Current situation of acoustic environment in childcare facilities in Japan: A comprehensive survey in Kumamoto City region

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Abstract. This is a report on survey results gathered from questionnaires and site visits conducted at licensed child daycare centers in Kumamoto City, a regional core city of approximately 735,000 population, and its adjacent Koshi City (app. 59,000 population). The survey involved 132 centers, and responses were received from 2,075 childcare providers. Results from the site visits indicated that about half of the classes in the centers were acoustically separated by sound insulators such as fixed walls, while the remaining half utilize movable partitions or multiple classes held in a single room. Only 13% of daycare rooms were equipped with sound-absorbing materials. Many childcare providers responsible for children aged three or older, who have more conversation than younger children, reported problems involving throat damage and difficulty conducting conversations. There were indications that using sound-absorbing materials in daycare rooms and separating class spaces by soundproof wall could mitigate these situations.

1. Introduction
Child day-care centres, in which children of 0 to 5 years old spend most of their active hours in a day, have had two major problems in terms of the acoustic environment: high sound pressure levels due to children’s activity [1], [3] and low speech intelligibility due to the high sound pressure level and excessive reverberation, which could interfere verbal communication of children [4], [5]. It is considered to be possible to alleviate these problems by means of architectural acoustic design. Actually, guidelines with specific values are provided by World Health Organization [6] and Western countries have legislations or standards for the acoustic design of child day-cares [7], [9]. Also, the authors have been conducting on-site experiments by temporarily providing sound-absorbing materials to daycare rooms since 2008 and the results indicated considerably greater noise reduction than that was estimated by the increase of equivalent sound absorption area in the rooms [10].

In Japan, however, there are presently no effective acoustic design standards or guidelines, and there is little research in this area. However, child daycare centers are rapidly proliferating without much consideration given to acoustic environments for children, particularly in designated large cities in response to the growing demand for daycare services as women participate more broadly in society alongside men. In this respect there is an urgent need of acoustic design guidelines for child daycare centers in Japan. Based on this background, the present study undertook a large-scale survey to investigate the current state of acoustic environments in daycare centers.
2. Survey overview

This survey comprised inspection of daycare buildings and questionnaires distributed to the daycare administrators and childcare providers. The objective of the inspections was to capture room configurations and partitioning between rooms, as well as any use of sound-absorbing materials. Room configurations in daycare centers are multifarious, in general, and there are many examples of rooms being divided not by fixed walls so as to enable more flexible usage, employing structures that were ineffective in sound insulation such as movable partitions and furniture. Also, reflecting the current lack of design guidelines, it was expected that there was little construction using sound-absorbing materials. Having a grasp on the current state of these factors will provide an important basis for the development of acoustic design guidelines in the future.

The study looked at all of the “licensed nursery schools,” the official English expression of nationally licensed daycare centers, in two cities in Kumamoto Prefecture (Kumamoto City, a regional core city with a population of about 735,000, and its adjacent Koshi City, with a population of about 59,000, in 2015.1 currently). In order to survey all of the centers, we obtained the cooperation of nursery school associations in each city and introduced the survey at regular meetings of school directors, distributing complete sets of questionnaires and requesting that they be distributed to and then collected from their childcare providers. We later visited each of the centers and collected the answered questionnaire sheets, and also conducted inspections. This resulted in site inspections of 132 centers out of a total of 140, and more than 2,000 responses collected from childcare providers described in table 1.

Items for site inspections are listed in Table 2. The surveyors needed to inspect each of the sites visually because we expected that personnel on-site might not be knowledgeable about which materials would absorb sound and that there would be various space configurations.

Two questionnaires were created, with one for administrators and one for childcare providers. The questions are listed in Table 3. The providers were asked to answer their subjective evaluation on 3-5 step scales. Administrators were mainly asked about general information about the center.

| City    | Daycare centers | Surveyed centers | Provider responses |
|---------|-----------------|------------------|-------------------|
| Kumamoto| 122             | 115              | 1809              |
| Koshi   | 18              | 17               | 266               |
| Total   | 140             | 132              | 2075              |

Table 2. Items in site inspection.

In the center

- Room arrangement (type of partition between rooms, number of story, surface materials (sound absorptive or not), class arrangement.
- Surrounding environment, sound insulation measures.

Table 3. Questions regarding acoustic environment.

- **Providers**
  - Difficulty of conversing with children, room reverberation, throat damage frequency, noise from other classes, suitability of the room for childcare, disturbance by noise from outside, concern about noise from the childcare center to neighbours.

- **Administrators**
  - Year of building construction and renovations, construction structure, frequency of receiving complaints, numbers of providers and children, class configurations (mixed ages, etc.) Concern about acoustics of the center.
3. Inspection result

3.1. Number of children
Number of children per center was answered by the administrator of each center described in figure 1. The mode was around 100 children and seven centers had more than 200 children with 320 as the maximum. This result was compared with the official capacity of the centers and it was revealed that 95% of the centers exceeded the official capacity with half of them exceeding 15-20%. This is considered to be a reflection of the current demand for child daycare in the cities in Japan.

3.2. Types of class environments
Table 4 summarized the room separation between classes. Based on the result and from a view point of sound insulation, the room separation was categorized into four types as shown in the table. “Common rooms” indicates toilets and closets shared between two rooms located on either side. “Partial openings” are doors or other openings provided to enable access back and forth between two rooms without a hallway being accessed.

The result indicated that 51% of the classrooms were acoustically separated with fixed walls. Movable partitions, which have poor sound insulating performance in general, were used in 20% of class borders, and 11% had partial openings with adjacent rooms that were usually open and did not allow for sound insulation. In 19% of the cases, single rooms were being used for multiple classes. As a whole, acoustically insulated rooms turned out to be only half.

Table 4. Boundaries between classes

| Type        | Class Boundaries             | Number of class | Ratio (%) | Ratio (%) |
|-------------|------------------------------|-----------------|-----------|-----------|
| Separated   | Fixed walls                  | 330             | 41.9      | 51.1      |
|             | Shared room (door closed)    | 41              | 5.2       |           |
|             | Partial opening (door closed)| 32              | 4.1       |           |
| Movable     | Movable partition (closed)   | 154             | 19.5      | 19.5      |
| Adjoined    | Movable partition (partially open) | 8   | 1.0       | 10.7      |
|             | Shared room (door open)      | 44              | 5.6       |           |
|             | Partial opening (door open)  | 32              | 4.1       |           |
| Same room   | Movable partition (open)     | 25              | 3.2       |           |
|             | Same room (bookcases, columns, etc. partitioning) | 88   | 11.2      | 18.7      |
|             | Same room (no partitions)    | 34              | 4.3       |           |
| Total       |                              | 788             | 100       | 100       |

Table 5. Numbers of childcare provider responses by age of homeroom children.

| Ages (year) | 0 | 1 | 2 | 3 | 4 | 5 | Mixed ages | Total |
|-------------|---|---|---|---|---|---|------------|-------|
| Nos.        | 474 | 355 | 374 | 190 | 153 | 150 | 379 | 2075 |

Figure 1. Distribution of number of children per center.

Figure 2. Use of sound-absorption in ceilings.
3.3. Use of sound-absorbing materials
Visual inspections of the childcare rooms and play halls in 132 centers were performed to determine whether or not sound-absorbing materials were in use (figure 2). Results indicated that some type of sound-absorbing material was in use in 36 % of the play halls and 13 % of the childcare rooms, and that in most cases, rock wool ceiling board, which is the most commonly used material in Japan because of its fire resistance performance, was used. When we inquired during inspections about the reasons for using acoustical board we were most often told that the architect recommended its use or decided its use without informing the administrator. In many cases, center personnel were not aware that the boards were sound-absorbing.

4. Result of questionnaire survey
4.1. Totals by ages of children
The results of responses by childcare providers to the questionnaires are reported here but, due to space limitations, only major results will be presented. There are children from the age of birth up to five years in daycare centers and the activities vary greatly depending on the ages of the children in a class. The results were therefore compiled on the basis of class age. Table 5 shows the number of respondents classified by the age of the children they oversee.

Figure 3 shows the providers evaluations of how easily they could speak with children in the daycare room. The combined ratio for “difficult” and “somewhat difficult” was 4-5% for those taking care of 0 and 1-year-olds, but this number increased to 14-20 % for those minding children aged three or older, who have greater language ability. There was a tendency for an increase in the complaints of throat damages (figure 4), as was the case for ease of communication as the age of the children being supervised increased. In particular, more than 20 % of those caring for five-year-olds answered more than “at least once or twice a week”.

Daycare centers receive complaints about noise, and this could be a concern to for childcare providers. The result indicated that such concern increased for whom caring four or five-year-old groups (figure 5). A question in the questionnaire given to administrators inquired about the number of complaints received involving noise disturbances. 92 % of the response was “at most once a year” and the remainder was “a few times a year,” with no respondents answering more frequently.
4.2. Evaluation vs. sound absorption in childcare rooms

In this survey, whether sound-absorbing material was used and the type of room partition in each childcare room was known by the inspection. Also, the homeroom of each of the childcare provider was known by the questionnaire. Combining these two datasets, it was enabled to divide the providers into groups by the room properties.

Figures 6-8 compiles evaluations of the providers caring three-or more-year-old groups classified according to the use of sound-absorbing materials in their home rooms. In Figures 6 and 7, it is seen that a tendency for a high percentage of childcare providers in rooms lacking sound-absorption to report frequent occurrences of conversational difficulty and throat damages. Since a minority of rooms having sound absorption (the sample with/without sound absorption was around 87 and 485), chi-square tests on the high response groups answering the top 2 categories with/without sound absorption indicated not significantly different. However, the risk ratio of high response without sound absorption was 1.47 and 1.41 for difficulty of conversing and frequent throat damage, respectively, is considerable.
4.3. Evaluation vs separating childcare rooms
As with sound absorption, here the room separation is discussed here and again, totals include only childcare providers caring for children aged three or older (figures 9-11). In the same way as above, high responses are compared by four types of room separation.

The results showed obvious differences in the evaluation. High responses of difficulty of conversing increased when the space of the class was acoustically connected (same room or adjoined). On the other hand, disturbance by noises from other classes increased even the spaces were separated by movable walls. This indicated that movable walls can reduce speech disturbance but cannot reduce feeling of disturbance between rooms. Possibly reflecting this feeling, the evaluation of not suitable for childcare decreased with the increase of sound insulation (figure 11). These results clearly indicated the advantage of sound insulation.

5. Conclusions
As stated above, a survey based on inspections and questionnaires revealed the current state of child daycare centers where little consideration was given to acoustic design regarding space configurations and sound absorption. Combined result of inspection and questionnaire survey also revealed a potential effect of use of sound-absorbing materials in rooms and sound insulated separation between classes.

This study, which is a census of the regional core city region, can be considered to represent the current state of acoustic environments of daycare centers in Japan and to provide foundational material useful in establishing acoustic design guidelines for daycare centers in future.

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