

# Definition of Senior Citizens and Proposal of Senior Age Index for District Planning in Aged Society

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■ **Summary** : Because of the decrease of birthrate and the aging of citizens, our country is advancing toward the very aged society. Therefore, including how to utilize senior citizens in a society, strategies for aged persons have been studied as an important city's policy in these years and been strongly promoted. However, the situations of senior citizens are different at each district in a city quantitatively and qualitatively. Therefore, the detailed statistical characteristics of aged persons at a district should be studied to find essential measures against elderly people on a district planning and management.

Firstly, we study the age distributions at every statistical district on the census of Fukuoka City. As a result, persons over 55 years old are defined as senior citizens and divided into several groups depending on the meaning of advanced ages for their life. Then, a new index is proposed to evaluate the aged situation of society at a district. And, the relationship between our proposed index and the distributions on senior citizen's ages is looked into on the viewpoint of the spatial structure. In addition, some serious districts with the high rate of aged citizens are picked out and usefulness of index is illustrated in detail to understand the meanings of aged society.

■ **Keywords** : Senior citizen, senior age index, aged society, district planning, Fukuoka City.

## 1. Introduction

Our country is advancing the decreasing process of population since 2005. In this condition, many villages and towns is shifting to a very aged society from an aged society, with the lowering of birthrate and the enlargement of aged person's rate. And, such situations are found in not only rural areas, but also even a few districts in a large city at the present time.

In the above situation of our country, the population of Fukuoka City is yet increasing, but the increase of aged persons, who are over 65 years old, is larger than it. In comparison for 10 years between 1996 and 2006, the rate of aged persons had increased 48.6%, while the population was only 9.3%. As a result, the aged person's ratio in population has changed from 11.7% to 15.9%. The aging of population will advance, and the city will become an aged society soon as well as local areas of our country. From this fact, it is important to develop urban policies for an aged society. And, it is required to achieve them without fail in the present time of increasing of population.

We can seldom find any same distributions of citizen's ages on each district. There are many types of aged conditions and various properties in ages-distributions of individual districts. Therefore, it is important to study strategies on senior citizens on the basis of the detailed situation of aging, together with rates

and indexes of the aged at each district. And, we desire to develop really the effective and efficient policies for the aged.

However, a rate of the over 65 years old in population has been used in practice as a guide, which only shows the outline of an aged society. Therefore, as strategies for senior citizens, houses for the aged were built at random taking no thought of the other conditions and barrier-free plans of public spaces and facilities were only promoted picking a district of the high rate of aged citizens, regardless of ages-distributions. Meanwhile, by the reason that number of senior citizens is not the majority, there are several cases that strategies for senior citizen have been put off and that the active power of aged persons has not been utilized enough in a community.

By these facts, there are some severe criticisms concerning city's policies on senior citizens. Conventional strategies for aged persons were not always effective, and there were also cases that those were unsuitable and undesirable under certain circumstances.

Such issues on strategies of senior citizens are caused by insufficient investigation and non-effective evaluation of ages-distributions, especially the detailed distributions of senior citizens. Because the shape of distributions is complex and its characteristics are hardly understood, the more a city is divided by small districts, the more the comparison and evaluation of individual ages-distributions among districts is difficult.

Firstly, it is studied that conventional indices for senior citizens are not useful to understand the aged conditions at a district. Then, the distributions of ages divided at a unit of 5 years old on districts are studied by the application of principal component's analysis. Furthermore, meanings of each age in the distributions are discussed, and a senior citizen on an issue of district planning is defined.

A new index to understand senior citizens in age distributions is proposed, which has the standardized weight of death rate in every age of senior citizens. In addition, the proposed index is applied to statistical districts in Fukuoka City. Relationship between the proposed index and the conventional ratio on senior citizens is investigated, and the meaning of proposed index becomes clear.

Finally, some districts in Fukuoka City in which serious situations of senior citizens are shown are found with the senior aged index. And studying them on the situation of the aged, effectiveness of our proposed index is illustrated.

## **2. Conventional Indices for Aged Persons, and Those Problems**

To make a strategic plan of senior citizens, the aged person has been defined as to be over 65 years old, and the following three indices have been always used.<sup>3)</sup>

- a) Rate of the aged: percentage of persons over 65 years old in population.
- b) Ratio of aged population to working population: ratio of population over 65 years old to population from 15 years old to less than 65 years old.
- c) Aging index: ratio of population over 65 years old to juveniles less than 15 years old.

A rate of the aged represents the total frame of aged situations in population. However, aged persons

are spreading from 65 years old to over 85 years old. And, conditions on the health, work and family of an aged person are different depending on each step of his age and life style. Namely, many types of ages-distributions characterized at each district are obtained, because the life span of citizens has been extended with the progress of medicine and the life style of citizens has been variously developed with their urban activities. Therefore, the rate of the aged can not reflect the exact situations of ages-distributions to make district policies.

In addition, each district has the active aged and the inactive aged, and the initial aged citizen and the later aged citizen are mixed variously in a district (See Note 1). Therefore, real situations of aged persons at a district can hardly find by the use of the rate of aged persons. In particular, this fact of senior citizens will become the remarkable issue when the baby-boomers attain to the old age. The rate of aged persons at a district, where a lot of baby-boomers live, becomes abruptly large after a few years. And, it will be judged that the district is a very aged society jumped over an aged society, though there are many active senior persons.

The ratio of aged citizens to working population is a contrasted index at which the working generation means to support the aged persons. However, the system of pension will be reformed in future, including the tax reform such as a consumption tax. In such coming future society, the aged citizens will be partially supported by the same aged generation. On the other hand, many types of workers such as a part-timer, old age worker and volunteer will be popularized, and foreign workers also will increase with the headway of aged society. The retirement age will be extended, too. From these facts, the working meaning and the definition of worker's generation will change.

Namely, the conventional ratio on senior citizens to working population becomes meaningless. The community will shift toward the mutual help and cooperation between generations, in which the aged generation also will play an important role. So, the division in population by supporter of workers and non-supporter of the aged will get ambiguous and not significant.

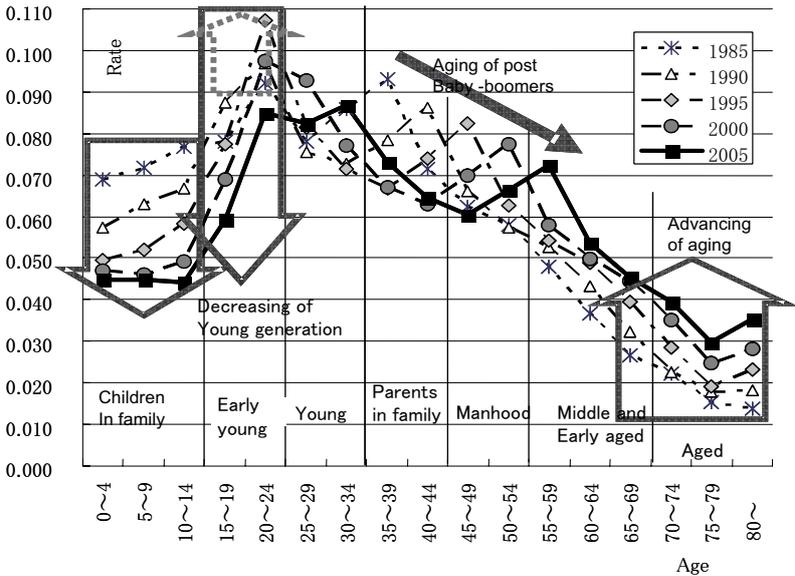


Figure 1 Shifting of ages-distributions of Fukuoka City<sup>1)</sup>

Although an aging index is the ratio of aged persons to juveniles, the index will become meaningless by the big increase of senior citizens and the decrease of children. That is, there are some serious districts where the percentages of the aged citizens are over 50%, and we can also find the specific districts where the rate of the aged persons is about 100%, as an extreme example. Of course, we can often find it at a district of the city, though most of them appear in the local area. At such a district, the ratio of the aged to juveniles becomes infinity. Therefore, the aging index on those districts is not useful at all to understand and compare each other.

In short, ages are classified by three groups of juvenile age, working age and senior age. And, conventional indices on the aged are defined by the relationship of the aged generation and others as above-mentioned. However, the paradigm-shift of socioeconomic situation is seen, and most of baby-boomers reach the aged generations soon. In such today and future, conventional indices on the aged population are not fitted to plan and evaluate the urban policies for senior citizen, and they are not so much meaning on issues of aged citizens.

### 3. Classification of Ages on the Basis of Spatial Distributions and the Definition of Aged Generation

On the basis of the census, distributions of ages on the population in Fukuoka City are shown as in Fig.1, which is graphed at steps of 5 years old. In the figure, two peaks at 20's ages and baby-boomers can be found. And, keeping such a shape of distributions, it is shifting toward the right side of graph. That is, the ages-distributions in our society are weakening those peaks by the decrease of children and the increase of aged population. As a result, the ages-distributions are becoming gradually flat.

#### (1) On real situations of a distribution of ages in a district

Referring to the above overviews of distribution, data of distributions of 111 statistical districts in Fukuoka City are analyzed by the principal component analysis. Table 1 shows eigen-values, contributing ratios, and factor loadings in the results.

The first principal component Z1 shows a synthetic variable of which numerical value reaches a big one by large rate of young people. Z2 is a synthetic variable which becomes a bigger numerical value with the larger rate of family type of people. Furthermore, Z3 is affected by students of their late teens, and Z4 is related with manhood ages of their late forties and early fifties. Z5 is affected by aged persons of over 80 years old.

To understand the distributions of citizen's ages at a district, some of typical districts are chosen and their ages-distributions are shown as in Fig.2.

Table1 Results of principal component analyses by ages-distributions at districts (Fukuoka, 2005)

Pri. Component	Z1	Z2	Z3	Z4	Z5	
eigenvalue	0.00197	0.00092	0.00045	0.00024	0.00015	
proportion(%)	0.5	0.2	0.1	0.1	0.0	
cum pro.(%)	48.0	70.3	81.1	87.0	90.6	
factor loading	0~4	-0.394	<b>0.744</b>	0.222	-0.335	-0.004
	5~9	<b>-0.597</b>	<b>0.608</b>	0.423	-0.220	0.015
	10~14	<b>-0.687</b>	0.439	0.481	-0.142	0.009
	15~19	0.203	-0.258	<b>0.780</b>	-0.021	-0.238
	20~24	<b>0.892</b>	-0.284	0.304	0.028	0.029
	25~29	<b>0.896</b>	0.174	-0.350	-0.023	-0.098
	30~34	<b>0.616</b>	<b>0.650</b>	-0.347	-0.099	0.042
	35~39	0.133	<b>0.898</b>	-0.110	0.188	0.155
	40~44	-0.196	<b>0.733</b>	0.249	0.331	0.254
	45~49	<b>-0.630</b>	0.243	0.107	<b>0.603</b>	-0.238
	50~54	<b>-0.620</b>	-0.222	-0.166	<b>0.592</b>	-0.041
	55~59	<b>-0.661</b>	-0.346	-0.246	-0.122	-0.456
	60~64	<b>-0.600</b>	-0.472	-0.229	-0.409	-0.241
	65~69	<b>-0.618</b>	<b>-0.548</b>	-0.256	-0.382	0.052
	70~74	-0.449	<b>-0.712</b>	-0.192	-0.052	0.415
75~79	-0.490	<b>-0.640</b>	-0.176	0.019	0.422	
80~84	-0.313	<b>-0.577</b>	-0.182	-0.121	<b>0.491</b>	
85~	-0.238	-0.266	-0.164	-0.340	<b>0.517</b>	
meaning	young	family	erl.young	manhood	aged	

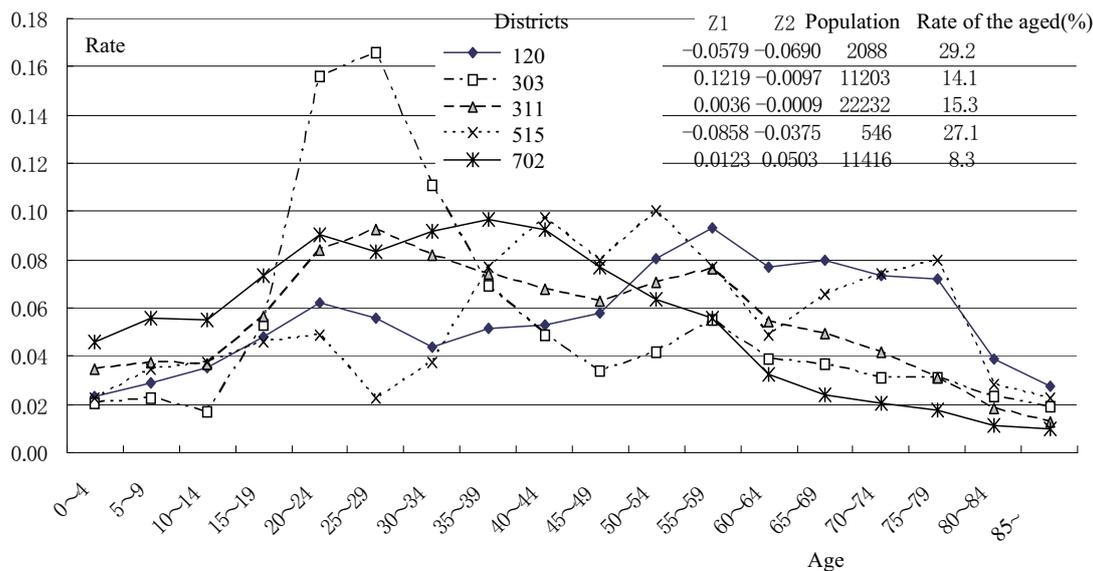


Figure 2 Ages-distributions at some characterized districts (2005)

Although ratios of the aged persons in two districts of Kiyokawa (303) and Toujin·Fukuhamma (311) are same as the one in Fukuoka City, Kiyokawa is characterized by the fact that the ratio of the persons of twenties is extremely big. The numerical value of Z1 of the young degree is plus and Z2 on the degree of family is minus.

On the other hand, at the district of Toujin·Fukuhamma (311), both of Z1 and Z2 are about zero and the peak in twenties is lower. Therefore, the distributions of citizen's ages are flat as a whole. The ratio of persons at latter half ages over 50 years old is getting lower as one grows older. On the relationship between the first half age of old persons and the second half age of them, the rate of the latter is smaller than the former.

Both of Shikanoshima (120) and Genkai·Oro (515) are islands and their rates of the aged are much high in comparison with other districts in Fukuoka City. The percentage of the aged in Shikanoshima is 29%, and in Genkai·Oro, 27%.

However, distributions on specific ages of the aged are different. In the district of Shikanoshima, the distribution from 60 to 75 years old is flat and after that, the rates become small in accordance with ages. And the rate of family's generation is comparatively small. At the district of Genkai·Oro, the ages-distribution on aged persons is a shape of mountain with a high peak in 70 years old or so. And, it is distinguished by the large rate of families' generation in the distribution, though it is not so big compared with Kiyokawa(303).

Although there is a difference among the ages-distributions of two districts, Z1 and Z2 of those districts are minus together, and we can find the difference from other three districts, because there is the advance of the aged society comparatively.

At the district of Nishijin (702), which is one of sub-centers of the city, numerical values of Z1 and Z2 are plus, though they are not so big. The ratio of juveniles is large, and the rates of young people and persons in middle age also are large. On the other hand, the rate of senior citizens is less than those of above-mentioned four districts.

As illustrated, there are many types of ages-distributions on districts and various aged conditions are

respectively found at every district. And, scores in principal components, Z1 and Z2, are different at each district, reflecting the situation of ages-distributions.

## (2) Classification of ages and the new definition of the aged

The definition of the aged which are persons over 65 years old has been originated from the WHO. However, it is doubtful whether it is useful for understanding the situations of the aged in our country. Are real states of the aged obtained by a rate of the aged? To answer this question, the cluster analysis is applied to ages-distributions of districts in Fukuoka City. Results are obtained as shown in Table.2 and Fig.1.

Table 2 Clusters of ages

group	ages	notes
1-1	0~4 5~9 10~14	child's age (15 years old or less in family)
1-2	35~39 40~44	parent's age (middle age in family)
2	15~19 20~24	young age
3	25~29 30~34	manhood age
4	45~49 50~54	middle age
5	55~59 60~64 65~69	early advanced age
6	70~74 75~79 80~84 85~	later advanced age

Namely, citizen's residences are spatially scattered under the influence of allocations of urban facilities, activities and land use. And, the spatial distributed structure of residents is yielded with being characterized into young, family or aged generations, and so on.

Table 2 shows the classification of citizen's ages depending on the conditions contributing to principal components, which reflects the similarity of spatial distributions of ages.

Group 1 of ages is the family's generations, which are given by persons of middle age and children of 15 years old or less. Group 2 is the young generation, and Group 3 is the juveniles. Group 4 is the middle age and Group 5 is generations of 55~69 years old. On the other hand, Group 6 is people of over 70 years old, who are the aged citizens literally.

In short, Table 2 is the significant classification of ages-distributions to study an urban strategy for every generation. Under this classification, generations of Groups 5 and 6 are almost equivalent into the aged of up to now, which has been traditionally used. However, in our proposed generations of Groups 5 and 6, persons from 55 to 64 years old are included to the aged. Therefore, we call the persons in Groups 5 and 6 the senior persons or the senior generation, in this paper (See Note 2).

## 4. Proposal of New Senior Age Index

### 4.1 On Ages-Distributions of Senior Persons

Situations of the ages-distributions in senior generations are different in each district. Hence, to develop a desirable urban strategy in accordance with the conditions of aged society of a city, it is required to find appropriately the conditions of the ages-distributions of senior generation and to disclose the details of characteristics of ages-distributions at the district. In this meaning, conventional three indices showing comprehensively the ages-situation in population are not appropriate, and we discussed it at the previous chapter. As a result, to understand the situation of very aged persons or aged citizens and to reflect the detailed conditions of distribution of senior citizens at the district, it is said that a new index should be pro-

posed.

For instance, obvious differences in the ages-distributions of senior citizens are found among two types of districts of Genkai·Oro, and Nishijinn or Kiyokawa as in Fig.6. The first type of distributions at a district is flat at the aged generations and is shaped by trapezoid. On the other hand, in the second type of distributions, the rate of aged persons is small. Therefore, importance and urgency on strategies for senior citizens are different among both types of distributions, because the strategies on the senior citizens become more serious at later aged persons than early aged persons.

In other words, it is natural that the senior persons are more inferior in health to the young people. An aged person has the high probability of getting a disease, and weakening willingness and spirit. From these facts, for the aged, the community activities, prevention of crimes and protection against disasters should be individually planned at each district.

If considering the different conditions of ages-distributions of the senior persons at each district, it is not appropriate to take a similar strategy under the same values in the conventional aged index. Considering the significance of age, it will be required to reflect individual states of ages-distributions at each district.

#### **4.2 Weight Coefficient by a Curve of Age-specific Death Rate**

What is the significance or the weight to consider each age of senior generation, in the planning of district's facilities? We propose to use a curve of death rate as an idea. The more citizens are old, the more carefully and essentially the district's facilities should be designed. Meanwhile, the probability of death corresponds with an age. And, it is possible to get the precise data of death rate on the basis of citizen's ages. In addition, although there is some difference between cities and rural areas with the medical progress and eating habits, the population of a city or a district is stable and hardly has large change in these years.

Circumstances to keep the health of the aged are steadily improving under the progress of medical technique. It is scarcely needed to say, but the present death rate became smaller in comparison with 20 years ago. In these meanings, it is significant to use the death rate in each age as a weight coefficient of citizen's age, of which the role is alike to a deflator of the economy.

Fig.3 shows the relationship between death rate and citizen's age, on the basis of data of Fukuoka City and our country. Both of them are almost same at outline, though there are some differences if checking in detail. And, it is found that each curve of death rate has a turning point at late half of 50's age of citizens. In the case of our country, the death rate is 487.6 per 100 thousand persons in their late fifties. It is 12064.6 in over 85 years old, too.

On the other hand, it is not convenient to have respectively the different weight coefficient at each district for the comparison of various districts, because it is required to get appropriate strategic plans on the arrangement and management of welfare facilities and city's infrastructures. Therefore, to indicate the urgency and priority of welfare facilities, etc., a unified index on the judgment criterion must be proposed.

From the above-mentioned consideration, it is seen that the weight coefficient depending on ages is

effective to understand the different types of ages-distributions. Therefore, the death rate in a 5 years old bracket based on the data of the country is proposed as a weight coefficient.

In Fig. 3, both of death rates of female and male are also shown. Noticeable differences of death rate among men and women are clearly found at late ages of the senior citizens. Therefore, a weight coefficient should be separately defined among male and female, even though using the data of our country.

The concept to get a weight coefficient is shown in Fig.4, and the weight,  $w$ , on an age is defined as follows:

$$w = \sqrt{(x-a)/(b-a)}$$

Where  $x$  = death rate in a subject age-group,

$a$  = death rate in 50~59 years old,

$b$  = death rate in over 85 years old.

In the above-mentioned definition on the weight coefficient, the square root of standardized death rate is used, instead of its direct rate. This is the careful consideration against concerns on which the numerical value " $\alpha$ " in Fig.4 is overestimated at over 85 years old and on which other age groups are not evaluated enough (See Table 3). Strategies for the aged are not only for the people of eighties or over 85 years old. Strategies should also reflect needs of people of their sixties or seventies: enjoying travel, keeping health, and bettering living.

In this consideration, the weight coefficient by the square root of death rate is proposed at the origin of one's late fifties (See the column of the right side in Table 3). Weight coefficients are in the range from zero of the age-group of 55~59 years old to 1.0 of the over

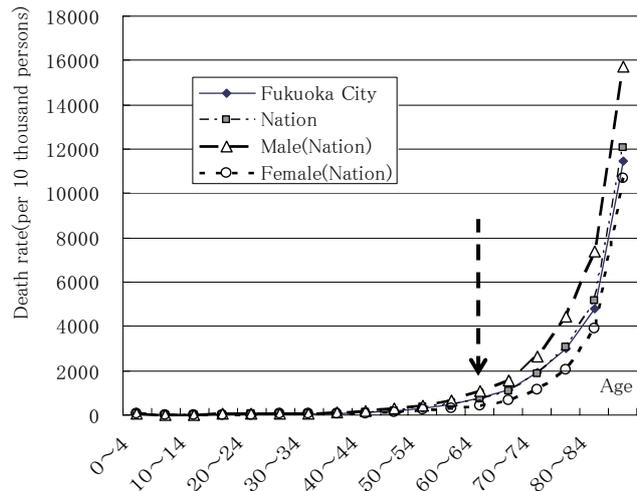


Figure 3 Death rate of Fukuoka City and Nation (2005)

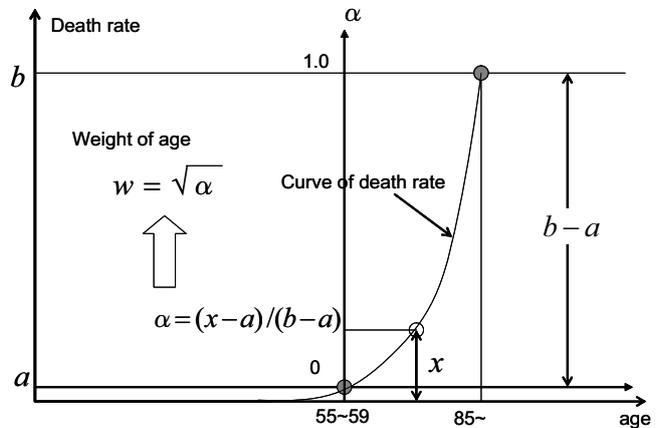


Figure 4 Concept of weight coefficient of age

Table 3 Weight coefficient by the death rate

age	$\alpha$			weight		
	all	male	female	all	male	female
60~64	0.022	0.025	0.013	0.147	<b>0.159</b>	<b>0.114</b>
65~69	0.052	0.060	0.035	0.229	<b>0.244</b>	<b>0.187</b>
70~74	0.116	0.132	0.081	0.341	<b>0.363</b>	<b>0.284</b>
75~79	0.221	0.250	0.165	0.471	<b>0.500</b>	<b>0.406</b>
80~84	0.402	0.445	0.346	0.634	<b>0.667</b>	<b>0.589</b>
85~	1.000	1.000	1.000	1.000	<b>1.000</b>	<b>1.000</b>

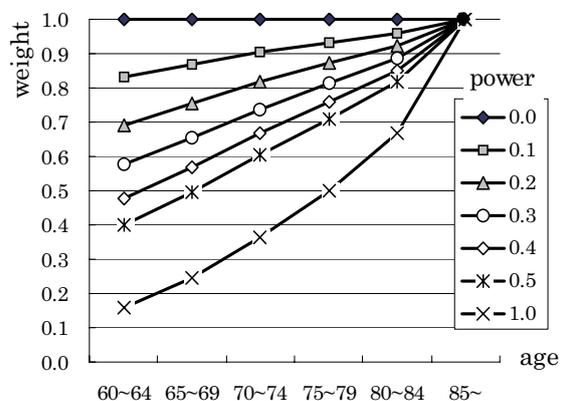


Figure 5 Weight of age (in the case of male)

85 years old, in each case of male and female as shown in Table 3.

In this paper, senior generations are people of over 55 years old. However, persons of over 60 years old are left to the study on issues of aged citizens, because the weighted coefficient of people at their late fifties is zero. Therefore, senior citizens are defined virtually as persons of over 60 years old, and they are the aged generation in wide sense.

Namely, the weight coefficient is given by the square root of  $\alpha$ , as far as it is not declared. However, the use of other weights may be needed under certain cases, too. For instance, the universal design of urban park must be studied for aged persons who can go out. On the consideration of such a subject at a district, the square root of  $\alpha$  gives the excessive weight for super-aged citizens. The weighted coefficient for the super-aged persons should be lowered and the one for the early aged citizens should be raised up. In this meaning, the new type of weighted coefficient must be proposed in stead of the square root of  $\alpha$ .

In short, as weights in these cases, 0.4, 0.3 and so on of the revised power may be proposed (See Fig.5). That is, it means that the power of zero is equivalent to 1.0 as a weight on all stages of generations, with which the aged indices are directly obtained by ratios of ages as well as the conventional indices. Therefore, weight coefficients are given by appropriate numerical values among both extreme cases, 0 and 0.5, on the power of  $\alpha$ , and an integrated index of ages-distribution of senior citizens can be found with it.

Although weight coefficients should be defined depending on the content of district planning, they will be concretely found by trial and error in application to many practical cases.

Table 4 Sub-division of old age and weight coefficient of age

age	Interpretation on common idea	death rate per 100 thousand citizens	weight		cluster by factor loading of PCA			sub-division of senior	notes		
			male	female							
55~59		322	0	0	11	7	5	old age in wide sense old age in narrow sense			
60~64	retiring age	488	0.159	0.114	12	7	5		pre-old age		
65~69	first half senior	1095	0.244	0.187	12	7	5		initial old age		
70~74		1832	0.363	0.284	13	8	6				
75~79	latter half senior	3057	0.500	0.406	13	8	6		mid-old age		
80~84		5136	0.667	0.589	14	9	6		late old age		
85~		12065	1.000	1.000	15	9	6				

### 4.3. Senior Age Index of District

The district at which the ages-distributions between male and female are different is easily found. For example, ages-distributions of two districts at which aged societies made progress and have averages of the aged rate are shown in Fig.6. If narrowed down to age-groups of over 55 years old, the ages-distributions in each district are much different between male and female. On the whole, rate in each age in distributions for female is larger than the one for male. And the distribution for male at the Genkai-Oro district (515) is much different against the one for female. On the other hand, there is small difference between both at Kiyokawa district (303).

Another viewpoint to pay an attention is that contents of strategies for male and female are not always same. The physical conditions of aged persons are different among men and women. There is the difference between male and female on type of diseases. Even necessary help on living or support of urban

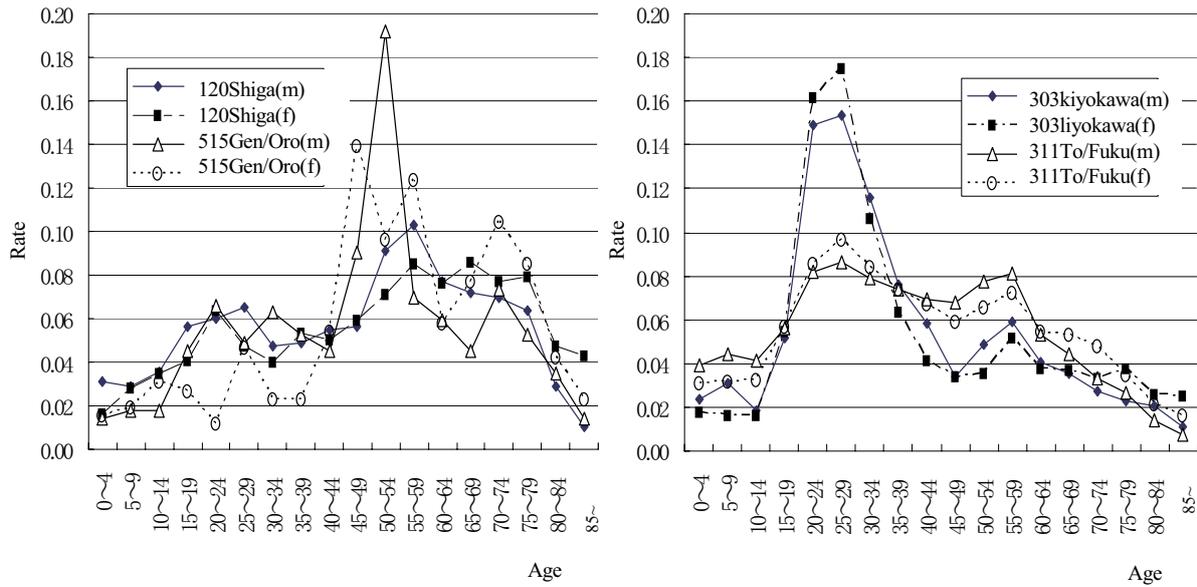


Figure 6 Ages-distributions of male and female at two districts

activities will require individual contents on male and female.

After all, there are some differences between male and female on the ages-distribution of citizens, weight coefficients on the basis of the death rate and the countermeasures for the aged. Therefore, meanings of the aging must be considered at male and female respectively and degrees of their aging should be evaluated individually. So, we propose the new senior age indexes on the aged groups over 55 years old for male and female, which are given by the summation of rates in the weight coefficient of the death rate on the ages-distributions.

$$S.A.I = \sum_i w_i \beta_i \quad (i=60\sim65, 65\sim70, \dots, 85\sim)$$

According to the survey of the Ministry of Land, Infrastructure and Transport, 431 very-aged communities had been found in our country in 2006, where the rates of the aged are 100%.<sup>4)</sup> All of citizens in such a community will become over 85 years old, before long. In such case, our proposed senior age index is just 1.0. In the uniform ages-distribution of a district where all of people are over 60 years old, the senior age index is 0.489 in the case of male and 0.430 in the case of female. On the other hand, it is natural that the index is zero in the case that all of population is less than 60 years old.

In every case of male and female, the senior age index is in the range [0 1.0]. In a sense, a senior age index is interpreted as the overall weighted value of ages-distributions of standardizing at the over 85 years old. Namely, our senior age index (in brief, S.A.I.) is proposed instead of the conventional ratio of the aged. The more the rate on later aged persons is large, the more the numerical value of our index becomes large.

#### 4.4 Sub-divisions of Aged Persons

Sub-divisions of senior citizens in the wide sense for the qualitative understanding of the aged citizen are studied as follow:

60 years old or so are ages of retirement at the age limit. In addition, 65 years old is the start of pen-

sion receiving, and it is the common understanding that more than 65 years old are the definitions of the aged. And, aged persons are classified into 4 sub-divisions as shown in Table.4 at the consideration of three viewpoints, which are the above mentioned facts, the death rate at ages-hierarchy in Table 3 and the result of cluster analysis of factor loadings.

Persons of early sixties are the pre-old age. And 65-74 years old are defined as the initial old age. 75-84 years old are the mid-old age, and more than 85 years old are the late old age. So, senior citizen's strategies are required to cope with each stage of the pre-old age, the initial old age, the mid-old age and the late old age. In addition, the over-sixties are the senior citizens at the wide sense. If the pre-old age gets rid from above senior citizens, the aged of over 65 years old is defined as "the senior citizen at the narrow sense" in this paper.

**5. Study on Senior Age Index of Statistical District in Fukuoka City**

The senior age index defined in the previous chapter is applied to the data of statistical districts in Fukuoka City and meanings of the proposed index are studied. Furthermore, the spatial distributions of senior age indices in the city are studied in this chapter.

**(1) Relationship between the ages-distributions of senior citizens and senior age indices**

The histogram of senior age indices and the table of basic statistics on ages-distribution at districts are shown in Fig.7. Indexes for male are given on the range of 0.0278~0.1635, and indexes at 3/4 of districts are estimated with values of 0.04~0.08 and the average is 0.0644. On the other hand, indexes for female are on the range of 0.0323~0.2844 and the average is 0.0841. At 70% of districts, indexes are values of 0.06~0.1.

In Fukuoka City, there are few districts of the high ratio of senior citizens except for a part of mountain's area. However, baby boomers have just reached 60 years old, and issues of senior citizen will become serious from now. From these facts, districts under the serious situation of distributions on ages of senior citizens are not found yet, except a few districts. Although there is strong correlation between a

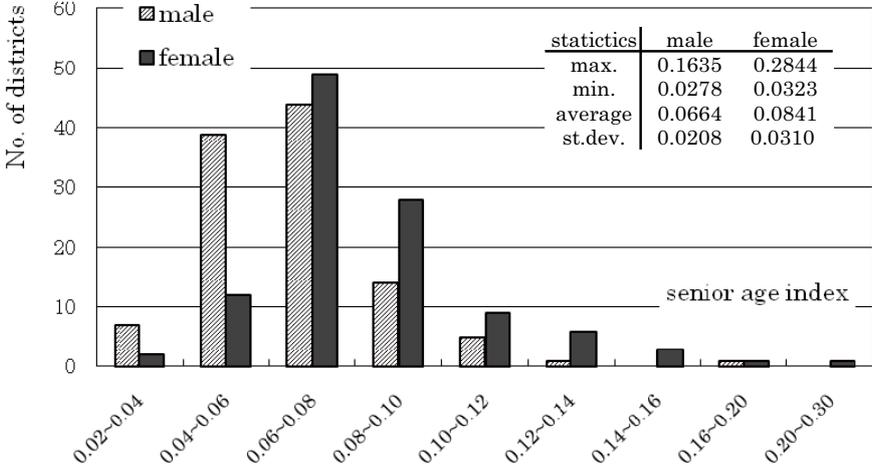


Figure 7 Histogram and basic statistics on senior age indices at districts in Fukuoka City

senior age index and an aged citizen's ratio, the problem is how the distributions on ages is reflected exactly into a senior age index at a serious aged district.

Therefore, to confirm the above-mentioned, several districts in which senior citizen's ratios of female are about 0.2 are selected, and the relationship between the ages-distributions of aged citizens and the senior age index at each district is shown in Fig.8.

Ages-distributions of the over-sixties at eight districts are shown in the figure and it is seen that distributions are different in each district. In the district 118 (Wajiro (west)), the rate of later aged citizens is large and becomes U-shaped. On the other hand, rates of people from late sixties to late seventies make the mountain-shape in the district 316 (Jigyohama). At other six districts, distributions getting lower toward the right mostly resemble each other, but rates of citizens in the later half of advanced ages differ each other.

Although there is the difference among ages-distributions of each district, rates of the aged are almost same as 0.2000-0.2064. In other words, the same numerical values in senior citizen's rates are obtained in spite of the difference of ages-distributions. In addition, the existence of baby-boomers influences the senior citizen's rates of the wide sense (in the case of people of over-sixties and weight coefficients by

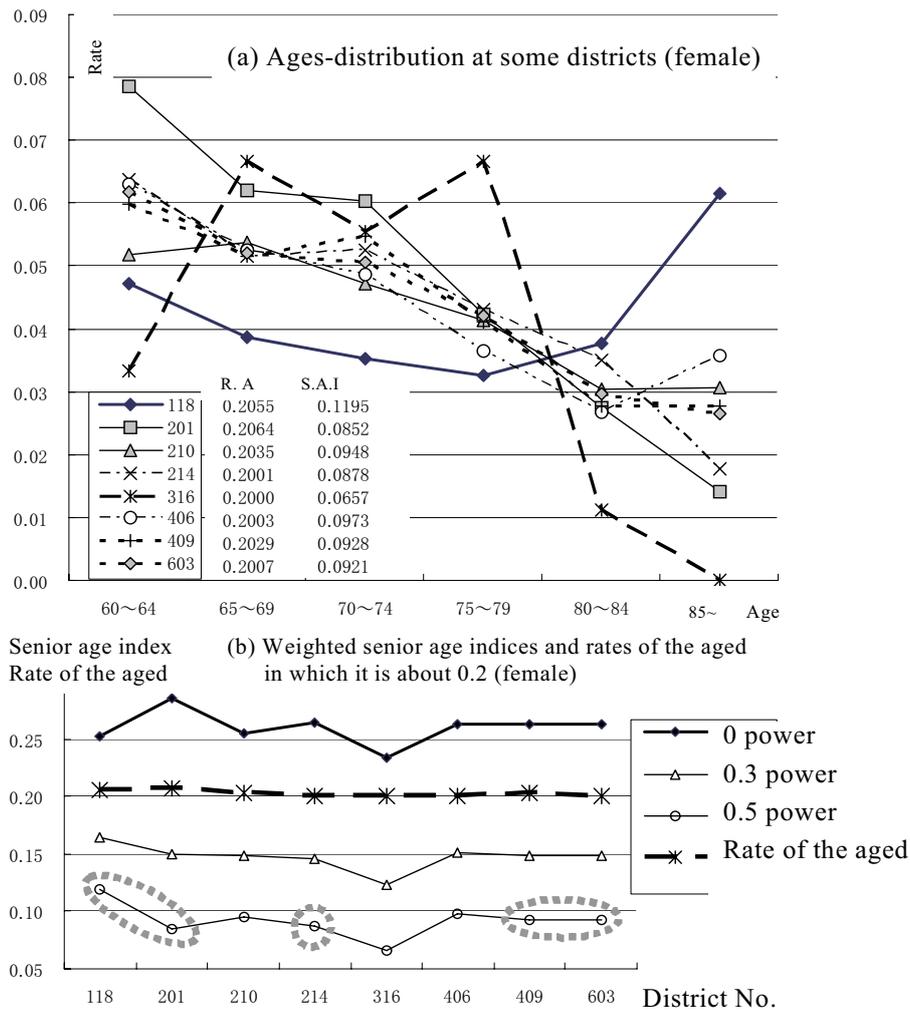


Figure 8 Ages-distributions and senior age indices of districts, in which rates of the aged are about 0.2 (female).

0 power of  $\alpha$ ), and is not always same, which is fluctuated as shown in Fig.8 (b).

The maximum of senior age indices in the case of the weight coefficient given by 0.5 power of  $\alpha$  is 0.1195 at the 118 district, and the minimum one is 0.0657 at the 316 district. At other 6 districts, their indices are 0.0852~0.0973 and different in response to the citizen's rate of the second half of aged life. Namely, the proposed senior age index is evaluated at a different angle from the aged rates in narrow sense or wide sense, because the senior age index is a numerical value which reflects more the situation of ages-distributions being serious under the advance of aged society. Therefore, it is possible to use a senior age index of district for the judgment on the importance of facilities for the aged.

Next, the relationship between senior age indices and ages-distributions of the aged is presented as in Fig.9, if selecting each 2 districts in every case which is classified by three types of small, middle, and big values of senior age indices.

Ages-distributions in the case of male are comparatively similar in shape, and it is seen that the senior age indices are roughly related to rates of the aged, except for the district 514 (Noko). Comparing dis-

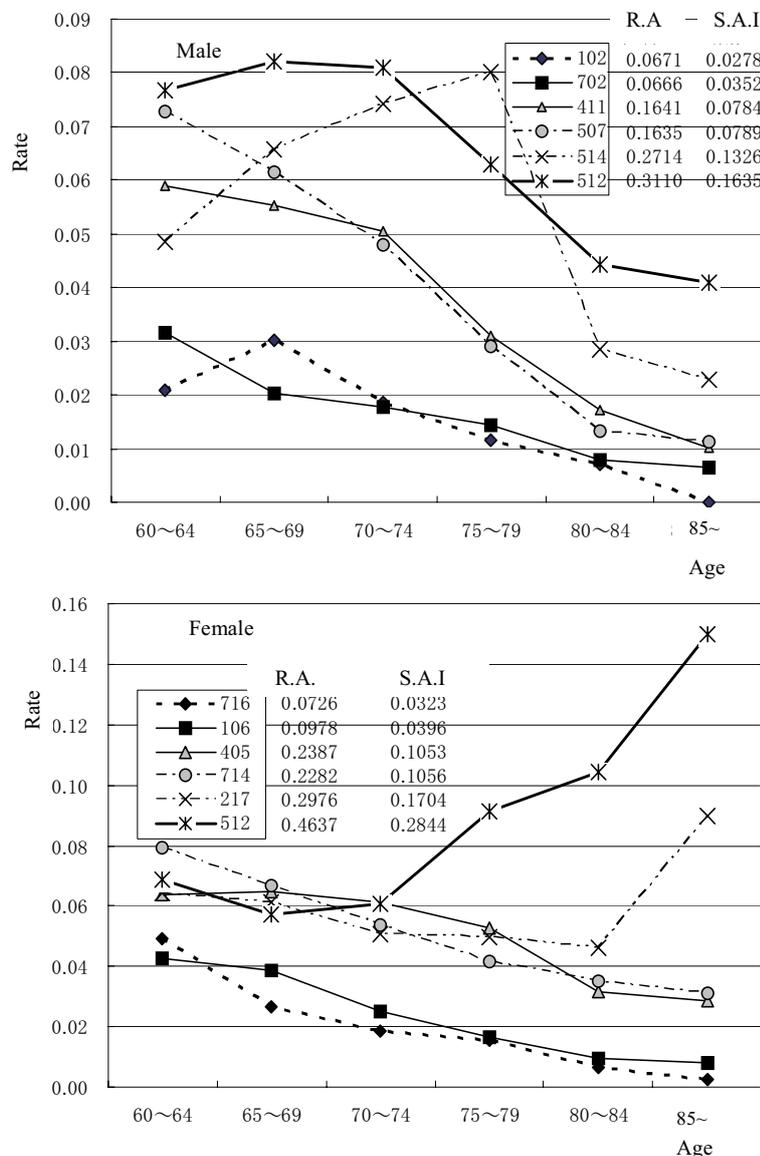


Figure 9 Relation between senior age indices and ages-distributions of the aged

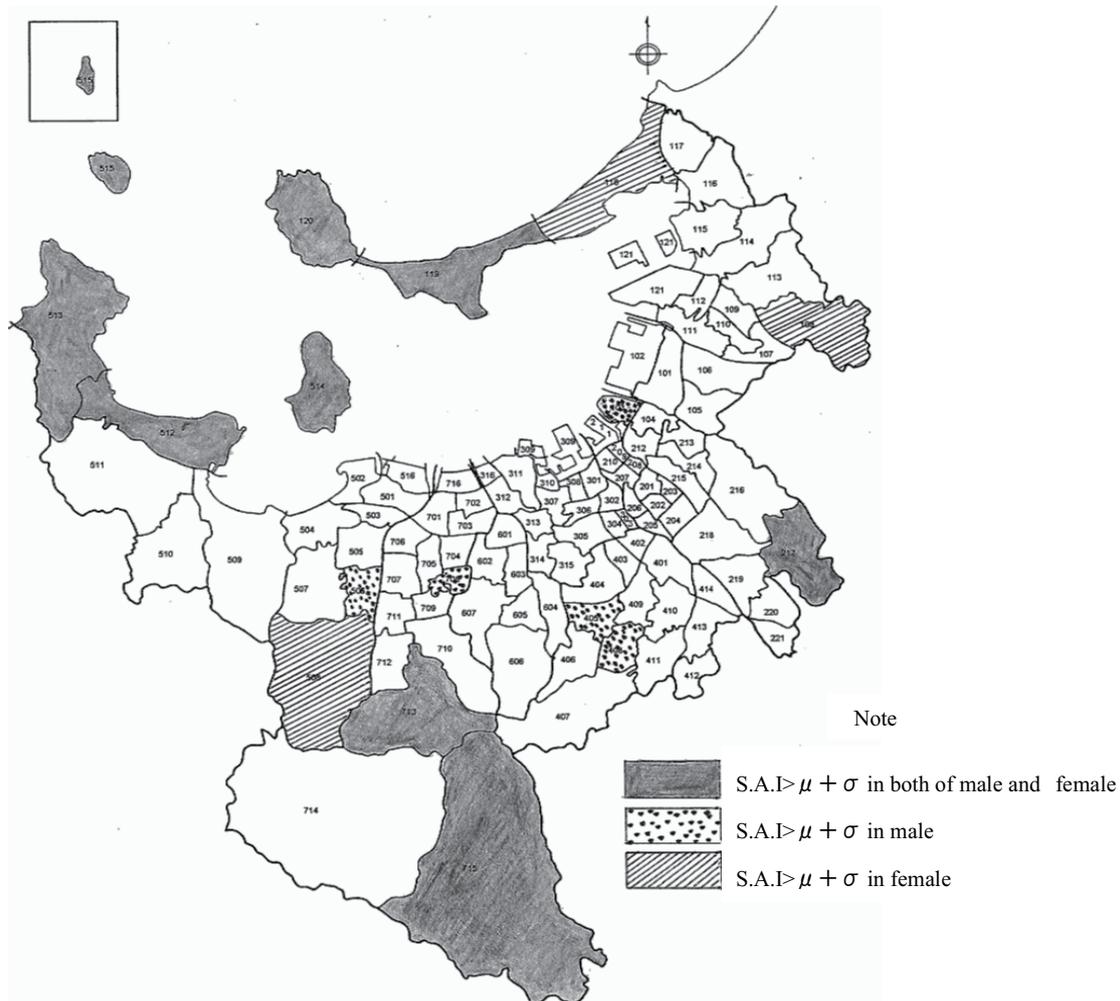


Figure 10 Statistical districts in which senior age indices are over  $\mu + \sigma$  in male, female and both.

districts of 512 (Imazu) and 514, the rate of people in eighties at the former is large, and that of persons in their late seventies is large at the latter. As a result, the difference of senior age indices is 19%, because the senior age index at the 512 district is 0.164 and at the 514 district, 0.133. We can find the obvious difference among both districts.

Meanwhile, comparing districts of 411 (Rouji) and 507 (Ikinishi), senior age indices are almost same, though rates of people in sixties are different each other. In addition, comparing two districts of 102 (Hakozaki) and 702 (Nishijin), it is clear that the score of senior age index depends on rates of the later aged and it does not much depend on the rate of people of sixties.

In the case of female, the senior age indices of districts 512 and 217 (Tukikuma) are big. This is the influence of big rate of persons in the second half of advanced age on the ages-distribution.

For instance, although rates of the aged at districts of 217 and 512 are 1.25 and 1.94 times as large as the one at the district 405 (Nagazumi), the senior age indices at those districts are 1.62 and 2.70 times as large as it. On the other hand, the rate of persons in the first half of advanced age at the district 716 (Mochihama) is larger than the one at the 106 district. In this case, the senior age index at the 716 district stays 1.23 times as large as at the 106 district, though the rate of the aged is 1.35 times as large as it.

As a summary of the above-mentioned, there is not so much remarkable difference of a senior age

Table 5 Characteristics of senior age citizens at districts with high values of S.A.I.

District No.	103	108	118	119	120	217	405	408	506	508	512	513	514	515	708	713	715
<b>Women(person)</b>	16056	9673	2635	1125	8067					2037	2178	1449	417	259		5919	1338
pre(60~64)	0.0591	0.0471	0.0710	<b>0.0764</b>	0.0640					0.0619	0.0689	0.0531	0.0767	0.0579		0.0728	<b>0.0770</b>
initial(65~74)	0.0994	0.0738	<b>0.1956</b>	<b>0.1636</b>	0.1118					0.1168	0.1180	0.1532	0.1751	0.1815		0.1027	<b>0.1390</b>
mid(75~84)	0.0760	0.0702	0.0983	<b>0.1262</b>	0.0958					0.0741	<b>0.1956</b>	<b>0.1394</b>	<b>0.1199</b>	<b>0.1274</b>		0.0762	<b>0.1173</b>
late(85~)	<b>0.0593</b>	<b>0.0616</b>	0.0395	0.0427	<b>0.0900</b>					<b>0.0545</b>	<b>0.1501</b>	<b>0.0366</b>	<b>0.0480</b>	<b>0.0252</b>		<b>0.0637</b>	0.0321
the aged (65~)	0.2287	0.2055	0.2732	<b>0.3324</b>	0.2976					0.2455	<b>0.4687</b>	<b>0.3292</b>	<b>0.3429</b>	<b>0.3320</b>		0.2326	0.2825
senior index>0.1151	0.1201	0.1195	0.1271	<b>0.1498</b>	<b>0.1704</b>					0.1258	<b>0.2844</b>	<b>0.1457</b>	<b>0.1550</b>	0.1333		0.1228	0.1282
order		11	12	8	<b>3</b>	<b>6</b>				9	1	5	<b>2</b>	<b>4</b>		10	7
senior index		11	12	8	<b>4</b>	<b>2</b>				9	1	5	<b>3</b>	<b>6</b>		10	7
<b>Men(person)</b>	56		2391	963	6983	8669	6852	3892		1872	1287	350	287	5996	5329	1239	
pre(60~64)	0.0357		0.0648	<b>0.0768</b>	0.0639	0.0618	0.0701	<b>0.0784</b>		<b>0.0767</b>	0.0575	0.0486	0.0592	0.0660	<b>0.0784</b>	<b>0.0807</b>	
initial(65~74)	<b>0.1260</b>		0.1163	<b>0.1412</b>	0.1131	0.1090	0.1108	0.1197		<b>0.1629</b>	<b>0.1321</b>	<b>0.1400</b>	0.1185	0.1047	0.1071	<b>0.1236</b>	
mid(75~84)	0.0536		0.0606	0.0924	0.0554	0.0659	0.0575	0.0509		<b>0.1070</b>	0.0940	<b>0.1086</b>	0.0871	0.0595	0.0533	0.0678	
late(85~)	<b>0.0179</b>		<b>0.0222</b>	0.0104	<b>0.0186</b>	0.0143	0.0150	0.0118		<b>0.0410</b>	0.0140	<b>0.0228</b>	0.0139	0.0125	0.0480	<b>0.0186</b>	
the aged (65~)	0.1964		0.1991	<b>0.2440</b>	0.1870	0.1892	0.1833	0.1824		<b>0.3110</b>	<b>0.2401</b>	<b>0.2714</b>	<b>0.2195</b>	0.1768	0.1753	<b>0.2098</b>	
senior index>0.0872	0.0923		0.1009	<b>0.1164</b>	0.0929	0.0939	0.0921	0.0878		<b>0.1635</b>	<b>0.1167</b>	<b>0.1326</b>	<b>0.1108</b>	0.0879	0.0889	0.1063	
order		<b>8</b>		7	<b>3</b>	<b>10</b>	<b>9</b>	11	<b>12</b>		1	<b>4</b>	2	5	13	<b>14</b>	6
senior index		<b>10</b>		7	<b>4</b>	<b>9</b>	<b>8</b>	11	<b>14</b>		1	<b>3</b>	2	5	13	<b>12</b>	6

Note) Numerical value in the netted block means to be big in the line.

index against a rate of the aged, if the difference of ages-distributions does not become large beyond the present conditions at districts of Fukuoka City. However, the senior age index will become more appropriate evaluation of aged situations in comparison with conventional rates of the aged, at the district in which the aging gets worse and the serious ages-distributions in aged stages is found.

## (2) Spatial distribution of senior age indices

The spatial distributions of senior age indices are shown in Fig.10. In the case of male, 14 districts, in which senior age indices are over 0.0872 in total of average and standard deviation, are found as a high aged district. These districts have serious issues of the aged society on male, and most of them are located on islands and peninsulas of three wards of Higashi, Nishi and Sawara.

On a similar way, 12 districts are found as serious districts on female, at which senior age indexes are over 0.1151. They match ones in the case of male except for 3 districts.

In short, the serious aged districts evaluated by the senior age indices at the criterion of  $\mu + \sigma$  are 9 in both view-points of male and female. And, only from the viewpoint of male, 5 districts are found, and only from female, 3 districts are pointed out as a serious aged district. So, the total of serious aged districts in Fukuoka City is 17 at present.

Table 5 shows the senior age index and the rate of the aged at above-mentioned 17 districts. According to the case of female, the rate of the aged is 20% or more, at each one of 12 districts. In particular, the rate of the aged attains to 46% at the district 512 (Imazu), in which the senior age index is the maximum value in the city. In addition, the rate of the aged at the later stage of over 85 years old is 15%, and at the mid-stage of the aged is 20%. From these results, the maximum senior age index is 0.284. Besides, this result is affected that some sanatoriums, welfare facilities, and care-centers for the aged are located to the district 512.

Although the rate of the aged at every district of 212, 417, 120, 513 and 515 is 30% or more, the order of senior age indices does not accord with the one in the rates of the aged. Especially, the district 217 (Tukikuma) reaches 9% on the later aged and its senior age index is 2nd in every district. On the other hand, the senior age index is evaluated as 6<sup>th</sup>, though the rate of the aged in the district 515 (Gennkai·Oro) is 33.2% and 4th.

Viewing districts selected by high senior age indices of male, U-shaped ages-distributions can hardly find out, while it is easily seen in the case of female. And, rates of the aged are at the range of 17.5~31.1%, which are small in comparison with the case of female.

Reflecting the death rate of each step of ages, a senior age index is obtained in response to the rate of the aged. Although order in senior age indices is changeable in from 3rd to 14th, the remarkable difference in each district can not be found.

From the senior age indices, it is seen that the district 512 (Imazu) is the highest level of aged conditions in male, as well as in female. The second high aged district is the district 514 (Noko). The district 513 (Kitazaki) follows them. These results are reasonable and understandable.

## 6. Conclusion

We discussed some issues of aged conditions at districts in the city. Namely, a rate of the aged is presently well used as an index to evaluate the situations of aged society for the district planning. This is no problem when the uniform district in the conditions of population or the wide area in the city is a subject and when baby boomers don't reach to the aged. However, in the remarkable advance of aged society and the decrease of population, the difference of aged conditions among districts becomes outstanding. Namely, when the area is divided in details and when baby boomers reach into the aged generation, the difference among ages-distributions of districts is expanded. Therefore, conditions of aged society at a district must be understood and interpreted in detail, and the appropriate evaluation of the situations of aged society is needed quantitatively and qualitatively.

The conventional indices on the aged are not effective to understand situations of the aged society, as discussed in Chapter 2. Therefore, we proposed a new senior age index in this paper. The main results are as follows:

- (1) On the basis of the spatial spread of ages-distributions, groups of ages were obtained as shown in Table 2. In the classification of ages, a senior group of citizens is defined by persons of over 55 years old, and it is divided by two sub-groups, the middle age and early old age and the later aged. It is natural that the senior age group is the subject of aged society.

Persons over 60 years old are defined as the aged in the wide sense and they are classified in detail by four sub-divisions; the pre-old age (60~65 years old), the initial old age (65~74 years old), the mid-old age (75~84 years old), and the late old age (over 85 years old).

- (2) The weight coefficient for the senior generation was unfolded on the basis of the death rate of sex distinctions as shown in Table3. And senior age indices of male and female were proposed by the use of the ages-distributions and weight coefficients.

Proposed index, S.A.I., reflects more situations of ages-distributions than conventional indexes, though not perfect. The proposed indexes do not have much large difference from the conventional indexes of the rate of the aged at the present situation, too. Therefore, we are not confused in practice by the use of our proposed index.

- (3) Applying our proposed senior age indices into the data of statistical districts in Fukuoka City, meanings of indices were studied. As a result, it is clear that the senior age indices can reflect the ages-distributions certainly.
- (4) Districts in which the headway of the aged society was serious were found at each case of male and female. They have a few issues of the aged society and indices are useful to find the order of them in seriousness. In short, our proposed senior age indices are useful to select serious aged districts and to find issues of the aged society. They are effective for the judgment of timing of strategies, too.

### **Notes**

- 1) Usually, dividing over 65 years old, the 65~74 years old are called the early old age. And, the over 75 years old is the later old age. However, they are called the first half of advanced age and the second half of advanced age, in this paper. They are also divided under the definitions of pre-old age, initial old age, mid-old age and late old age on the over 60 years old, as discussed in Chapter 4.
- 2) The concept of using 55 years old as criteria of division can be found at the definition of community of quasi-limitation on sustainability.
- 3) In this paper, although the senior age is defined by persons over 60 years old, persons over 65 years old are used in a rate of the aged.

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