were completed over the course of eight days within three clinics located at Fort Hood, TX. The highest daily average exposure level (LEP,d) value reached 83.7 dBA. The exact location of the highest (peak) level of noise could not be determined with the personal noise dosimetry protocol.

Exceedence times were maintained above or equal to 70dB for more than 50% of the day (Table 2). The frequency of impact noise, however, was not reported in this study due to limitations of the EXTECH® SL400 noise dosimeter. The results of this study indicate that the personal noise dose did not

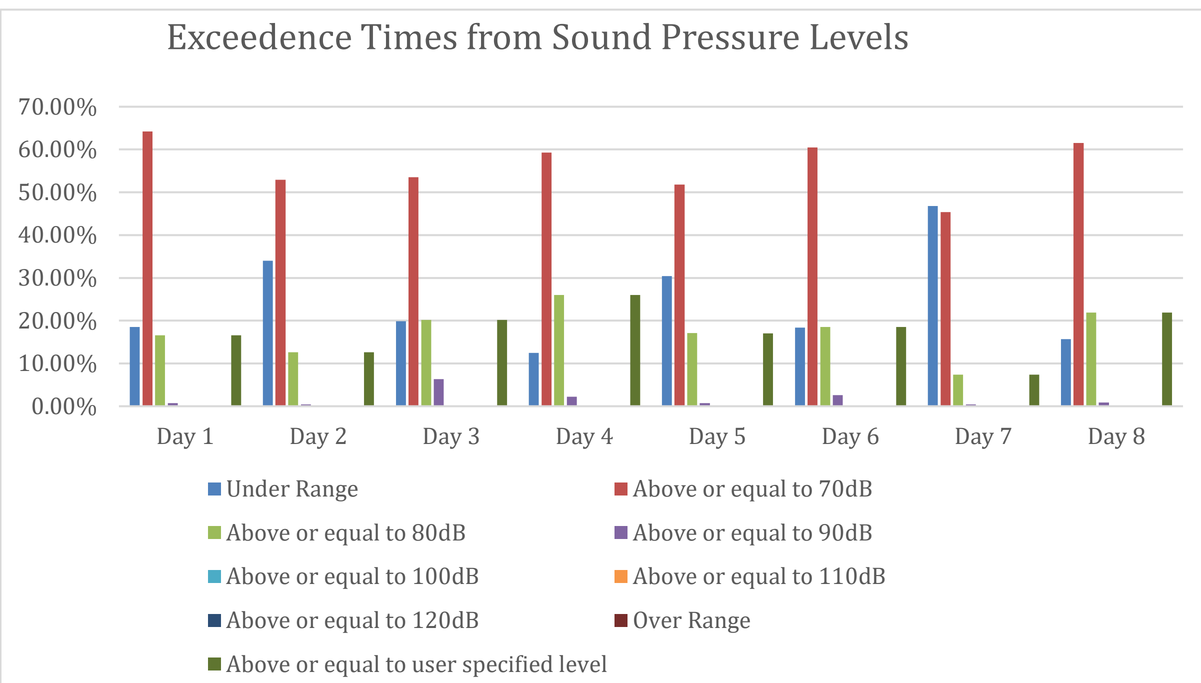

Table 2. Exceedence Times (in percentage) during clinical and laboratory procedures did not exceed industry guidelines.

exceed the daily permissible level (Table 1). See Appendix 1 for the table of complete results.

The TWA recorded with the EXTECH SL400 noise dosimeter ranged from 61.9dB(A) to 76.5 dB(A) TWA over the eight-day study. CRDAMC IH Department reported TWA ranges from 62.6dB(A) to 67 dB(A) for the noise survey conducted with the 3M ™ Sound Level Meter in October 2020.

DISCUSSION

This study sought to evaluate the cumulative daily noise exposure to potentially hazardous noise levels and high frequency noise from various noise sources and durations. The sounds included noise generated from high-speed suction, ultrasonic scalers, and the high-speed handpiece, which all generate high frequency noise as reported in many research studies [8,9,10].

When comparing the two different noise surveys, it is apparent that both show noise exposure risk below the OSHA standard acceptable risk level. In this study, personal noise dosimetry did register a higher level of noise than of that recorded using the sound level meter. The highest TWA measured with the sound level meter was 67 dB(A) and the highest recorded TWA with the personal noise dosimeter was 76.5 dBA. However, despite the rejection of the null hypothesis, there was not clear evidence that the wearable dosimetry testing definitively registers noise levels warranting a switch to this type of testing on a regular basis.

The results of this project show the current IH protocols for testing noise exposure in Army DTFs to be appropriate, but more research is warranted to ensure the noise levels are being accurately captured to reflect the overall exposure of the general dental practitioner within US Army DTFs. While not definitive in this study, the findings leave open the possibility that the traditional noise level survey does not fully capture a true value of noise exposure for dental professionals. Correction of some of the design issues discussed below could help provide a clearer understanding of the risk.

Dental procedures inherently produce intermittent noise. Therefore, variations will occur in the amount of noise generated based on the nature of the procedure and the amount of time the high-speed handpiece and other clinical and laboratory equipment is in use [8]. This may provide an explanation as to why the time weighted averages did not exceed 90dB regardless of the equipment used to measure the noise levels. Future study would be needed that accurately detailed the types of procedures being performed during the highest noise levels to draw clear conclusions about accurate time thresholds for these high-risk events.

The COVID-19 pandemic impacted the day-to-day operations within the Army DTF during this study. Modifications were made in schedules, decreasing the number of patients and procedures that are scheduled for treatment in the open bay dental treatment facilities. The clinic that has an open bay design may ordinarily have six to eight dentists providing patient care in chairs located adjacent to one another. During the study, the number was reduced to no more than three providers working simultaneously.

Another concern with the applicability of this project's findings to other dental clinics is the unique nature of a residency clinical environment; specifically, a reduced number of procedures performed per day may have lowered the overall amount of noise produced. Most of the data was collected in the dental clinic/laboratory of a general practice (AEGD) residency program. The training program requires the provider (resident) to stop the procedure in order to have procedural checks by faculty members. Residents of this program typically only perform three to six procedures each day. Civilian general dentists may typically complete eight to sixteen (or more) procedures during an eight-hour day. This increased time with the high-speed handpiece operating could impact the overall sound levels significantly. Thus, future researchers would be wise to conduct this study in a civilian practice as well before confidently espousing the benefit of wearable dosimetry equipment.

CONCLUSION

Although the null hypothesis was rejected, the average daily noise exposure of general dentists and auxiliary personnel within an Army DTF did not exceed the permissible noise level mandated by DoD (85dB) or OSHA (90dB) during the eight-hour workdays observed. The findings of this study are consistent with previous noise surveys conducted by the Industrial Hygiene Service, Department of Public Health, CRDAMC using traditional testing methods and, therefore, do not support a switch to the wearable dosimetry testing equipment at this time.

Further research with wearable dosimetry technology, involving providers maximizing the number of dental procedures performed per hour (pre-pandemic levels, preferably outside the residency setting and ideally incorporating a civilian practice) would be necessary to understand the true differences between the two types of testing equipment reviewed in this project.

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Appendix 1. Personal Noise Dose Meter Data for Eight Day Study

Variable	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8
Measurement Result								
Run Duration (Min.)	240.0	240.0	264.0	390.0	387.0	352.0	265.0	195.0
LEP, d (dB)	76.3	74.5	83.7	81.6	78.3	80.7	73.6	76.5
Leq (dB)	80.4	79.9	87.7	83.3	81.2	83.2	79.2	81.4
SEL (dB)	120.8	119.1	128.3	126.1	122.9	125.3	118.1	121.1
LAVG (dB)	84.4	84.0	90.1	85.5	84.3	86.4	84.4	84.6
Dose %	4.6	3.2	15.4	15.7	7.6	10.5	2.0	5.4
TWA (dB)	67.8	65.1	76.5	76.7	71.4	73.7	61.9	69.0
Exceedance Times								
Under Range	18.4	34.0	19.9	12.5	30.4	18.4	46.8	15.7
>= 70 dB (%)	64.2	52.9	53.5	59.3	51.8	60.5	45.4	61.5
>= 80 dB (%)	16.6	12.6	20.2	26.0	17.1	18.5	7.4	21.9
>= 90 dB (%)	0.7	0.4	6.3	2.2	0.7	2.6	0.4	0.9
>= 100 dB (%)	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0
>= 110 dB (%)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
>= 120 dB (%)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Over Range (%)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
>= User specified level	16.6	12.6	20.2	26.0	17.1	18.5	7.4	21.9
Statistical Exceedance Levels (dB)								
L5%	85.5	83.9	95.1	88.5	85.0	88.1	82.4	86.7
L10%	83.0	81.5	88.5	86.2	82.9	84.8	79.0	84.6
L50%	74.6	71.9	74.8	77.4	72.0	73.9	*	75.3
L90%	*	*	*	*	*	*	*	*
L95%	*	*	*	*	*	*	*	*

Note. * = Under Range.