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NOISE LEVELS AND NOISE SOURCES IN THE OPERATING THEATRES

Operating theatre is supposed to provide a sterile and quiet work environment for patients and medical staff. The aim of this paper is to reveal the noise levels and noise sources in the operating theatres. A total of 20 operations were measured in three departments of hospital, namely orthopedics, gynaecology, chirurgery. Each operation was generally conducted by six medical staff. The average time of one orthopedics operation is 118 min, but one genecology surgery only spends 72 min. The chirurgery surgeries take longest average time that holding 196 min. Based on actual measurement and behavior observation, the results showed that the L_{eq} range of surgeries from 42.2 dBA to 94.6 dBA in three departments. The main noise sources were talking, door opening and closing, and surgical instruments, which happened 5.8 of occurrences in the three departments of surgeries. Frequent Using the aspirator, chirurgery surgeries are different from other operations. It happened 0.08 per minute. Gynaecology surgeries have the unique noise source of baby crying, which happened 0.03 per minute. Analysis of the noise sources shows that sound sources are partially avoidable.

Keywords: operating theatre, noise level, noise source

1. Introduction

With the rapid development of medical treatment, increasing attention has been paid to the acoustic environment in the healthcare settings over the world. World Health Organization (WHO) suggested that the noise level should not exceed 40 dBA in operating theatres [1]. However, a large number of previous studies have shown that the acoustic environment in operation rooms rarely satisfy these criteria. Noise will not only interfere with the sleep of patients, but also reduce the efficiency of the medical staff [2-4]. In addition， noise can also interfere with the communication between doctors and nurses, and hurt physical and mental health of medical staff [5-6].

However, most of the previous studies focused on the hospital wards, consulting room and waiting area. Less attention has been focused on the acoustic environment in operating theatre. Jonathan M. Kracht et al. conducted a systematic study on the noise level in the operation room. The surgeries monitored span a range of L_{eq} from 53.0 to 70.5 dBA, and the averages by category range from 58.0 to 67.0 dBA. The study could not explain the cause of the noise. Because it was only monitored for 24 hours, and there was not recording and observation [7]. Chrisoula Tsiou et al. analysed the noise levels at different stages in the operating theatre. The maximum measured level of noise during the main procedure of an operation was measured at L_{eq}=71.9 dBA, L_1=84.7 dBA, L_{10}=76.2 dBA, and L_{99} =56.7 dBA. But they did not count the number of noise sources, and the type of sound source is not comprehensive enough. In addition, the noise level of the specific operations are also studied, mainly in the department of neurosurgery, plastic and orthopaedics [8]. Lilia Chen et al. studied the

level of noise during craniotomy, discectomy, and hip surgery. An employee can be exposed to 88 dBA for no more than four hours, 91 dBA for two hours, 94 dBA for one hour, 97 dBA for 0.5 hours, and so on. Meanwhile, they called on concerned about the health of medical staff [6].

The aim of this study is to analyse the noise level and the noise source in operating theatres, and provide essential data for the development of noise control guidelines. In this based study, through researching noise sources and noise levels of orthopaedics, chirurgery and gynaecology surgeries, some suggestions are put forward to solve the problems of the sound environment in ORs.

2. Methodologies

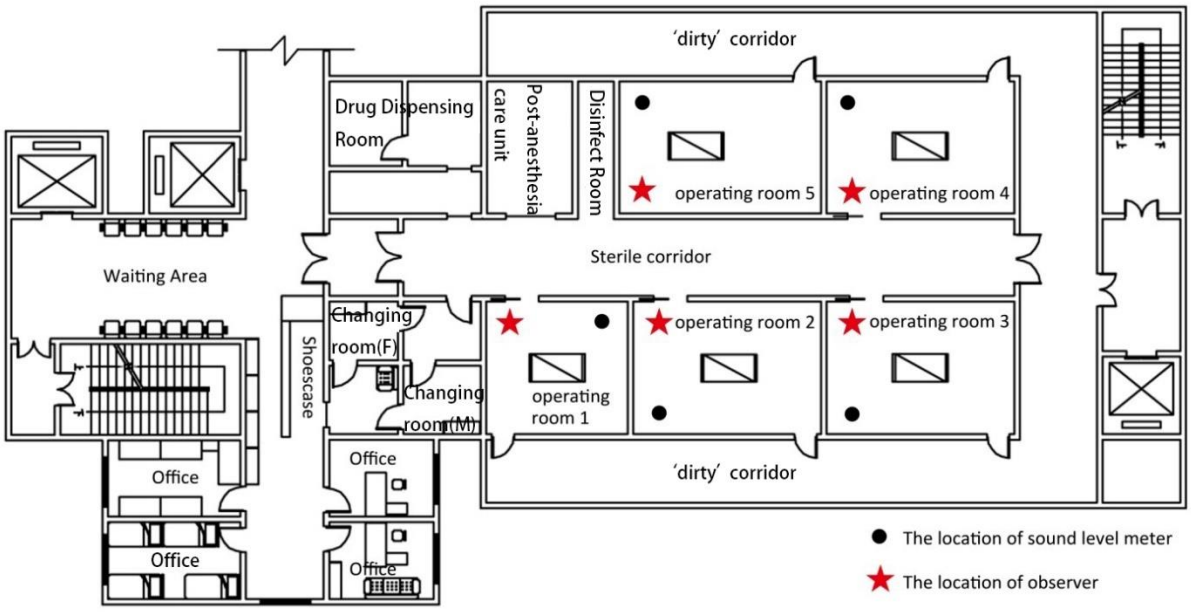

Figure 1: Floor-plan of operating theatres in the hospital

2.1 The settings

Chongqing Jiulongpo District Hospital of Traditional Chinese Medicine in China was chosen as the case study site. It covers an area of 34.5 acres, the annual outpatient volume of nearly 400 thousand people, discharged patients nearly 20 thousand people. Measurements were undertaken in five operating theatres, in response to recurrent complaints from anaesthesiologist and nurses about high noise levels. These departments of Operations are well known for being very stressful, occasionally leading staff to 'burnout' and psychosis, and noise has been identified as a potential cause of these conditions. The five operation rooms were divided into two sides (figure 1). There is a sterile corridor in the middle of operating theatres, and the pollution corridors on sides. The largest area is the operating theatre 5, which has 42 ㎡. But the operating theatre 1 has the smallest area, about 30 ㎡. The other rooms have the same amount of floor space, about 35 ㎡. Suspended ceilings and walls in the operating theatres were sandwich plate, and the floors were PVC, which are materials with low sound absorption coefficient. Ethic approval has been obtained from the local hospital prior to the field measurement and observation study.

2.2 Acoustic measurements

Surgery is generally divided into elective surgery and emergency surgery. In order to efficiently collect the data, elective surgeries are selected. It is usually scheduled for Monday to Friday working

days, and mainly in the morning every day. Due to the number of equipment are limited, and there is only one observer. Therefore, the 10 groups only test noise levels, noise sources and noise levels were measured in other 10 groups. A Bruel and Kjaer 2250 Sound level meter and Sony recording pen are placed in the corner of the room (figure 2). To avoid interference with general healthcare activities, Sound level meters and recording pens are placed in the corner of the room away from the reflecting surfaces as appropriate. Meanwhile, in order to hold a sterile environment, the observer is required to stand near the door of the operating theatre. A total of 20 groups were involved in the study.

(a) (b)

Figure 2: Acoustic measurements (a) The operating theatre (b) the position of sound level meter

3. Results

3.1 noise levels

Table 1 summarize the consequences for the different surgeries of noise levels, which include orthopaedics, gynaecology and chirurgery. The categories in the table are sorted by the duration of the operation. In general, the proportion of surgical staff are concerned with the operative difficulty and the time of operation. Due to the proportion of surgical staff will affect the noise levels, so the number of medical staff in each operation are recorded in Table 1. Average of each operation has 6 medical staff in three departments. Except the doctors, anaesthesiologists and nurses, sometime orthopaedics surgeries have an instrument manufacturer. In gynaecology surgeries, the paramedic will care for the baby in the surgeries of uterine-incision delivery. The average results of each surgery indicated that L_{eq} in department of orthopaedics, gynaecology and chirurgery was 62.3 dBA. The average of L_{eq} in chirurgery, orthopaedics, and gynaecology: 63.3 dBA, 62.4 dBA, 61.9 dBA. Meanwhile, the maximum of L_{eq} in chirurgery, orthopaedics, and gynaecology: 94.6 dBA, 90.8 dBA, 91.4 dBA. Overall, the range of L_{eq} from 42.2 to 94.6 dBA in three departments. The time of surgeries from 12min to 348min. The average time of one orthopaedics operation is 118 min, but one gynaecology surgery only spends 72 min. The chirurgery surgeries take longest average time that holding 196 min. On the one hand, it may be related with the time of surgeries. The more time for operations, the more opportunities for noise. on the others, it may be concerned with the different equipment and tools of operation.

Table 1: The proportion of surgical staff, Average L_{eq}, range and duration of sound measurement (in sec) per operation.

No.	Department	Type of surgery	The number of medical staff	L_{eq} dB(A)	SPL range dB(A)	Total time of surgery

1	**Orthopaedics**	Removal of right clavicle fixation	3 orthopaedists, 1 anaesthesiologist, 1 circulating nurse, 1 instrument nurse	61.8	47.1-90.8	84min
2	**Orthopaedics**	Resection of tendon sheath cyst of right ankle	3 orthopaedists, 1 anaesthesiologist, 1 circulating nurse, 1 instrument nurse	62.5	49.6-88.5	91min
3	**Orthopaedics**	Internal fixation removal	3 orthopaedists, 1 anaesthesiologist, 1 circulating nurse, 1 instrument nurse	60.0	46.1-90.2	100min
4	**Orthopaedics**	Internal fixation for intertrochanteric fracture	2 orthopaedists, 1 anaesthesiologist, 1 circulating nurse, 1 instrument nurse, 1 instrument dealer	60.4	42.2-89.3	112min
5	**Orthopaedics**	Internal fixation of right bone	3 orthopaedists, 1 anaesthesiologist, 1 circulating nurse, 1 instrument nurse	60.6	47.7-82.0	130min
6	**Orthopaedics**	External fixation of femoral fracture	3 orthopaedists, 1 anaesthesiologist, 1 circulating nurse, 1 instrument nurse	64.4	46.4-85.9	134min
7	**Orthopaedics**	Internal fixation of right femur	3 orthopaedists, 1 anaesthesiologist, 1 circulating nurse, 1 instrument nurse	64.9	52.5-89.0	144min
8	**Orthopaedics**	Internal fixation of right acromion scapula	3 orthopaedists, 1 anaesthesiologist, 1 circulating nurse, 1 instrument nurse	64.4	45.3-84.3	151min
9	**Gynaecology**	Painless abortion	1 gynaecologist, 1 circulating nurse	60.4	49.1-83.2	39min
10	**Gynaecology**	Hysteroscopy	1 gynaecologist, 1 anaesthesiologist， 1 circulating nurse	59.8	49.1-91.4	53min
11	**Gynaecology**	Uterine-incision delivery	3 gynaecologists, 1 anaesthesiologist, 1 circulating nurse, 1 instrument nurse, 1 paramedic	61.2	50.9-87.4	61min
12	**Gynaecology**	Laparoscopic exploration	2 gynaecologists, 1 anaesthesiologist， 1 circulating nurse, 1 instrument nurse	63.9	50.1-91.2	61min
13	**Gynaecology**	Uterine-incision delivery	3 gynaecologists, 1 anaesthesiologist， 1 circulating nurse,	60.1	50.3-86.2	71min

			1 instrument nurse 1 paramedic			
14	**Gynaecology**	Uterus cyst removal	3 gynaecologists, 1 anaesthesiologist， 1 circulating nurse, 1 instrument nurse	63.5	50.6-83.4	74min
15	**Gynaecology**	Uterine-incision delivery	3 gynaecologists, 1 anaesthesiologist， 1 circulating nurse, 1 instrument nurse 1 paramedic	61.7	48.6-86.5	85min
16	**Gynaecology**	Uterine-incision delivery	3 gynaecologists, 1 anaesthesiologist， 1 circulating nurse, 1 instrument nurse, 1 paramedic	66.5	47.8-85.6	87min
17	**Gynaecology**	Laparoscopic hysteromyoma removal	3 gynaecologists, 1 anaesthesiologist， 1 circulating nurse, 1 instrument nurse	59.9	50.5-89.1	165min
18	**Chirurgery**	Exploratory laparotomy	3 surgeons, 1 anaesthesiologist， 1 circulating nurse, 1 instrument nurse	62.9	44.4-83.0	107min
19	**Chirurgery**	Cholecystectomy	3 surgeons, 1 anaesthesiologist， 1 circulating nurse, 1 instrument nurse	62.5	43.7-90.0	132min
20	**Chirurgery**	Exploratory laparotomy and intestinal resection	3 surgeons, 1 anaesthesiologist， 1 circulating nurse, 1 instrument nurse	64.5	50.3-94.6	348min

3.2 noise sources

Figure 3-4 shows a bar diagram of noise sources as a function of the average number of occurrences, for the surgeries. The list of noise sources is ordered as the per minute of occurrences, and show the top 10.

A total of 10 surgeries' noise sources were recorded，including 2 chirurgeryare surgeries, 4 orthopaedics surgeries, and 4 gynaecology surgeries. There are about 30 sound sources in the operating theatres. Figure 3 shows that in the chirurgery surgeries, the main sources of noise were talking, door opening and closing, and surgical instruments. whilst for both the gynaecology surgeries and orthopaedic surgeries, the main sources of noise were same with the chirurgery surgeries (Figures 4 and 5). Despite differences observed in the three diagrams, it is worth noticing that five sources out of ten are common to all lists: talking, door opening and closing, surgical instruments, moving chair, and talking in the corridor. Figure 3 indicated that talking happened 1.5 per minute. Compare with figure 4 and Figure 5, talking happened 1.1 and 0.6 per minute in orthopaedics and gynaecology surgeries. Talking is all the highest frequency of sound sources, including chat and work exchange. Frequent Using the aspirator, chirurgery surgeries are different from other operation. It happened 0.08 per minute. Gynaecology surgeries have the unique noise source of baby crying, which happened 0.03 per minute.

During in the three departments of surgeries, the rooms suffer from external noise, such as talking in the corridor, which happened 0.27 per minute. It can also be noted that, apart from the Figures 4, there are phone ringing listed in Figures 3 and 5. Impacting desk noise was observed in only 0.04 of occurrences. This suggests that these types of noise sources do not appear to be of particular concern in such busy environments.

Analysis of the noise sources shows that sound sources are partially avoidable. This happened 2.0 per minute in the operations of three departments. On the other hand, many of the noise sources cannot be eliminated, including for example impacting of surgical instruments, surgical equipment (including aspirator, high frequency electric knife, electric drill and anaesthesia machine) and baby crying.

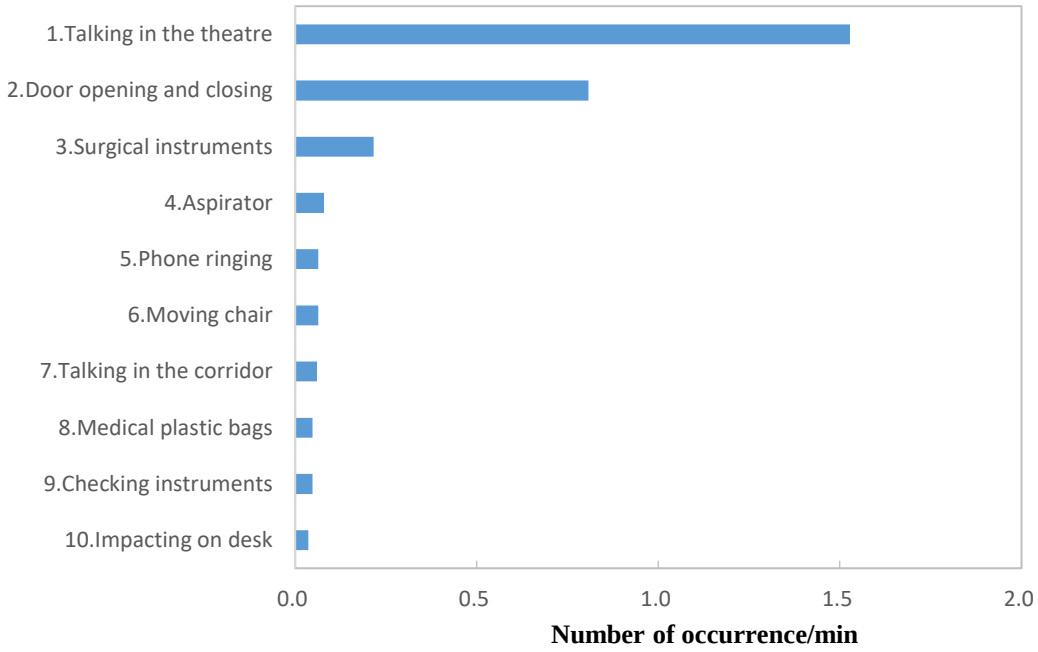

Figure 3: Noise sources as a function of average number of occurrence (per min) for observed Chirurgery surgeries

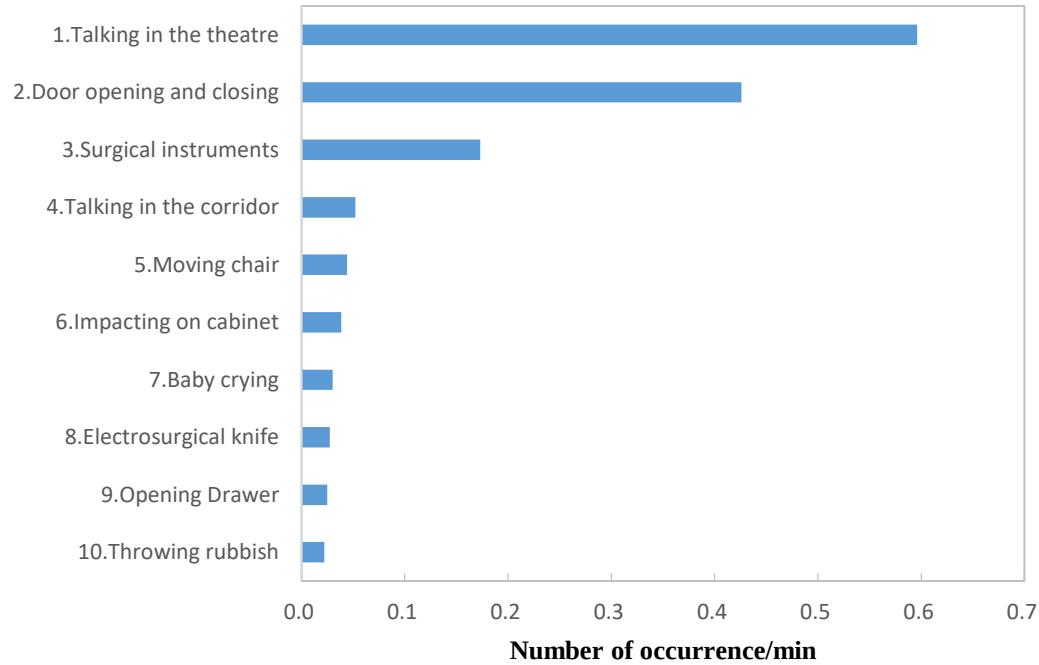

Figure 4: Noise sources as a function of average number of occurrence (per min) for observed Gynaecology surgeries

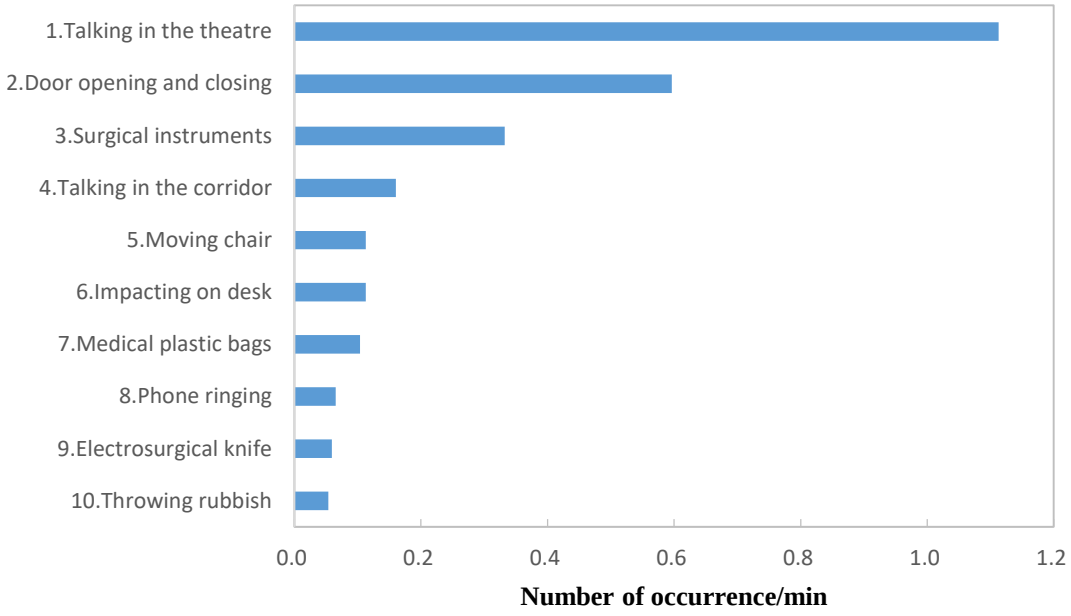

Figure 5: Noise sources as a function of average number of occurrence (per min) for observed Orthopaedic surgeries

4. Conclusions

The study showed that operating theatres was a noise sensitive area with the noise levels ranged from 42.2 dBA to 94.6 dBA in Chongqing Jiulongpo District Hospital of Traditional Chinese Medicine. The noisy environment may affect communication among the staff, which would increase risk of accidents. The health of patients and staff would be both threatened by excessive noise as well, during long time surgeries. The peak of the noise level in operating theatres was only 94.6 dBA. Significant differences can be found in some previous studies which concluded that the peak noise levels were range from 78.6 dBA to 106 dBA in ORs. It may be related to the type of surgeries. Meanwhile, the research of noise sources indicated that talking in the theatre is the main. It happened 1.0 per minute. The study showed that noise source is partially avoidable. Subsequent to these findings, the next step of this project is to study on noise control strategies in the operating theatres.

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