THE CHARACTERISTICS OF MAJOR NOISE SOURCES IN THE HOSPITAL CORRIDORS

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This paper aims to investigate the behaviour patterns of typical noise sources in the hospital corridors, and relate their patterns to healthcare environment. The long corridor of Cardiology Department at a Chinese hospital was chosen as the case study site for 24-hour measurements and observations. An observation approach was applied for the noise behavior with several indicators considered. The noise levels in the Cardiology corridor greatly exceeded the WHO guidelines by at least 15dBA, with large time variations. Only four typical noise sources contributed to more than 10% of the total number of occurrences, namely talking, door closing, cough and footstep. Talking was identified with the shortest intervals, and the longest durations at day time, while footstep became the main night-time noise source.

1. Introduction

It has been widely recognised that various noises play an important role in the healthcare settings. Recently, a large number of newly-built hospitals in China often have 2000 or more beds, but the healthcare resources are still insufficient. One of the solutions is to place more beds in corridors for patients, if all the wards were fully occupied. However, it makes hospital corridors more congested and noisier. Previous studies indicated that the hearing threshold of patients is lower than healthy people, which makes them more sensitive to noises. Not only the staff working efficiency, but also the patient sleep and recovery tend to be affected by the excessive noises in the corridors.

Excessive noises could lead to neurasthenia, arrhythmia, fluctuation of blood pressure, gastrointestinal dysfunction, dizziness and other untoward reactions. World Health Organization (WHO) suggested that the noise level should not exceed 30dBA, and the nocturnal peak level should be less than 40dBA in hospitalization area. Similarly, the Chinese guideline advised the maximum ambient noise level in hospitals as 45dBA at daytime and 40dBA at night-time.

Most of previous studies were only noise level surveys in hospitals. The characteristics of noise sources in corridor have largely been ignored. Therefore, the aims of this study are to investigate the behaviour patterns of typical noise sources in the corridors of a Chinese hospital, through a series of field observations. It is expected that the results of this study would contribute to the development of appropriate strategies or design criteria for creating a better sound environment in the future hospitals.
2. Methods

2.1 Case study site

The long corridor of Cardiology Department at Yibin 2nd People's Hospital was selected as the case study site. This hospital provides the highest level of healthcare services and the best medical equipment in Yibin region, China. In this department, there are approximately 90 beds in the wards, but 30-40 additional beds could be further placed in the corridor in case of insufficient wards. The corridor (45m×2.1m×2.5m) was never refurbished with acoustic treatments, including the non-absorptive ceilings, floors and walls.

![Figure 1. The studied Cardiology corridor at a Chinese hospital](image)

2.2 Measurement procedure

2.2.1 Instrumental recording

A type1 sound level meter AWA6228 was used to measure 24-hour SPL in the corridor. The acoustic parameters $L_{\text{Aeq,1min}}$ and $L_{\text{AFmax}}$ were chosen to represent the equivalent and maximum noise levels. The one minute interval allowed the accurate identification of various and dynamic noise sources in the healthcare setting.

The presence of the sound level meter should not cause interference with general healthcare activities. However, there’s no space to place the equipment on the corridor. As the alternative solution, the meter was hung below the ceiling (approximately 0.6m from ceiling) in the middle of corridor, as displayed in Figure 1.

2.2.2 Observation

The observation was synchronized with instrumental recording. It aimed to obtain significant forms of noise behaviour distinguished from the ambient environment. Each noise occurrence was recorded along with the detailed information, such as the time of occurrence.

Apart from the sound level, three other types of descriptors were yielded for the behavioural observations of noise sources in the hospital corridor, namely frequency, duration and interval. Frequency refers to the total number of occurrences of a noise with a specific behaviour pattern per unit
time, whereas duration is the length of time for which a single occurrence of noise lasts, in the units of time such as minute. Another time-relevant measure is interval, presenting the time between one specified source generating a kind of noise and another generating the same noise.

3. Results

3.1 Noise levels

The 24-hour equivalent sound levels (L_{eq}) were measured for the Cardiology corridor. The L_{Aeq} in day-time (6:00–22:00) was 61.1 ± 6.4 dBA, and 47.0 ± 6.9 dBA in night time (22:00–6:00). Both of them exceeded the WHO recommended levels by a large extent, more than 15 dBA. The definition of daytime and night-time periods was based on the relevant Chinese standard GB50118-2010.

A total of 1440 values were obtained over 24 hours for L_{Aeq1min} and L_{AFmax}, as shown in Figure 2. It can be clearly seen that the peak noise level, implying the noisiest period, was measured during day-time, as expected. The difference between day-time and night-time noise levels were 14.1 dBA and 15.8 dBA, for L_{Aeq1min} and L_{AFmax} respectively.

As demonstrated in Figure 2, there were large variations in terms of noise levels, especially for L_{AFmax}. The maximum level of L_{AFmax} was 88.9 dBA at 11AM. With regard to the time variations, a sharp rise could be observed from 6:00 to 8:00, as the patients and their carers got up and washed in the morning. Noisier periods were normally found from 8:00 to 12:00, when staff hand-over and ward round occurred, this made the corridor crowded and noisy. A decline were found from 14:00 to 15:00, as a result of the quiet lunch break with less people and less activities. Moreover, an obvious SPL decrease could be observed from 23:00 at night, indicating patients and carers went to bed gradually.

![Figure 2. 24-hour L_{Aeq} (dBA) and L_{AFmax}(dBA) for the Cardiology corridor](image-url)
3.2 Noise sources

Due to the good sound insulation, the examined corridor did not suffer much from the external noises, like road traffic noises. Therefore, only the internal noises were analysed in this study as the main sources. Figure 3 and Figure 4 illustrates several bar diagrams of typical noise sources as a function of the number of occurrences for the Cardiology corridor at daytime and night-time. For each source, the number of occurrences was given as a function of SPL, interval and duration range. Five typical noises and six noises were included for daytime and night-time, whereas ‘others’ referred to all the other observed noises.

It should be noted that, during the daytime, talking was identified as the key noise source in the corridor with the highest frequency, shortest intervals, and the longest durations. It could be heard almost every minute throughout the observation, therefore made a significant contribution to the daytime acoustic environment in the corridor. Apart from talking, doors closing of wards was observed with the second highest frequency, and the shortest duration (nearly 1s), followed by cough and footstep. For a number of typical noise sources, their SPLs were generally within the range of 60-70 dBA. Approximately 20% of doors closing and cough levels were measured between 70 and 80 dBA, whereas most of the trolley noise levels were above 70 dBA.

Consistent with the above corridor noise level measurements, it can be seen that SPLs of typical noise sources decreased significantly at night-time, most of the time in the range of 40-60 dBA. The occurrences of night-time talking decreased sharply, compared with the daytime talking events. Footstep became the main noise source at night, with the highest frequency (11.8 times per hour in average) and longer duration than the daytime footstep noises. On the other hand, there was no trolley noise identified during the night time observation, but snoring from patients and their carers appeared as a new noise source along the corridor. Moreover, the interval and duration data of night-time door closing were similar with day-time situations.

Table 1. Noise sources as a function of number and percentage of occurrences

<table>
<thead>
<tr>
<th>Noise source</th>
<th>Occurrences</th>
<th>Noise source</th>
<th>Occurrences</th>
</tr>
</thead>
<tbody>
<tr>
<td>Door closing/squeaking</td>
<td>180 (29.3%)</td>
<td>Spitting</td>
<td>6 (1.0%)</td>
</tr>
<tr>
<td>Footstep</td>
<td>145 (23.6%)</td>
<td>Keys dropped</td>
<td>5 (0.8%)</td>
</tr>
<tr>
<td>Cough</td>
<td>112 (18.2%)</td>
<td>Radio</td>
<td>4 (0.7%)</td>
</tr>
<tr>
<td>Talking</td>
<td>85 (13.8%)</td>
<td>Beeper</td>
<td>3 (0.5%)</td>
</tr>
<tr>
<td>General activity</td>
<td>12 (2.0%)</td>
<td>Plastic bag ripping</td>
<td>3 (0.5%)</td>
</tr>
<tr>
<td>Thump/bang</td>
<td>12 (2.0%)</td>
<td>Dropped object</td>
<td>3 (0.5%)</td>
</tr>
<tr>
<td>Cleaning</td>
<td>12 (2.0%)</td>
<td>Yawning</td>
<td>2 (0.3%)</td>
</tr>
<tr>
<td>Phone ringing</td>
<td>11 (1.8%)</td>
<td>Sneezing</td>
<td>1 (0.2%)</td>
</tr>
<tr>
<td>Cupboard closing</td>
<td>8 (1.3%)</td>
<td>Crying</td>
<td>1 (0.2%)</td>
</tr>
<tr>
<td>Trolley</td>
<td>8 (1.3%)</td>
<td>Knocking</td>
<td>1 (0.2%)</td>
</tr>
</tbody>
</table>

Table 1 gives a full list of 20 common noise sources observed in the hospital corridor, as a function of number and percentage of occurrences. However, as observed, only 4 types of high-frequency noise sources contributed to more than 10% of the total number of occurrences, namely talking, door closing (29.3%), footstep (23.6%), and cough (18.2%). In other words, the influences of other noise sources on the corridor acoustic environment could be neglected. Furthermore, according to our face-to-face interviews with patients and staff, some noises were perceived more annoying than other sources. In particular, noises from trolley and talking tended to be more unacceptable for both patients and staff\textsuperscript{11-12}. 

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Figure 3. Typical noise sources as a function of number of occurrences at day time:
(a) SPL, (b) Interval, (c) Duration
Figure 4. Typical noise sources as a function of number of occurrences at night time:
(a) SPL, (b) Interval, (c) Duration
4. Conclusions

The measured noise levels in the Cardiology corridor greatly exceeded the recommended WHO guidelines. The equivalent noise levels were obtained as 61.1 dBA in daytime and 47.0 dBA in night-time. For both L_Aeq and L_AFmax, large time variations were observed. Among a number of observed noise sources, only four typical noise sources were responsible for more than 10% of the total number of occurrences, namely talking, door closing, cough and footstep. Talking was identified with the highest frequency, shortest intervals, and the longest durations at day time, followed by door closing. During night time, footstep became the main noise source.

5. Acknowledgements

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