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Original Article

Noise levels and sound pollution associated with various operative procedures and equipments in a pediatric dental environment—A clinical study

Mousumi Goswami*, Darrel Singh, Binny Vashist, Sugandha Marwaha

Department of Pedodontics and Preventive Dentistry, ITS Dental College, Hospital and Research Centre 47, Knowledge Park III, Greater Noida, Uttar Pradesh 201308, India

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ABSTRACT

Aim: To analyse sound levels and sound pollution in a Pediatric Dental Clinic and to analyse whether the levels are significant to the extent of being a health hazard.
Methods: Noise levels were measured in a Pediatric dental clinic in an institutional setting with a precision noise level meter ((HTC 1350). Recordings were taken at different times of the day, at the centre, chair-side, reception, play area and four corners of the department keeping the microphone at a distance of 6 in. from the operator's ear. The noise levels of various equipments i.e. suction, micromotor, airotor were measured with the equipments turned on and during cutting operations with the microphone placed at a distance of 6 in. from the sound source. The sound levels for the laboratory equipments were taken at a distance of 6 in. and 2 m.
Results: The highest mean sound levels were recorded at the reception, play area and chair-side area with least mean sound levels recorded at 9:00am which increased at 11:30am & 2:00pm and reduced again at 3:30pm The maximum sounds were produced by the lathe trimmer, airotor and scaler.
Conclusion: Noise levels in a pediatric clinic approach the level of risk of hearing loss [85 db(A)]. This would have a serious effect on both providers and patients and a concerted effort would be required to control the noise levels and thus avoid the potential health hazards that it poses.

1. Introduction

The dental work environment has potentially hazardous noise levels. The high speed turbines, compressors, high velocity suctions, motors all contribute to the noise levels. There is a certain level of noise that the pediatric patients themselves generate by a vociferous suppression of their fear and disagreement with their crying and screaming. The acoustic significance of children screaming is that during short periods of time it may create high sound level spikes.[1] Thus the noise levels attained achieve significant values and can lead to significant discomfort and detrimental health effects.

It is an established fact that exposure to noise levels above 80 dB is associated with adverse consequences.[2] The detrimental effects comprise of the auditory, non-auditory and physiological effects. Prolonged exposure to excessive noise levels damages the delicate hearing mechanism of the inner ear thus causing noise-induced hearing loss (NIHL).[3] The non-auditory and physiological effects of increased noise levels include hypertension, sleep disturbance, decreased learning abilities, increased stress reactions, interference with concentration and communication, annoyance, mental fatigue and a reduction in efficiency.[2,3–7] Furthermore, noise may adversely impact patients by inducing fear and anxiety thereby making the patients uncooperative and decreasing the likelihood of the patient accepting the dental treatment.

Thus due to the potential damaging effects of exposure to high noise levels adoption of stringent protocols aimed at reduction of these noise levels assumes a centre stage not only from a dentist's perspective but also from the view point of the patient coming to the clinic. Hence the present study was designed to analyse, measure and compare noise levels of different equipments among

* Corresponding author at: Department of Pedodontics and Preventive Dentistry, ITS Dental College, Hospital and Research Centre, Greater Noida, 201306 Uttar Pradesh, India.
E-mail addresses: mousumi_leo@yahoo.co.in (M. Goswami), drdarrelsingh@gmail.com (D. Singh), vashist.binnu@gmail.com (B. Vashist), dr.sugandha11@gmail.com (S. Marwaha).

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dental learning areas at different time intervals and to assess whether the levels attained are significantly close to the levels that are proven to cause health hazards.

2. Materials & methods

This study was conducted in the Department of Pedodontics and Preventive Dentistry, I.T.S Dental College, Hospital & Research Centre, Greater Noida. The sound levels were measured with a precision sound level meter (HTC sound level meter 1350) with a microphone. Frequencies were measured in A-weighted sound levels in decibels [dB (A)].

The study was divided into three phases. Phase I consisted of recording of noise levels in the clinical area measured on three days of the week (Monday, Wednesday and Saturday), the days corresponding to the days of maximum footfall in the department. The areas designated for measuring the noise levels were the centre of the department, chairside, reception, play area and four corners of the clinical area. Fig. 1 gives the basic layout of the department.

The department is a centrally air conditioned unit with a total area of 4097.81 sq ft. The clinical area is a square shaped area (805.68 sqft) with PG cubicles ($8^{1/2} \times 10$ sqft) on one side and an open UG working area on the other.

The centre of the department was calculated from the four corners of the department by using a measuring tape (marked o in Fig. 1). The four corners of the clinical area are marked as abcd in Fig. 1. During the recording the air-conditioners were switched off for any non-desirable inclusions. Noise levels were assessed at various time intervals of the day (9:00 am, 11:30 am, 2:00 pm, and 3:30 pm). The microphone was placed at the designated areas to record noise levels at base line during different time intervals. A set of three readings were taken at an interval of 30 seconds each. The measuring device was set at zero before recording noise in any particular area.

Phase II consisted of the recordings done in a cubicle ($8^{1/2} \times 10$ sqft). The noise levels of various equipments i.e. suction, micromotor, airotor were measured with the equipments turned on (without cutting) and during cutting operations. The noise levels were measured while the patient was seated in the dental chair with the operator working in the oral cavity. While measuring the noise levels, the microphone was placed at a distance of 6 in. from the sound source near the operator's ear to simulate the intensity of noise reaching the eardrum. The noise levels for the Suction pumps were recorded while running free and when in contact with the mucosa.

Phase III consisted of the recordings of equipments in the preclinical lab area of the department (marked l in Fig. 1). The equipments whose noise levels were recorded consisted of Lathe trimmer, vibrator and ministar pressure moulding machine. The noise levels were recorded with the microphone being kept at a distance of 6 in. from the noise source and three sets of recordings were taken for each equipment. Another set of readings were taken with the microphone being held at a distance of 2 m from the noise source. This was done to simulate the person within a 2 m radius who would also be exposed to the same noise.

The data collected was subjected to statistical analysis. Inter group comparisons were made using one way Analysis of Variance and post hock Tukey's analysis. The level of significance was set at 0.

3. Results

The results of statistical analysis of the mean sound levels in the Phase I, II & III were tabulated. Table 1 shows the mean sound levels measured with HTC sound level meter-1350 and a microphone in

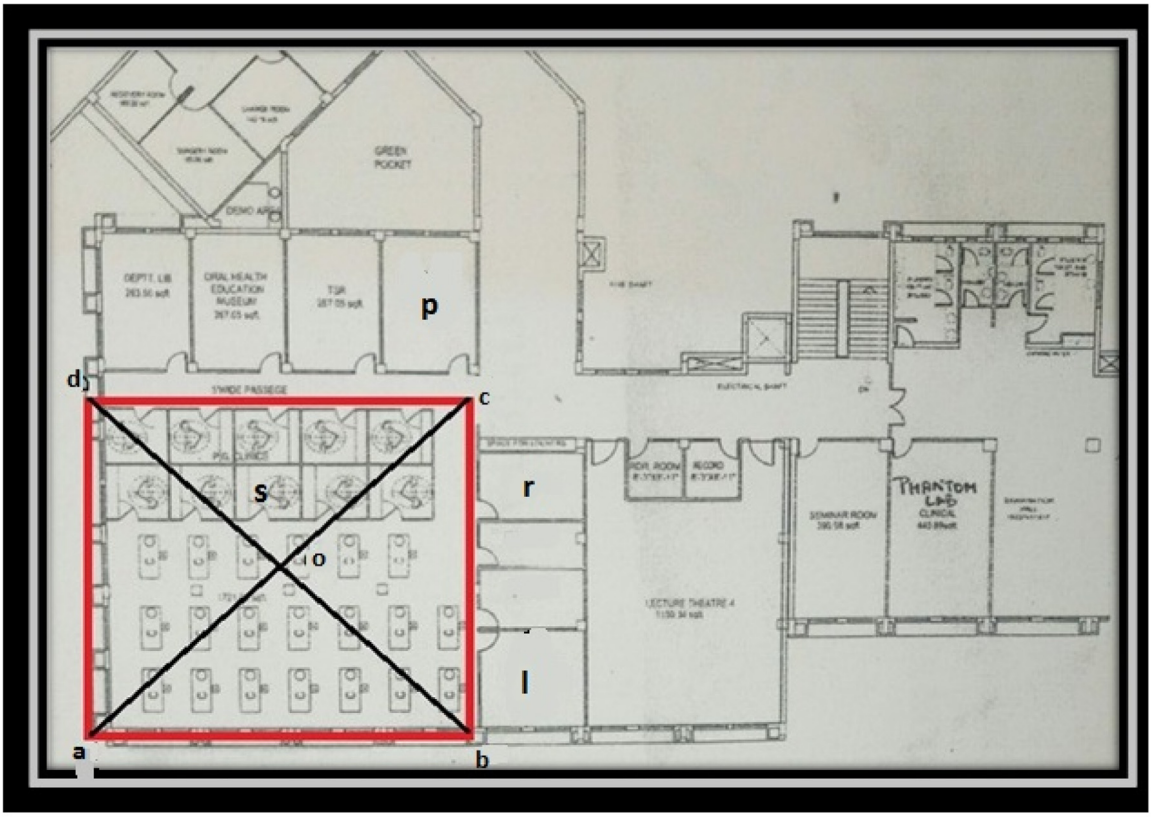

Fig. 1. Department Layout.

Table 1
Noise levels at different times.

Day	Location	9:00 am		11:30 am		2:00 pm		3:30 pm	
		Mean	Std. Deviation	Mean	Std. Deviation	Mean	Std. Deviation	Mean	Std. Deviation
Day 1	Centre of department (o)	61.72	1.67	68.40	1.15	70.68	1.46	69.63	0.76
	Chairside (s)	58.90	1.31	70.30	0.95	71.77	1.43	58.42	0.79
	Reception (r)	59.92	2.47	70.12	1.85	74.77	2.76	70.78	1.01
	Play area (p)	57.57	0.81	70.18	7.94	76.03	5.70	59.48	1.96
	Corner (a)	56.93	1.81	64.73	1.67	65.87	1.57	57.38	0.96
	Corner (b)	58.55	0.98	68.60	2.79	64.57	2.57	62.80	0.41
	Corner (c)	60.35	1.58	69.60	2.40	68.80	2.91	62.83	2.29
	Corner (d)	60.05	2.46	65.25	1.25	64.65	1.77	59.42	0.67
Day 2	Centre of department (o)	59.70	0.57	71.00	1.33	74.23	2.13	69.58	0.77
	Chairside (s)	57.12	0.81	71.87	2.11	74.45	3.16	58.18	0.39
	Reception (r)	60.95	3.52	70.30	1.65	80.82	4.08	70.70	1.03
	Play area (p)	54.20	3.80	71.88	4.99	77.30	2.05	57.77	2.63
	Corner (a)	58.35	0.78	65.42	1.60	64.82	1.50	58.23	0.91
	Corner (b)	57.43	0.96	66.38	1.30	64.92	2.42	66.60	1.49
	Corner (c)	59.53	1.90	73.08	2.66	69.78	1.27	63.23	2.29
	Corner (d)	60.93	0.88	67.30	1.57	63.05	2.04	58.93	2.36
Day 3	Centre of department (o)	61.28	2.07	69.68	1.85	73.17	1.11	69.58	0.77
	Chairside (s)	57.50	1.53	71.10	1.10	74.45	3.16	58.18	0.39
	Reception (r)	64.47	3.49	70.75	1.89	83.67	4.80	69.65	2.79
	Play area (p)	55.72	2.52	70.62	3.42	77.97	2.49	57.95	2.48
	Corner (a)	58.63	0.86	65.15	1.99	65.08	1.57	58.78	1.45
	Corner (b)	57.22	1.13	66.93	2.17	65.03	2.35	67.57	1.94
	Corner (c)	60.60	2.52	73.17	4.79	69.85	1.27	69.10	1.68
	Corner (d)	61.73	0.85	68.00	0.86	64.20	2.15	58.98	2.21

the 8 selected locations in the department of Paediatric& Preventive dentistry at four particular timings on 3 decided days of the week. Sound frequencies were measured in A-weighted mean sound levels in decibels [dB (A)].

4. Day 1

The highest mean sound levels were measured as 76.03 dB, 74.77 dB and 71.77 dB at the Play area, Reception and Chair side area at 2:00pm respectively. Other high mean sound levels were measured at the Reception area (70.78 dB) at 3:30pm, Center of the department (70.68 dB) at 2:00pm, Chair side area (70.30 dB); Play area (70.18 dB) and the Reception area (70.12 dB) at 11:30am. The least mean sound levels were measured as 57.38 dB at the Corner (a) at 3:30pm and as 57.57 dB at the Play area at 9:00am. Table 1 reveals that the mean sound levels in the different regions of the department on Day1 were lesser in morning times but hiked in the timings of 11:30am and 2:00pm and further dropped down at 3:30pm.

5. Day 2

The highest mean sound levels were measured as 80.82 dB, 77.30 dB and 74.45 dB at the Reception, Play area and Chair side area at 2:00pm respectively. Other high mean sound levels were measured at the Center of the department (74.23 dB) at 2:00pm, at Corner (c) (73.08 dB); Play area (71.88 dB); Chair side area (71.87 dB);at the Center of the department (71.00 dB) and the Reception area (70.30 dB) at 11:30am. The least mean sound levels were measured as 54.20 dB at the Play area and as 57.12 dB at the Chairside area at 9:00am. The Table 1 depicts that the early and late hours of Day2 were peaceful than that from 11:30am to 2:00pm.

6. Day 3

The highest mean sound levels were recorded as 83.67 dB, 77.97 dB and 74.45 dB at the Reception, Play area at 2 and Chair side area at 2:00pm respectively. Other high mean sound levels were measured at the Center of the department (73.17 dB) at 2:00pm, at Corner (c) (73.17 dB); Play area (70.75 dB); Chair side area (71.10 dB); Play area (70.62 dB) and the center of the department (69.68 dB) at 11:30am. The least mean sound levels were measured as 55.72 dB at the Play area and as 57.22 dB at the Corner (b) at 9:00am. The pattern of variation in measured mean sound levels at the different timings of Day3 was similar to that of Day 1 & 2.

On all the 3 days of data collection, least mean sound levels were recorded at 9:00am which later on increased at 11:30am & 2:00pm and curtailed again at 3:30pm. This was probably due to maximum number of footfalls of patients at around 11:30am and 2:00pm. (Table 1)

Table 2
Noise levels of scaler.

Scaler	Noise levels			
	Minimum	Maximum	Mean	Std. Deviation
a) Running free	59.60	60.10	59.88	0.17
b) Running in contact with the tooth without suction	77.60	85.50	81.83	2.55
c) Running in contact with the tooth with suction	81.10	87.30	84.05	2.25
Chi square value	10.33			
P[a] value	0.006, S			
Post hoc pairwise comparison[b]	b,c > a			

Table 3
Noise levels of suction.

Suction	Noise levels			
	Minimum	Maximum	Mean	Std. Deviation
a) Running free	73.40	74.30	73.85	0.40
b) Running in contact with the mucosa	72.50	75.40	73.77	0.95
Chi square value	−0.210			
P[b] value	0.833, NS			

Table 4
Noise levels of micromotor.

Micro motor	Noise levels			
	Minimum	Maximum	Mean	Std. Deviation
a) Running free	64.70	66.10	65.43	0.51
b) Running in contact with the tooth without suction	73.50	78.10	75.55	2.01
c) Running in contact with the tooth with suction	79.60	82.80	80.90	1.14
Chi square value	12.00			
P[a] value	0.002, S			
Post hoc pairwise comparison[b]	c > b > a			

Table 5
Noise levels of airotor.

Airotor	Noise levels			
	Minimum	Maximum	Mean	Std. Deviation
a) Running free	77.40	83.80	79.32	2.33
b) Running in contact with the tooth without suction	80.50	86.60	83.15	2.58
c) Running in contact with the tooth with suction	85.20	90.20	87.63	1.87
Chi square value	8.33			
P[a] value	0.016, S			
Post hoc pairwise comparison[b]	c > a			

The results of the noise levels of equipments measured in clinical areas are tabulated in Tables 2–5. The maximum sound levels recorded with the scaler (Table 2) running in contact with the tooth with suction was 87.30 dB and running in contact with the tooth without suction was 85.50 dB which were similar. The maximum level recorded with the scaler running free was 60.10 dB.

The maximum noise levels produced by the suction (Table 3) were similar while running free(74.30 dB) and in contact with mucosa (75.40 dB).

The maximum sound levels recorded with the micromotor (Table 4) running in contact with the tooth with suction was 82.80 dB and running in contact with the tooth without suction was 78.10 dB. This difference was statistically significant. The maximum level recorded with the micromotor running free was 66.10 dB

Mean noise levels associated with the use of air rotor is depicted in Table 5. Noise levels were significantly higher ($p < 0.05$) when the airotor was functioning in contact with the tooth along with suction than when it was running free, with the recorded mean values being 87.63 and 83.15 respectively. Noise produced by the airotor running in contact with the tooth without suction was not found to be significantly different than when it was running free or it was running in contact with the tooth along with suction.

Noise levels for lathe trimmer and vibrator (Table 6) were less at 2 m distance as compared to 15 cm distance and this difference was found to be statistically significant, The noise level of moulding machine was less at 15 cm than at 2 m but this difference failed to reach the level of significance.

Table 6
Noise levels of dental laboratory engines.

Laboratory engines	15 cm			2 m			t-value	p-value
	Min.	Max.	Mean	Min.	Max.	Mean		
Lathe trimmer	101.3	101.7	101.5	94.7	96.2	95.45	19.07	.003
Vibrator	79.0	80.6	79.8	73.5	74.0	73.75	-19.05	.003
Moulding machine	52.7	56.4	54.55	54.2	54.5	54.35	.972	.434

7. Discussion

Sound is transmitted as a wave of energy that has both amplitude (intensity) and frequency. Sound intensity levels (IL) are measured by relating the intensity (I) of one sound to the reference intensity.[8]

The equipment used to measure the sound levels in the present study (HTC Sound Level Meter 1350) measures the sound pressure level (in dB) by representing the frequency response of the ear. This calculates the A-weighted sound measurement [dB(A)], the design of which mimics the response of the human ear. Since human hearing responds differently to all frequencies, sound measured in frequency bands may be A-weighted or adjusted to account for the approximate frequency dependence of human hearing. The result is a single number descriptor, the A-weighted sound level in decibels dB (A), where the letter A stands for the use of a specific type of low-pass electric filter.

The present study was undertaken to assess the sound levels perceived in the pediatric dental clinic in an institutional setting and to evaluate whether the sound levels approach the levels considered hazardous.

The phase I of the study consisted of evaluation of the sounds levels at the different locations of the clinical area at different times of the day. The choice of the timing was 9:00 a.m., 11:30 a.m., 2:00 p.m., and 3:30 p.m. in accordance to the patients' inflow to the clinic that is during peak hours and at the end of the institution's working hours. The results indicated that the maximum sounds were recorded at the reception, play area and the chair-side area. This could be due to the cumulative effect of the noises being produced in the department being manifested at these areas. On all the 3 days of data collection, least mean sound levels were recorded at 9:00am which later on increased at 11:30am & 2:00pm and curtailed again at 3:30pm. This was probably due to the maximum number of patient footfall at around 11:30am and 2:00pm. The results indicate that the time of the day influenced the sound being generated with more sounds associated with a greater number of patients being treated at that particular time thus adding to sound levels.

Phase II consisted of the recording noise levels of various equipments i.e. suction, micromotor, airotor with the equipments turned on (without cutting) and during cutting operations. The distance of 6 in. was chosen as it is the minimum distance that is present between the operator and the sound source at any given point of time, while simulating the noise intensity reaching the ear drum[2].

Mean noise levels associated with the use of scaler is depicted in Table 2. The noise levels were found to be significantly higher ($p < 0.05$) when the scaler was running in contact with the tooth (with or without suction) as compared to when it was running free with the sound levels recorded as 84.05, 81.83 and 59.88 respectively.

Mean noise levels associated with the use of suction is depicted in Table 3. No significant difference was found with the suction running free or running in contact with mucosa with the recorded mean values being 73.85 and 73.77 respectively.

Mean noise levels associated with the use of micromotor is depicted in Table 4. Noise levels were found to be significantly higher ($p < 0.05$) when the micromotor was functioning in contact with the tooth along with suction as compared to without suction, which was further significantly higher than that running free, with the sound levels recorded as 80.90, 75.55 and 65.43 respectively. This is in accordance to a study conducted by Qsaibati ML, Ibrahim O. who measured noise levels produced by various equipments used in dental areas of learning under different working conditions.[2]

Mean noise levels associated with the use of airotor is depicted in Table 5. Noise levels were significantly higher ($p < 0.05$) when airotor was functioning in contact with the tooth along with suction than that it was running free, with the recorded mean values being 87.63 and 83.15 respectively. Noise caused by air rotor running in contact with the tooth without suction was not found to be significantly different than that it was running free or it was running in contact with the tooth along with suction.

Thus when comparing the various equipments used in the dental operatory it was found that almost all the equipments produced significant sound levels which were quite close to the value deemed responsible for causing deleterious health effects with the maximum sound being produced by the use of airotor. A noise exposure of more than 7 h/ day at 91 dB is considered to be hazardous as given by Occupational Safety and Health Act (OSHA1972, 1981)[9]. The dentist should make a conscious effort to reduce his exposure to this noise pollution. Maintenance of equipments and instruments is also of paramount importance as aged instruments might also produce more noise. Another aspect of high sound levels which assumes a far greater significance in pediatric settings is its role in enhancing anxiety. Muppa et. al. suggested that noise produced in a dental setting is anxiety provoking. They emphasized that more than 60% of the subjects visiting the dental clinic felt annoyed to extremely annoyed from dental tools.[10] Allen KD, Stanley RT, McPherson K.[11] and Elmehdi HM.[12] identified noise produced in dental clinic; sound of dental drill as potential anxiety provoking stimuli in young children.

Phase III consisted of the recordings of equipments in the preclinical lab area of the department (marked 1 in Fig. 1). The equipments whose noise levels were recorded consisted of Lathe trimmer, vibrator and ministar pressure moulding machine. The noise levels were recorded at a distance of 6 in. and 2 m from the equipments for evaluation of the sound levels perceived by the operator and any person within a distance of 2 m. The highest sound levels were produced by the use of the lathe trimmer. The values recorded at both 6 in. and 2 m were above the safe hearing levels with the mean values of 101.5 & 95.45 dB. The sound levels at 15 cm were significantly higher than that recorded at 2 m.

The sound levels produced by the vibrator at both 6 in. and 2 m were significantly lower than the lathe trimmer but still nearer to the critical level of 80 dB considered hazardous with the mean values of 79.8 & 73.75 dB

The noise level of moulding machine was less at 15 cm than at 2 m but this difference failed to reach the level of significance.

7.1. Limitations

The noise level would change according to the condition of the instruments and equipments also (new/old) The same sound would intensify more in a smaller clinical area and diffuse in larger set-ups. So, these variables could have been included in the study.

8. Conclusion

Within the limitations of the present study it was found that dentists are exposed to high sound levels in their everyday practice as most of the dental instruments produce noise more than 80 dB (harmful to the ear). Dental workers inevitably suffer from noise pollution due to the use of various equipments and clinical exposure to diverse patients. Efforts must be made to reduce excessive noise in and around the workplace. Appropriate preventive measures must be taken to reduce the noise levels within the range prescribed by Occupational Safety and Health Administration. A strict emphasis on hearing conservation program must be made in order to reduce the risk of noise induced hearing loss.

8.1. Recommendations

- Use of sound proofing in cabins and laboratories
- Use of mufflers along with regular change of bearings in suctions, lathe machines and vibrators
- Regular oiling of airotor cartridges
- Regular assessment of sound levels to which the dental personnel are routinely exposed to.

Conflict of interest

The authors have none to declare.

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