# APPLICATION OF SYSTEMS THINKING MODEL TO EVALUATE HEALTHY CITIES

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### 1. Introduction

A super-aging society in Japan means that the health level of its citizens is declining. The Ministry of Health, Labor, and Welfare released guidelines<sup>1)</sup> for healthy urban planning to extend the average life expectancy (ALE) and healthy life expectancy (HLE) while reducing the life expectancy gap and decrease the number of people needing long-term care. However, there is no standard definition of healthy urban planning. This research aims to describe the mechanism by systems thinking model and evaluate the effectiveness of health policies.

#### 2 Construction of Systems Thinking Model

(1) Overview of Systems Thinking Model

This study replicated the mechanism of healthy urban planning by creating a systems thinking model by observing examples such as Smart Wellness Cities.

Systems thinking<sup>2)</sup> (Figure 1) is a simulation method that represents a complex system. The advantages are that it, ①Ignores external disturbances, ②Can easily convert variables, and ③Expresses nonlinearity.



Figure 1. Structure of Systems Thinking Model

# (2) Concept of Healthy Urban Planning

The mechanism of healthy urban planning is represented in Figure  $2^{3}$  and example of processes are shown in equations (1) and (2).



Figure 2. Mechanism of Healthy Urban Planning

$$(HLE) = x_0 + x_1 \text{ (Ratio of Elderly Citizens)} -x_2(Ratio of Long-term Care Patients)$$
(1)

$$(ALE) = y_0 - y_1 \text{ (Ratio of Long-term Care Patients)} - y_2 \text{ (Ratio of Lifestyle Disease Patients)} + y_3 (Medical Service Level) + y_4 \text{ (Elderly Ratio)} (2)$$

ALE and HLE is calculated using a projection model. HLE is defined as years spent not in long-term care and since only the elderly require long-term care, the key factors to determine HLE are ratio of elderly and long-term care patients. On the other hand, extension of ALE is partly credited to medical technology, better diet and habits which will decrease lifestyle disease cases. Furthermore, ALE is considered an extension of HLE. Therefore, the key factors for ALE are variables of HLE, medical service level, and ratio of lifestyle disease patients.

Other evaluation indices are determined using the following methods. Life expectancy gap is the difference between the life expectancies. Longterm care expenses is the total spent by long-term care patients. Medical expenses is the sum spent on medical services by each population group. Other equations are also determined by observing causeeffect relationships in the real world.

Furthermore, several parameters (e.g. medical

expenses) were based on actual data, while others (e.g. long-term care patients) were determined using the trial-and-error method which were compared to actual data for validation. For example, ratio of locomotive syndrome is determined at 32.8%; a study found that it is  $40\%^{4}$ . Thus, the variable can be determined significantly.

### 3. Results and Analysis

The projections for HLE (Figure 3) and ALE (Figure 4) are shown. The graphs show the results when healthy urban planning is not implemented and when it is implemented at a sensitive parameter setting of 0.3.



Figure 4. Average Life Expectancy

It is evident that the implementation of healthy urban planning has a beneficial effect on health promotion. Although ALE and HLE are extending, the growth rate of HLE doesn't exceed the growth rate of ALE. Thus, there is no reduction in the life expectancy gap at its current parameter (0.3). Current policies don't achieve ideal growth rate for HLE and further analysis is required to pinpoint advanced health policies.

Healthy urban planning has a positive impact on reducing long-term care expenses and boosts regional revitalization, which contributes to economic growth. However, medical expenses remain unchanged (Figure 5). Possible causes are the increase of elderly population, or the setting of the model.

Moreover, most policies aim to increase the amount of exercise in the elderly. However, increasing health motivation in younger citizens might be more effective to combat aging society in the long-term.



## 4. Conclusion

The mechanism of healthy urban planning is described clearly by applying systems thinking model. Process of health promotion, reduction of locomotive/metabolic syndromes are explored. Implementation of health policies increases health motivation and extends ALE and HLE. When standard of health policy, infrastructure, and medical service is high, life expectancy gap is reduced. However, ways to improve health policies has not been explored. A drawback of this framework is lack of annual data at the municipality level. This study solely pertains to the exercise aspect of health and disregards other conditions such as mental health, diet, viral diseases, etc. Lastly, revision and expansion of the model are necessary to include nonlinearity and further reflect actual healthy urban planning.

#### **References and Citations**

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