Noise level and its influences on dental professionals in a dental hospital in Hong Kong

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Abstract: Noise was recognized as one of major indoor environmental issues in dental settings. This study presents the noise measurements and questionnaire surveys conducted in the clinics for pediatric dentistry and laboratories in the Prince Philip Dental Hospital in Hong Kong. Noise level and octave noise spectrum were measured at 60 locations distributed around the working areas. Totally 60 valid questionnaires were collected, of which 30 were completed by dental surgery assistants (DSA) and 30 by laboratory technicians. Data were coded and analyzed statistically using SPSS 19.0. The average noise levels in the dental clinics and laboratories were 62.6 dB(A) and 67.7 dB(A), respectively, which are well below the limit of 85 dB(A) for causing hearing loss. Statistical analysis shows that there is a significant difference in hearing status (condition of hearing ability) between different gender, age and occupation groups. Among others, noise generated by the equipment operated by others presents a principal influence on dental professionals. Importantly, suddenness and frequency of noise occurrence, rather than noise level, produce a significant influence on dental works. Most dental professionals work routinely and do not take any precautions or actions against noise at work.

Practical application: The findings of this study should first increase the understanding of acoustical environment in dental settings for clinicians and its influence on dental professionals and second help designers and engineers improve the acoustical environment in dental settings.

Keywords: Noise, dental hospital, clinician, measurement, questionnaire survey

1. Introduction

Noise is recognized as one of major indoor environmental issues in dental settings, which became an important occupational hazard of dental professionals[1-2]. Noise in dental settings is generated by both dental sources (e.g., handpieces, suction tubes, turbines, ultrasonic scalers and cutting machines) and non-dental sources (e.g., phone ring, talking, broadcasting and air conditioner). Many previous studies reported that noise levels in dental settings were mostly higher than 65 dB(A) and even reached up to 99 dB(A) in dental clinics and laboratories[3-4], while some other studies reported much lower noise levels approximately from 55 dB(A) to 65 dB(A)[5-6]. The intensity of noise exposure is normally different among different occupations, e.g., dentists, dental surgery assistants (DSA) and laboratory technicians.

Long-term exposure to noise could induce both auditory and non-auditory effects[7-8]. Auditory disorders, tinnitus and hearing damage are common harmful effects of prolonged exposure to noise in dental settings[9]. Particularly, noise-induced hearing loss is an common auditory effect among dental professionals, which can be caused by exposing to noise levels above 85 dB(A) for 8 hours/working day without any hearing protection[10-13]. Many studies focused on the occupational noise-induced hearing loss[6, 14]. It was reported that a prevalence of 5% to 20% of hearing loss occurring among dental professionals[3, 6, 15]. Note that a large discrepancy in the prevalence of hearing loss was found in previous studies, and no consensus on this issue can be achieved to date.

In order to decrease the prevalence of hearing loss among dental professionals, ISO standard 7785:1997[16] suggested that the noise levels (namely, sound pressure levels) generated by the high-speed handpieces should be below 65 dB(A) and should never exceed 80 dB(A). Since then, the noise levels produced by new dental equipment are generally below 85 dB(A)[17]. However, it must be noted that aged or worn dental equipment could still produce noise levels exceeding 85 dB(A)[18-19]. Apart from the development and appropriate maintenance of dental equipment, a common consensus on decreasing the prevalence of hearing loss is to promote the use of protective measures[20]. Some studies reported that there was slight or no hearing loss among dentists, if control measures, including protective measures, were strictly implemented[15].

In addition to hearing loss and damage, non-auditory effects, such as annoyance, anxiety, irritation and concentration difficulty, are also prevalent among dental professionals[21-25]. It was found that over 90% of dentists claimed annoyance to noise in dental hospitals[26]; approximately 10-20% of dental professionals reported having high dental anxiety levels [27]; and around 60% of dental professionals felt bothered because of noise at work[28].

Previous studies focused on noise level and its influence on dental professional in general dental settings, but few of them was related to dental settings especially for pedodontics. Owing to the involvement of children’s crying, it is expected that the acoustical environment in such dental settings would be different with those for adults. The objective of this study is therefore to investigate the noise level and its influence on dental professionals in a dental hospital for pedodontics. On-site measurements of noise level and questionnaire surveys of dental professionals were conducted in the Prince Philip Dental Hospital in Hong Kong. Noise measurements were performed in both the clinics for pediatric dentistry and laboratories, while questionnaires were distributed to dental surgery assistants (DSA) and laboratory technicians. Based on the commercial package SPSS 19.0, factor analysis, regression coefficient analysis, Spearman rank correlation analysis and Pearson Chi-square test were used for data processing. Findings of this study are intended to increase the understanding of the noise level in dental settings and its influence on dental professionals.

2. Method

2.1 Description of the hospital

Noise measurements and questionnaire surveys were conducted in the Prince Philip Dental Hospital[29] in Hong Kong in December 2013. This dental hospital was located in the middle-level of the Hong Kong Island. The hospital had clinics and laboratories, which thus could provide various types of dental services. It also served to train dental students of the Faculty of Dentistry, the University of Hong Kong. This study was conducted in its clinics for pediatric dentistry as well as the implant laboratory and prosthetics laboratory. Note that, outside the hospital, there were only narrow roads, where the traffic intensity was relatively low.

Dental clinics were located on the second floor and laboratories on the fourth floor. The general layouts of the dental clinics and laboratories are presented in Figure 1. DSA worked in the dental clinics and they assist dental treatment for child patients. Technicians worked in laboratories for making dental models, dentures, ext. Noise measurements were conducted in both dental clinics and laboratories, while questionnaires were completed by personnel worked in these rooms. Both noise measurements and questionnaire surveys were conducted in the working areas to reveal the real-life acoustical environment at work. Measurements and questionnaires surveys were conducted from 9:00 a.m. to 12:00 noon and from 2:00 p.m. to 5:00 p.m. in a normal working day. Note that both the dental clinics and laboratories were not very reverberant. There were no significant and noticeable spatial variations of sound pressure level in these spaces.

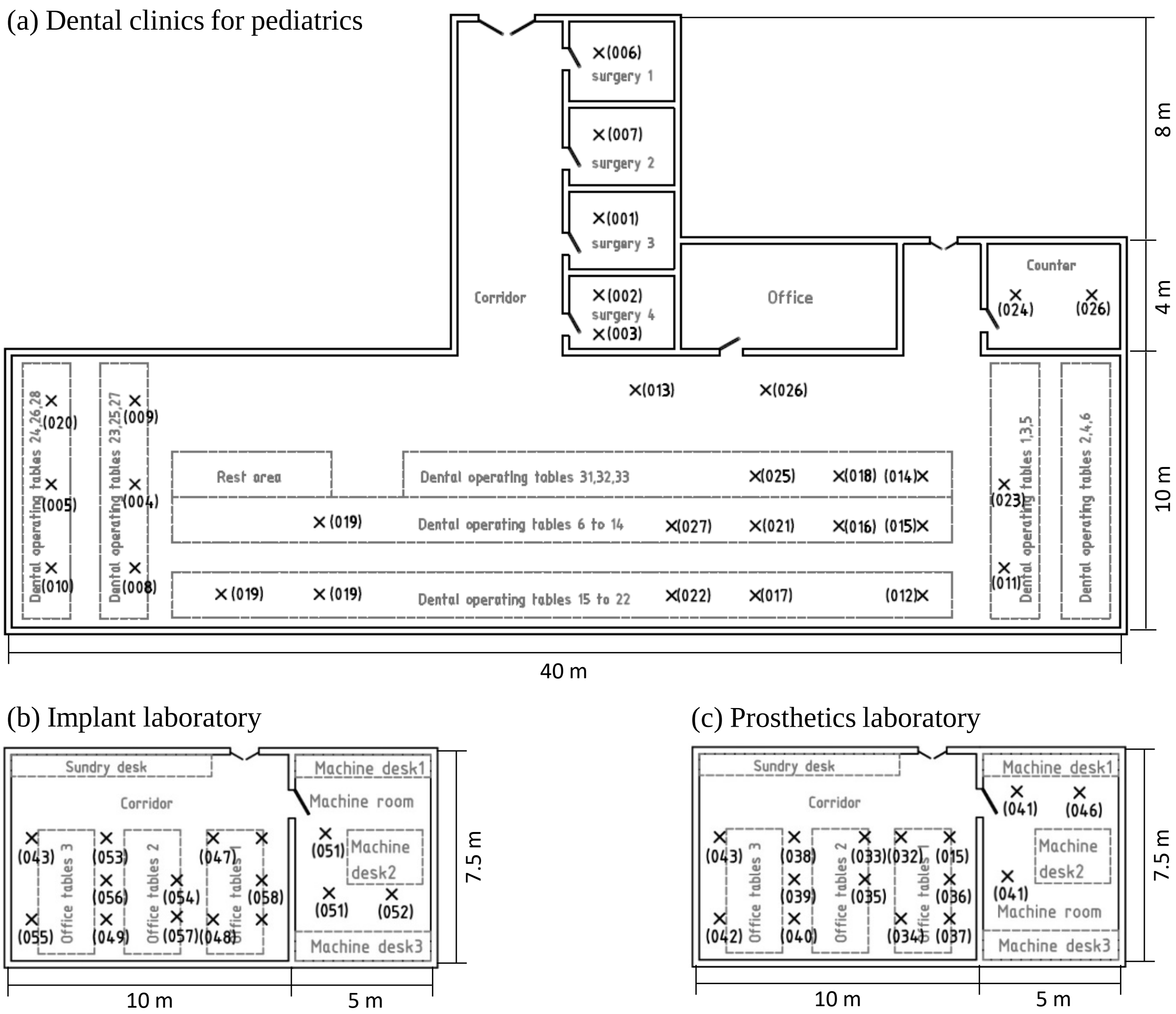

Figure 1 Layout of the dental clinics for pediatrics, implant laboratory and prosthetics laboratory, where the locations for noise measurements and questionnaire surveys are also marked with (×).

2.2 Noise measurements

An advanced, dual-channel, handheld analyzer and sound level meter (Type 2270; Bruel & Kjaer, Naerum, Denmark) was used to perform the noise measurements. Type 2270 is a highly versatile, modular device platform with many application modules such as sound recording, frequency analysis, fast Fourier transform and advanced logging (profiling). It provides sound intensity measurements, sound power measurements, and two-channel building acoustics measurements. In this study, noise levels in terms of equivalent continuous A-weighted sound pressure level (LAeq) were measured and their octave band spectrum was analyzed. Note that no measurements for different sound sources were conducted and therefore no analysis for the proportion of direct and indirect sound fields was made.

Noise measurements were conducted at 60 locations in working areas (marked in Figure 1) at the height of around 1.1-1.2 m, which is close to the height of the ears of a seated dental professional. Measurements at each location lasted for approximately 10 minutes. During measurements, any unnecessary conversations between experimenters and dental professionals were avoided. The dental professionals suggested that there were no noticeable temporal variations of sound pressure level in the working areas during working periods. These short-term measurements were intended to reveal the general noise levels in this dental hospital and to provide basic background information for the analysis of questionnaire data.

2.3 Questionnaire surveys

The number of dental professionals who completed the questionnaires in this hospital was 60, of which 30 were DSA from dental clinics and 30 were technicians from laboratories. The questionnaire is presented in appendix at the end of this paper. The questionnaire contained 19 questions in total, which were intended to investigate the dental professionals' sensation on the noise level in the dental hospital and the degree they were affected. The rationale of the 19 questions was described as follows.

Questions 1-8 were designed to survey the dental professionals' subjective sensation and response to the noise in this dental hospital, including their sensitivity to noise, their rating on acoustical environment, self-evaluated influence of noise on them and their actions against noise. Questions 9-15 surveyed the noise sources affecting dental professionals, which include various types of noise sources commonly occurred in dental hospitals, such as equipment, air conditioning system, computers, people's talking, phones and broadcasts. These questions would help rank the noise sources based on their influence on dental professionals. Questions 16-18 examined personal symptoms caused by noise in the dental hospital, which included emotional and working aspects. The selection of these two aspects for survey was based on some initial noise measurements and personal communications with dental professionals (not shown in this paper), which tended to convey that the noise levels in this hospital were not high enough to cause hearing loss. The answers for these three questions would provide direct evidence on the influence of noise on dental professionals. Questions 19 surveyed their overall hearing status. Note that dental professionals answered all questions based on a five-point scale, except for Questions 1 and 8. Ethics approval of the questionnaire surveys was obtained from the Institutional Review Board of the University of Hong Kong/Hospital Authority Hong Kong West Cluster (UW 14-010).

2.4 Statistical analysis

The data were coded and analyzed using the commercial package SPSS 19.0[30], which provides general statistical analysis methods including those introduced in this section. Pearson Chi-square test was used to present the bivariate associations of hearing status with gender, age and occupation. Chi-square test is a statistical test applied to sets of categorical data to evaluate how likely it is that any observed difference between the sets arose by chance. The Spearmen rank correlation coefficient is a non-parametric measure of statistical dependence between two variables that assesses how well a relationship can be described using a monotonic function. This correlation coefficient was applied to investigate the relationship between the noise characteristics and the degree that the noise influences dental professionals. Stepwise regression is a step-by-step selection model that involves automatic selection of independent variables. This analysis was further used to rank the noise sources based on their influence on dental professionals.

3. Results and analysis: noise measurements

3.1 Equivalent continuous A-weighted noise level

This section presents and analyzes the measured noise levels in both the dental clinics and laboratories. Figure 2 shows the measured 10-minute averaged noise levels, LAeq, at the 60 locations. The mean value of the LAeq obtained at the 60 locations is 65.2 dB(A) with a standard deviation of 6.4 dB(A); the mean value (standard deviation) for the dental clinics and laboratories alone are 62.6 dB(A) (4.3 dB(A)) and 67.7 dB(A) (7.1 dB(A)), respectively. Figure 3 presents the statistical summary of the number of measured locations where the measured average noise levels fall in different ranges. This summary shows that noise levels in the whole dental hospital range mostly between 60 dB(A) and 70 dB(A). However, the peak number in the dental clinics fall in the range between 60 dB(A) and 65 dB(A), whereas this in laboratories is between 65 dB(A) and 70 dB(A).

Figures 2 and 3 indicate that the noise level in laboratories is on average larger than that in dental clinics by nearly 5.1 dB(A). Particularly, there are 5 out of 30 locations (16.7%) in laboratories where the noise levels are larger than 70 dB(A). This high-level noise does not occur in dental clinics. The high-level noises in laboratories are mainly caused by the cutting machines located in the machine rooms, as shown in Figure 1. There is one location (out of 60 locations), location 52 in machine room (see Figure 1), where the average noise level is larger than 85 dB(A). On-site personal communications with machine users indicate that the cutting machines are used intermittently, the 8-h averaged noise level should not reach the value of 85 dB(A). However, long-term monitoring of the noise level in the machine rooms should be conducted to examine if necessary protective measures must be implemented to avoid hearing loss of machine users.

The noise level in the dental hospital during the present measurements is in general not too high to cause hearing loss to the dental professionals. This finding is supported by some previous studies[4-6, 26], which, however, is not inconsistent with those reported in many other studies[3, 31]. For such conflicting findings, two explanations may be made. First, the very high-level noises reported may be attributed to (a) the use of aged or worn dental equipment[18-19] and (b) the involvement of other strong noise sources, such as penetration of traffic noise through building envelopes with poor tightness. Second, the lower noise in dental hospital should be attributed to the development of modern dental equipment and machines[17, 26] that considerably reduces the degree of noise produced[18, 32]. Despite of no hearing loss, it should still be noted that these noise levels are high enough to cause other negative effects, such as annoyance, anxiety, tinnitus, irritation, conversation interference and concentration difficulty[24, 26, 28].

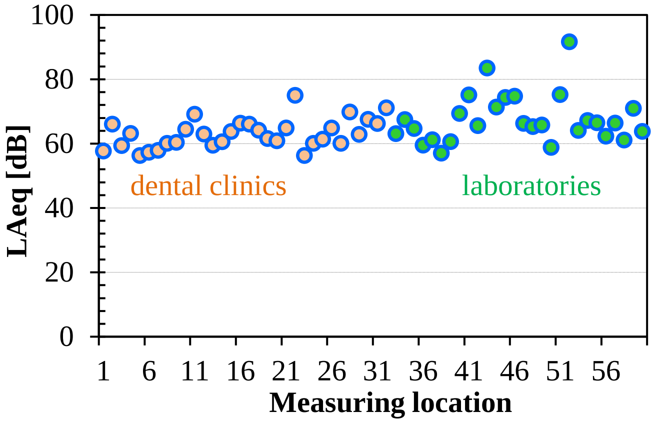

Figure 2 Measured noise levels in terms of LAeq at the 60 locations.

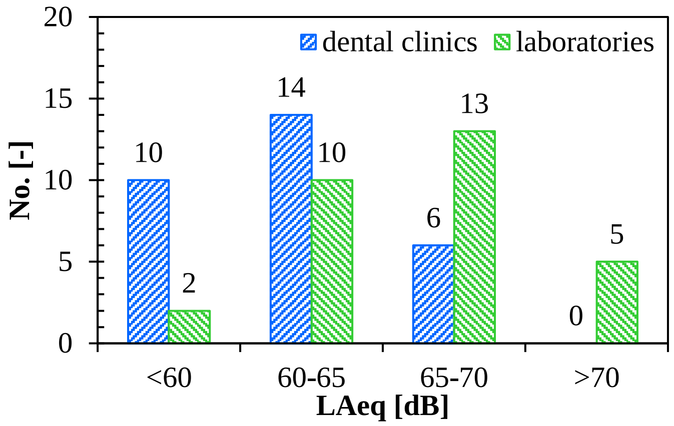

Figure 3 Statistical summary of the number of measurement location where the measured average noise levels fall into a specific noise range.

3.2 Octave band noise spectrum

In order to analyze the noise levels at different frequencies, the octave band spectrum analysis was performed for the measured noise levels at the 60 locations. Table 1 presents the average octave band spectrums and their standard deviations in both dental clinics and laboratories. From this table, two major observations can be made. First, regardless of frequency, both average noise levels and standard deviations in the dental clinics are smaller than those in the laboratories. This should be attributed to the different noise sources and spatial volumes as well as furnishes in these two types of rooms. The machines used in the laboratories produce much higher noise levels with a higher temporal fluctuation than those generated by the dental equipment for surgery in clinics. In addition, the dental clinics have a much larger space in comparison to laboratories. It is beneficial for a larger space to attenuate noise level. Second, none of the frequencies of the noise in both types of rooms show a distinctively high level. For dental clinics, the mean noise level decreases with increasing octave band centre frequency, while such a decrease is only slight for laboratories. Considering that the main contributors of the high-frequency noise are dental equipment and machines, this octave band spectrum analysis suggests that noise produced by cutting machines has more high-frequency spectrums than that by dental equipment. In both types of rooms, apart from the dental equipment and cutting machines, other noise sources contribute significantly to the overall noise level. This later observation, again, suggests that relatively lower noise level can be generally maintained in modern dental hospitals, due to the advancement of dental equipment and appropriate maintenance.

Table 1 Mean octave band spectrums and their standard deviations in both dental clinics and laboratories; SD denotes standard deviation.

Frequency (Hz)		32	63	125	250	500	1000	2000	4000	8000
Dental clinics	Mean	59	56	56	58	59	57	54	51	48
	SD	1.8	2.2	2.3	2.2	4.0	4.1	4.9	4.3	6.4
Laboratories	Mean	63	59	61	61	62	60	58	59	59
	SD	4.3	5.1	5.3	4.7	5.0	5.8	7.4	9.0	10.5

4. Results and analysis: questionnaire surveys

4.1 Demographic characteristics of the subjects

Totally 60 questionnaires were completed, which were all valid for analysis (see Table 2). The 60 subjects contained 19 males and 41 females. Half of the subjects were from clinics for pediatric dentistry and another half from laboratories. In general, majority of workers were over 40 years old and their daily working hours were usually 8.

Bivariate associations between hearing status, gender, age and occupation were tested using Pearson Chi-square test. The results of frequency distributions in the subjects' demographic characteristics are presented in Table 2. It can be observed that there is a significant difference in hearing status between different gender, age and occupation groups ($p < 0.05$). First, a higher percentage of females show a better hearing status than males. The main reason for this difference should be the fact that most of females worked in the dental clinics and most of males worked in the laboratories. Given that the noise level in laboratories is generally higher than that in dental clinics (see Section 3), the males should have a worse hearing status than females. Second, on average, elder workers tend to show worse hearing status than younger workers. On the one hand, it is a natural phenomenon that people's hearing ability degrades as their age increases. On the other hand, elder workers normally had a longer period of time, during their life, exposing in such a noisy environment. The longer time people exposes in noisy environments, the more hearing loss in decibels possibly occurs. Third, laboratory technicians show worse hearing status when compared to DSA, which, again, should be attributed to the fact that the noise level in laboratories is higher than that in dental clinics.

In general, regardless of gender, age and occupation, there are 30% of subjects indicating that their overall hearing status is bad or very bad. This subjective vote does not support the measured noise levels (Section 3), which should be caused by two reasons. First, people tend to give conservatively more negative comments to their physical conditions and living conditions (namely, workplace here) with the expectation of improvement. Similar findings were found in our previous questionnaire survey for subjective sensation on noise and other environmental parameters[33-34]. Second, dental professionals, especially elder ones, have exposed to more serious noisy workplaces before the advancement and upgrade of dental equipment[31]. Their hearing damage may not be caused by exposing to noise in today's workplace, but by exposing to high-level noise in their previous workplaces.

Table 2 Cross-tabulation of hearing status with gender, age and occupation.

		Hearing					Total	Pearson Chi-square
		Very good	Good	Medium	Bad	Very bad		
Gender	Male	0	2	10	5	2	19	0.044
	Female	1	16	13	11	0	41	
	Total	1	18	23	16	2	60	
Age	20-30	0	8	4	0	0	12	0.015
	30-40	0	2	4	0	0	6	
	40-50	1	5	3	10	1	20	
	50-60	0	3	12	6	1	22	
	Total	1	18	23	16	2	60	
Occupation	DSA	1	13	7	9	0	30	0.035
	Technician	0	5	16	7	2	30	
	Total	1	18	23	16	2	60	

4.2 Influence of noise on work

Noise has three main characteristics, including noise level, suddenness of noise occurrence and frequency of noise occurrence. Noise levels in this dental hospital were measured, as reported in Section 3. Suddenness of noise occurrence was evaluated by Question 6 (see Appendix for this question and other questions mentioned later). Frequency of noise occurrence was evaluated by Question 3. In addition, some questions were designed to examine the influence of noise on continuity of work (Question 4), quality of work (Question 7), interest of work (Question 18), and necessary conversation of work (Question 5). Here the 'conversation of work' refers to the necessary conversation related to dental works between colleagues during working hours.

Table 3 presents the Spearman rank correlation coefficients of the influence of noise on work with noise characteristics. From this table, three major observations can be made. First, the noise level does not show a strong influence on dental works. Among others, noise level show a slightly higher influence on the interest of work. As reported in Section 3, the noise level in the dental hospital, especially in the dental clinics, was not unacceptably high. Under such a noise level, dental works can be properly performed. Second, suddenness of noise occurrence generates a significant influence (P-value < 0.01) on dental works, except for the interest of work. Particularly, the correlation coefficient of working quality and suddenness of noise occurrence is 0.530 even with the P-value at the level of 0.01. It is easy to understand that psychologically unexpected events normally produce a higher influence to people than that by expected events. Third, frequency of noise occurrence has also a significant influence on dental works, especially on the quality of work and the necessary conversation of work (with P-value < 0.01). In summary, suddenness of noise occurrence shows highest level of influence on dental works, followed by frequency of noise occurrence, while the noise level within the range recorded in the present study does not show an obvious influence on dental works.

Table 3 Spearman rank correlation coefficients of the influence of noise on work with noise characteristics.

Influence on	Noise level (LAeq)	Suddenness of noise occurrence	Frequency of noise occurrence

Continuity of work	0.04	0.516**	0.326*
Quality of work	0.114	0.530**	0.368**
Interest of work	0.201	0.180	0.294*
Necessary conversation of work	0.153	0.403**	0.338**

**Correlation significant at the 0.01 level (two-tailed)
*Correlation significant at the 0.05 level (two-tailed)

4.3 Rank noise sources

After correlation analysis of the influence of overall noise on dental works (see Section 4.2), this section intends to rank noise sources influencing dental professionals. Questions 9-15 invite dental professionals to vote the influence of different noise sources on them. Totally seven types of noise sources are examined, which include dental equipment operated by the subjects and by others, as well as air conditioning system, computers, people's talking, phones and broadcasts. Stepwise regression is used to rank the influence of these noise sources on dental professionals based on the questionnaire surveys. The regression analysis shows that the latter five types of noise sources have a relatively negligible influence on dental professionals, as most of them score that the influence is 'No influence' or only 'A little' influence. These five types of noise sources are therefore excluded in the later analysis.

Table 4 shows the coefficients of regression for noise from equipment (with the threshold for significance equal to 0.01). It can be seen that noise from the equipment operated by others has significant *P*-value when compared to that from subjects' own equipment. The standardized beta reveals the relative influence of the two noise sources on dental professionals. Again, noise from the equipment operated by others presents a principal influence on dental professionals and noise from subjects' own equipment shows a secondary influence. The reason for this rank is obviously that the noise produced by subjects' own equipment is expected, but that by others is unexpected. An unexpected noise comes very likely with a strong suddenness, which, among other characteristics of noise, shows the largest influence on dental works (see Section 4.2).

Table 4 Coefficients of regression for noise from the equipment.

	Standardized Beta	*t*	Sig.
Noise from equipment operated by others	0.431	8.754	0.001
Noise from their own equipment	-0.246	-0.208	0.042

4.4 Behaviour of the subjects

This section analyzes the human behaviours in response to the noisy workplace. Question 2 is design to categorize dental professionals into different groups in terms of their self-evaluated sensitivity to noise. Question 8 collects the information regarding actions taken by dental professionals when exposing to a noisy workplace. Correlation analysis between action against noise and noise level is conducted, while the action is also correlated to the subjects' sensitivity to noise. Results are presented in Table 5, which allow making the following three important observations.

First, in general, actions taken by dental professionals have no significant correlations with noise level ($P > 0.05$). This result may be caused by that the subjects have no a clear sense of the difference between different noise levels from 55 dB(A) to 80 dB(A). As the noise level around their working areas changes frequently with time, they do not pay a special attention to the noise level (known by personal communication with dental professionals). Second, most dental professionals do not take any actions. Particularly, most of them do not complain and change less noisy equipment or workplace. One explanation for this result is that dental professionals have had a good knowledge of the acoustical environment in dental hospitals even well before work, probably since they were trained in dental schools. Such an expected noisy workplace would significantly lower the dissatisfaction of dental professionals. However, there does have one third of dental professionals taking some physically protective measures such as earplug. Third, there is a significant correlation between action 1 (A1) and the self-evaluated sensitivity level to noise ($P < 0.05$). This means that dental professionals with different sensitivity levels to noise hold significantly different attitudes towards the action complaining to colleagues or hospital authority. The results show that those dental professionals who are more sensitive to noise are more likely to complain to others. This finding is in consistency with common sense. In contrast, actions 2, 3 and 4 taken by dental professionals do not have significant correlations with their sensitivity level to noise. However, regardless of sensitivity level to noise, most dental professionals tend to take no actions against noise.

Table 5 Cross-tabulation of active action with noise level and subjects' sensitivity to noise; A1, A2, A3 and A4 represent the four actions: complain, apply protective measures, use less noisy equipment, and move to a less noisy workplace, respectively; S1, S2, S3 and S4 represent the self-evaluated sensitivity level: a little, medium, sensitive, and very sensitive, respectively; *P* refers to Pearson Chi-square coefficient.

		A1			A2			A3			A4		
		Yes	No	*P*	Yes	No	*P*	Yes	No	*P*	Yes	No	*P*
LAeq (dB(A))	55-60	3	9	0.507	4	8	0.680	0	12	0.430	0	12	0.692
	60-65	3	21		6	18		3	21		2	22	
	65-70	2	17		8	11		1	18		1	18	
	70-80	0	5		2	3		1	4		0	5	
	Tota	8	52		20	40		5	55		3	57	

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Sensitivity to noise	S1	0	19	0.006	6	13	0.317	1	18	0.816	1	18	0.453
	S2	2	16		6	12		0	18		0	18	
	S3	3	15		8	10		2	17		2	16	
	S4	3	2		0	5		0	5		0	5	
	Total	8	52		20	40		3	55		3	57	

5. Discussions

Noise measurements and questionnaire surveys conducted in the dental hospital reveal the acoustical environment and its influence on DSA and laboratory technicians, which increase the understanding of noise issue in such dental settings and provide useful information for the improvement of workplace for dental professionals. However, it is important to discuss the limitations of this study and thus suggest the possible areas for future studies.

First, this study is limited to 60 subjects and one hospital. The Prince Philip Dental Hospital is the only dental hospital in Hong Kong and 60 dental professionals are not a small sample size in a dental hospital, the findings obtained from this study should be sufficient to represent the general conditions in such hospitals. More studies should be conducted in other dental hospitals in the world.

Second, noise measurements were conducted near the working tables during a normal working day, which should reveal the general acoustical environment exposed by dental professionals at work. However, the measurement at each location lasts only for 10 minutes. Considering that the noise level at a specific location varies constantly over time, a longer period of measurement at each location should enable a more accurate evaluation of the acoustical environment in the hospital.

Third, the questionnaire is limited to specific 19 questions, which does not include some aspects, such as detailed assessment of hearing damage and other noise related physical conditions. Detailed assessment of hearing damage could be performed by including questions regarding tinnitus, difficulty in hearing telephone conversation, hearing status assessed by others, painful ears, turning the radio or television louder than accepted by others, and difficulty in speech discrimination. Other physical conditions could be assessed by asking if they are regular user of some symbolic medicines, such as aminoglycosides, quinine, and cisplatin. Although the noise level in the Prince Philip Dental Hospital is mostly well below 85 dB(A) and the hearing status of most dental professionals is generally not poor, the assessment of hearing and other noise related physical conditions would be useful for a comprehensive observation of the influence of noise.

Fourth, depending on the tightness and sound insulation of building envelopes[35-36] as well as the outdoor environments[37], the incursion of outdoor noise could modify the indoor noise level[38]. An analysis of background noise would be useful for an accurate evaluation of the noise level generated purely indoors[39]. However, the background noise in this hospital was not measured, because of a couple of reasons. The primary reason is that the hospital had a very busy schedule including both treatment for patients and training for dental students. It was difficult to find a vacant day for the measurement of background noise. Another reason is that the traffic type and intensity were very different between weekday and weekend. Therefore, the background noise recorded in a possible weekend cannot represent that in a weekday, even if measurement in a weekend was allowed.

6. Summary and conclusions

The noise measurements and questionnaire surveys conducted in the Prince Philip Dental Hospital in Hong Kong lead to the following observations.

The average noise levels (standard deviation) for the dental clinics and laboratories are 62.6 dB(A) (4.3 dB(A)) and 67.7 dB(A) (7.1 dB(A)), respectively, which are well less than the 8-h averaged noise limit for hearing loss, namely 85 dB(A).

A significant difference in self-evaluated hearing status between different gender, age and occupation groups ($p < 0.05$) is observed. Owing to a high noise level in laboratories, a higher percentage of males (technicians) in laboratories show worse hearing status than females (DSA) worked in dental clinics. Moreover, elder dental professionals on average report worse hearing status than younger ones.

Unexpected suddenness of noise occurrence shows significant influence on dental works. In comparison, frequency of noise occurrence has a less but still significant influence on dental work, particularly on the quality of work and necessary conversation at work. However, noise level, within the range reported in this study, shows a weak influence on dental works.

Noise from the dental equipment is the dominant noise source in comparison to others, of which noise generated from the equipment operated by others presents a principal influence on dental professionals and that from their own equipment shows a secondary influence.

Most dental professionals do not take any precautions or actions against noise at work. Particularly, most of them do not complain, change less noisy equipment or move to less noisy workplace. Actions taken by dental professionals are not dependent obviously on the noise levels from 55 to 80 dB(A) as well as on the self-reported sensitivity level to noise, where an exception for the latter is the action complaining to others.

Acknowledgement

The Prince Philip Dental Hospital, The University of Hong Kong, is especially acknowledged for the opportunity provided for us to conduct the measurements and questionnaire surveys. We would like to thank the dental professionals in this hospital for kindly spending their time completing the questionnaires. We also thank the PhD student Xiaofeng Shi as well as the master students Lishan Chen and Zhenbin Wu from The Hong Kong Polytechnic University for their assistances provided during the on-site measurements and questionnaire surveys.

Declaration of conflicting interests

The authors declare that there is no conflict of interest.

Funding

This research received no specific grant from any funding agency.

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Appendix – Questionnaire for noise in dental hospital

Gender: □ male □ female **Occupation**: □ DSA □ Technician **Age**: **Length of service**:

1. Where do you work?

□ Dental clinic for pediatrics (small) □ Dental clinic for pediatrics (large)
□ Laboratory (small) □ Laboratory (larger room)

2. Are you sensitive to noise?

□ Not at all □ A little □ Medium □ Sensitive □ Very sensitive

3. Do you think noise occurs frequently during work?

□ Not at all □ A little □ Medium □ Frequent □ Very frequent

4. How often were you interrupted by noise during work?
□ Not at all □ A little □ Medium □ Often □ Very often

5. Do you have any difficulties in talking to your colleagues due to noise?
□ Not at all □ Occasionally □ Medium □ Often □ Very often

6. Have you ever been scared by a sudden noise during work?
□ Not at all □ Occasionally □ Medium □ Often □ Very often

7. Do you think noise already affects your work?
□ Not at all □ Occasionally □ Medium □ Highly □ Very highly

8. Have you taken the following actions against noise at work?
□ Do not take any action
□ Complain to colleagues or hospital authority
□ Apply protective measures (for example earplug)
□ Attempt to use less noisy equipment
□ Move to a less noisy workplace (for example move to another surgery table)

Please rate the noise sources below based on the degree they influence your work:

	No influence	A little	Medium	High	Very high
9. Noise from your equipment operated by yourself	□	□	□	□	□
10. Noise from equipment operated by others	□	□	□	□	□
11. Noise from air conditioning system	□	□	□	□	□
12. Noise from computers	□	□	□	□	□
13. Noise from people's talking	□	□	□	□	□
14. Noise from phones	□	□	□	□	□
15. Noise from broadcasts	□	□	□	□	□

Do you have the following symptoms?

	Not at all	Occasionally	Medium	Often	Very often
16. Annoyance, tension and irritability	□	□	□	□	□
17. Unable to concentrate on work	□	□	□	□	□
18. Loss of interest in work	□	□	□	□	□

19. Your hearing status is:
□ Very good □ Good □ Average □ Poor □ Very poor