Analyses of the Amount of Water Use and Preparedness for the Cutoff of Water Supply at Elderly Facilities in Tokyo

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ABSTRACT
To obtain basic information about the emergency water supply for elderly people, the amount of water use and preparedness for the cutoff of water supply at elderly facilities in Tokyo were investigated. Questionnaires about water use in October 2012 and preparedness for the cutoff of the water supply were sent to 1,251 of these facilities located in Tokyo, and 214 answers were obtained. Based on the data from facilities not involving outpatient users, the daily water use per person admitted was calculated. Median values were 411 [L/day/person-admitted], and 431 [L/day/person-admitted] for the Designated Facility Covered by Public Aid Providing Long-Term Care to the Elderly (n = 13), and the Welfare Facilities for the Elderly (i.e., Nursing Home, Low-Cost Home, and Fee-Based Home for the Elderlies) (n = 22), respectively. Note that these values include the water used by workers and visitors at the facilities. Meanwhile, the preparedness was summarized based on all of the valid answers. As a result, the ratio of water receiving tank possession and the stock drinking water were high. However, there are still room for improvement of the introductions of the emergency water supply agreement and the emergency drill considering the cutoff of the water supply.

Keywords: emergency water supply, facilities for elderly people, questionnaire, Tokyo, water use

INTRODUCTION
The accidental cutoff of water supply makes citizens to live under inconvenient and unsanitary conditions. Thus, provision of an emergency drinking water supply is of high priority to prevent the spread of waterborne diseases (Loo et al., 2012). Aside for having high vulnerability to disaster, elderly people are easy to suffer from diseases because of the lowering of their physiological functions and the resisting power (Watanabe, 2010). There is no doubt that clean water plays an important role in hygiene management. Therefore, water management for elderly people under a disaster with water cutoff is very important. In Japan, birth rate has been declining and the aging population has been increasing for many years. Due to this shift, there has been a growing concern with regards to the disaster prevention measures for the elderly (Tamura et al., 2006). In fact, the vulnerability of the elderly was actualized in many disasters including the East Japan Earthquake in 2011 (Tada et al., 2013). Moreover, the special nursing facilities, a kind of facility for elderly in Japan, are used by the high risk group for infectious diseases (Miyamoto et al., 2001). That is why the emergency water supply at the facilities for elderly people is very important.

Basically, the prompt procurement of the required amount of clean water is a key to keep the good health conditions of the elderly. That is why it is important to understand
how much water is needed for elderly care. Meanwhile, much information is available for the amount of daily water use per individual (e.g., Murakawa et al., 1990; US EPA, 1997; Mae et al., 2003; AIST, 2007), however, there are limited numbers of studies to clarify the amount of water use per individual in the elderly facilities in Japan. Sugawara et al. (2009) implemented a questionnaire survey of water consumption of buildings for the elderly in Tohoku area, Japan, as a part of the study on the environmental load database for buildings of non-house purpose, and the water consumption per unit floor space of facilities was clarified. Also, a database including water consumption per unit floor of various welfare facilities was posted on the internet by Japan Sustainable Building Consortium (JSBC, 2013). On the other hand, the water use per person in elderly facilities is important for the design of emergency water supply. Furthermore, to remove its vulnerability, the current status of preparedness for the cutoff of water supply in the care facility for the elderly people should be understood, and the weaknesses should be overcome. In this study, the daily water use for elderly care is clarified based on the written questionnaire survey for the care facilities for the elderly people in Tokyo. The questionnaire also asked the preparedness for the cutoff of water supply as well as their equipment available for use in the emergency water supply.

MATERIALS AND METHODS

Target facilities
There are some types of care facilities for elderly people in Japan. Facilities based on the Long-Term Care Insurance Act includes designated facility covered by public aid providing long-term care to the elderly people and long-term care health facility, whereas welfare facilities for the elderly people includes nursing home for the elderly, low-cost home for the elderly, and fee-based home for the elderly. Furthermore, Social Welfare Act describes “the services through which the needy are given the use of long-term care health facilities for the elderly people as provided for in the Long-Term Care Insurance Act, free of charge or at low cost”.

There is a possibility that the water use and preparedness for the cutoff of water supply vary with the location and the season of the year. One of the ways to avoid the regional difference is the survey by prefecture. Also, the seasonal variation could be avoided by limiting the period of subjected as just one month. That is why the target area and season were decided to be Tokyo metropolitan and in October 2012, respectively. In addition, Tokyo metropolitan area has large number of those facilities. Specifically, the facilities subjected to investigation were chosen with reference to the information provided by the Bureau of Social Welfare and Public Health, Tokyo. Detailed numbers of facilities were described in the results and discussion section.

Questionnaire
The questionnaire survey was carried out after the approval of Ethical Committee of National Institute of Public Health (NIPH-IBRA#12032). A written survey was implemented in January 2013. Questionnaire written in Japanese entitled “Questionnaire Survey about the Water Use and Emergency Water Supply at the Time of Disaster in a Facility for Elderly” with the request letter including the description of the purpose of this survey was sent to the facilities by regular mail. Facility manager or
a person who is well informed of the facilities and apparatus was designated as the respondent. The duration of response was about 3 weeks. Handwritten completed questionnaires were sent back to our institute also by regular mail. Furthermore, this survey was implemented at the same time with the questionnaire about the environmental hygiene management in social welfare facilities performed by other research groups in our institute.

The following are the questions included in the questionnaire.

- The number of elderly people admitted in October 2012
- The amount of water used in a month and its (their) source(s) in October 2012
- The states of possession/preparation of special equipment/countermeasures available for the cutoff of the water supply

In the questionnaire, the situation of the cutoff, the water supply in the past and other special counterplans in water management for the prevention of infectious diseases were also asked. However, it was not mentioned here with considering the purpose of this paper.

**Analyses**

To calculate the water use, only facilities without outpatient service and do not use the private water supply, rainwater, and well were intended. Furthermore, there is a possibility that the lifestyle, i.e., self-sufficiency of daily life, effects on water use, facilities based on the Long-Term Care Insurance Act (called “care facility” below; the nursing care level of the elderly admitted is high), and welfare facilities for the elderly (called “welfare facility” below; the nursing care level of the elderly admitted is low) were estimated separately.

The daily water use was calculated by Eq. (1),

$$Q_{\text{day},a} = \frac{Q_{\text{month}}}{d_{\text{month}} n_{\text{adm}}}$$  \hspace{1cm} (1)

where, $Q_{\text{day},a}$ is the daily amount of water used in a facility per person admitted in a month [L/day/person-admitted]; $Q_{\text{month}}$ is the total amount of water used in the facility in the month [L]; $d_{\text{month}}$ is the total number of days in the month [day]; and $n_{\text{adm}}$ is the elderly person admitted in the facility in the month [person-admitted]. Note that the number of workers and visitors was not considered in this calculation. That is to say, the water used by the workers and visitors were included in the daily water use as a necessary amount to care for the elderly people. Outliers obtained as a result of the calculation were also excluded by the test of rejection of Smirnoff-Grubbs at 5% significance level. The statistical difference in the amount of water used between the care facility and elderly welfare facility was estimated by $t$-test. The results were estimated by maximum, upper quartile, median, lower quartile, and minimum values. Statistical analyses were performed by Excel-Toukei 2010 (Social Survey Research Information, Japan) and Microsoft Excel 2010 (Microsoft).
Preparedness for the cutoff of water supply can be divided roughly into two types, i.e., fixed assets and others. The fixed assets include the possession of physical equipment such as water receiving tank, and the others consists of emergency stocks, cooperative agreements, and emergency drill.

**RESULTS AND DISCUSSION**

**Questionnaire reply rate**

The detailed numbers of sent and replied questionnaires are shown in Table 1. Total numbers of sent and replied were 1,251 and 214, respectively. And the whole reply ratio was 17.1%.

<table>
<thead>
<tr>
<th>Group</th>
<th>Type</th>
<th>No. Sent</th>
<th>No. of Replies</th>
<th>Reply Ratio [%]</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Designated Facility Covered by Public Aid Providing Long-Term Care to the Elderly People&lt;sup&gt;2)&lt;/sup&gt;</td>
<td>425</td>
<td>83</td>
<td>19.5</td>
</tr>
<tr>
<td></td>
<td>Long-Term Care Health Facility&lt;sup&gt;3)&lt;/sup&gt;</td>
<td>190</td>
<td>33</td>
<td>17.4</td>
</tr>
<tr>
<td>Facilities Covered by Long-Term Care Insurance&lt;sup&gt;1)&lt;/sup&gt;</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Welfare Facilities for the Elderly People&lt;sup&gt;4)&lt;/sup&gt;</td>
<td>Nursing Home for the elderly</td>
<td>33</td>
<td>11</td>
<td>33.3</td>
</tr>
<tr>
<td></td>
<td>Low-Cost Home for the elderly</td>
<td>52</td>
<td>11</td>
<td>21.2</td>
</tr>
<tr>
<td></td>
<td>Fee-Based Home for the elderly</td>
<td>551</td>
<td>76</td>
<td>13.8</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>1,251</td>
<td>214</td>
<td>17.1</td>
</tr>
</tbody>
</table>

1) facility based on the Long-Term Care Insurance Act (Act No. 123)
2) including intensive care home for the elderly people based on the Act on Social Welfare for the Elderly (Act No. 133)
3) including the facilities used free of charge or at low cost under the Social Welfare Act (Act No. 45)
4) facility based on the Act on Social Welfare for the Elderly (Act No. 133)
Water use
Considering the validity of response and the test of rejection described in the materials and method section, the numbers of answers available to evaluate the water use were 13 and 22 for the care facilities and the welfare facilities, respectively. All of these 13 care facilities were the designated facility covered by public aid providing long-term care to the elderly people. Figure 1 show the relationship between the water use and the number of elderly people admitted. The number of elderly people admitted to the care facility subjected in this calculation (90.8 ± 27.7 [person-admitted/facility]) was significantly larger than that of the welfare facility (57.1 ± 36.2 [person-admitted/facility]) (p < 0.01, t-test). Figure 2 shows maximum, upper quartile, median, lower quartile, and minimum values of the water use. Firstly, we noticed that the variation of the amount of water used in elderly welfare facilities was larger than that of the care facilities. The median value of the care and welfare facilities are 411 [L/day/person-admitted] and 431 [L/day/person-admitted], respectively. Statistical significance test (t-test) revealed that there is no statistically significant difference in the amount of water used between these two groups of facilities. Those frequencies are also depicted in Fig. 3. The ranges of 400 – 600 [L/day/person-admitted] and 200 – 400 [L/day/person-admitted] were the most frequent class in the care facilities and the welfare facilities, respectively. Considering these results, one of the possible reasons of the difference in variation is that the welfare facilities subjected in this calculation were more sensitive to the individual variability because of their small number of admission, and we concluded that we could not find out the dependency of the water use on the difference in the nursing level in this study. Further study is required to clarify the difference.

The comparison of various amounts of water use reported in literature is listed in Table 2. The amounts of water used in elderly facilities elucidated in this study are larger than that of daily life. A possible cause of this difference was the water use by worker and visitors.

![Fig. 1 - Daily water use in facilities as a function of the number of people admitted in each facility.](image)
Fig. 2 - Amount of water used in elderly facilities (maximum - upper quartile - median - lower quartile - minimum).

Fig. 3 - Frequency distribution of the amount of water used in facilities.
Table 2 - Unit values of water use evaluated in this study and reported in literature.

<table>
<thead>
<tr>
<th>Facilities</th>
<th>Value</th>
<th>Unit</th>
<th>Condition</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Designated Facility Covered by Public Aid</td>
<td>411</td>
<td>L/day/person-admitted</td>
<td>Median of 13 samples Oct. 2012, Tokyo</td>
<td>This study</td>
</tr>
<tr>
<td>Providing Long-Term Care to the Elderly</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Elderly Welfare Facility</td>
<td>431</td>
<td>L/day/person-admitted</td>
<td>Median of 22 samples Oct. 2012, Tokyo</td>
<td>This study</td>
</tr>
<tr>
<td>Daily life</td>
<td>313</td>
<td>L/day/person</td>
<td>Japan</td>
<td>AIST (2007)</td>
</tr>
</tbody>
</table>

**Fixed assets preparedness**

The multiplication of water supply systems such as the introduction of private water supply system, rainwater system, and the possession of well can be considered as the fixed assets preparedness. The introduction of water receiving tank is also effective as a countermeasure for the cutoff of water supply. Figure 4 shows the status of these installations. In this figure, “not introduced” is the case that it was clearly indicated in the answer, whereas “no answer” means no available data about it was given in the answer sheet, which are the same as for Fig. 6. The possession ratio of the water receiving tank higher than other systems/equipment, revealed that the emergency water supply using the water receiving tank is realistic under the present condition. The possession ratio of well is about 10%, however, the well water possible to drink is less than one-third of them. Meanwhile, because of its low introduction ratio, the emergency water supply using private water supply system cannot be expected much under the present condition. However, the price reduction of the membrane filtration system accelerated the introduction of private water supply system (Todoroki and Sawada, 2011), and the future progress of the introduction of the system as a multiplication of water supply is expected. Figure 5 show the frequency distribution of the volume ratio of water receiving tank (Eq. (2)) introduced in the elderly facilities.

\[
\theta = \frac{V}{\bar{V}_{\text{month}}} \cdot 100
\]  
(2)
where, $\theta$ is the volume ratio of water receiving tank to the daily use [%]; and $V$ is the tank volume [m$^3$]. Many of them have volumes of around 50% of the daily water use.

Fig. 4 - Introduction of various equipment that can be used in the cutoff of water supply.

Fig. 5 - Frequency distribution of the volume ratio to the daily consumption of the facilities.
Preparedness other than fixed assets

Preparedness other than fixed assets consists the stock of drinking water, stock of emergency toilet, emergency water supply agreement with other organization, and the implementation of emergency drill considering the cutoff of water supply. The status of preparedness is shown in Fig. 6. Especially, the high preparation ratio of the stock of drinking water is found, and in most facilities, the quantity of storage is 3 days. The introduction of the emergency toilet is 30 – 40%. Meanwhile, the emergency water supply agreement which is effective for emergencies was not necessarily high. Waterworks bureau and the local government were seen as the partners of the agreement and the small number of emergency drill was considered the cutoff of water supply. These results revealed the importance of promotion of such countermeasures in the future to reduce the vulnerability of elderly facilities for the water cutoff.

CONCLUSIONS

The overall situation of the facility for elderly people for the water use and countermeasures for the emergency water supply in Tokyo were clarified in this survey. The median values of the amount of daily water used in the elderly care and welfare facilities were estimated as 411 [L/day/person-admitted] and 431 [L/day/person-admitted], respectively. High introduction ratio of the water receiving tank which can be effective in the case of emergency was found. The high ratio of stock of drinking water was also clarified. The low introduction ratios of the emergency water supply agreement and the emergency drill considering the cutoff of the water supply indicate the necessity of the promotion of such preparedness.

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REFERENCES