Chapter

Causal Structure for the Healthy Longevity Based on the Socioeconomic Status, Healthy Diet and Lifestyle, and Three Health Dimensions, in Japan

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Abstract

This chapter aims to clarify the causal relationship between healthy life expectancy, socioeconomic status, dietary habits, lifestyle habits, and three health factors, as indicated by the WHO. In addition, the annual income threshold for couples to maintain a certain number of survival days will be clarified. Of the 16,462 elderly people aged 65 and over, 13,195 were included in the self-assessment questionnaire survey conducted in September 2001. A follow-up survey was completed in 2004, and 8,162 survivors were followed until August 2007. From a cross-lagged effects variation model, causal relationships were analyzed using longitudinal survival days between 2004 and 2007. After estimating a best-fit model, we discovered that current dietary and lifestyle habits did not determine healthy longevity. However, the survival days were more directly affected by three health-related dimensions three years earlier based on educational attainment and previous annual income indirectly. This study suggests that it might be of great importance for elderly individuals to emphasize income maintenance rather than focusing on diet and lifestyle improvements. In addition to showing a statistically significant relationship between income and survival days, we clarified that there is a threshold for income to maintain a certain number of survival days. For the elderly, it was 4.5 million yen(3,462 US $) for both sexes as a marital yearly income.

Keywords: survival rate, life style, socioeconomic status, income threshold, aged, Japan

1. Introduction

The increase in life expectancy of Japanese people is well-known worldwide [1]. Many studies have investigated the factors that determine the life expectancy of Japanese people [2]. In 2019, men had a life expectancy of 80.41, while healthy life expectancy was 72.68, a difference of 8.73 years. The average life expectancy of

women was 86.44 years, and the healthy life expectancy was 75.38 years, with a range of 12.06 years (Ministry of Health, Labor and Welfare 2022) [3].

In recent years, attention has been paid to the determinants regarding the average life expectancy and healthy life expectancy of older Japanese people. However, most of these studies used cross-sectional and ecological data [4, 5]. Therefore, it has been complicated and unclear to comprehensively analyze the causal structure, and various factors, including socioeconomic factors, for the healthy life expectancy of older people over their lifetime.

Canada's Lalonde Report [6] and USA Healthy People Strategy [7] addressed the importance of lifestyle habits related to diet and health, against the background that the contribution to medical health has not been significant to date. Many studies have explained the health effects of certain lifestyles [8, 9].

A favorable lifestyle reduces early mortality in people with specific diseases and lifestyles [10, 11]. In a large cohort of Japanese people, Tamakoshi et al. [12] showed that lifestyle significantly impacted life expectancy. However, lifestyle is not the only factor associated with individual survival days. Socioeconomic factors and the three health factors indicated by the WHO, physical and mental, and social factors, should also be considered.

Several reports highlight the impact of socioeconomic status on life expectancy. Socioeconomic differences were significantly associated with life expectancy [13, 14] and survival in older people [15]. Sugiura et al. [16] reported socioeconomic status as a background to the rapid increase in life expectancy of Japanese people after World War II. Considering the impact of Japan's socioeconomic position on health, Kagamori et al. [17] concluded that the difference in mortality was not trivial. However, research results have not been presented on the direct and indirect causal structure of socioeconomic conditions and life expectancy.

The World Health Organization (WHO) defines health as follows: Health is a better physical, mental, and social well-being, not merely the absence of illness or infirmity [18]. Based on this definition, studies have reported that three health-related aspects of physical, mental, and social well-being are related to life expectancy [19–24], Specifically, physical activity and function [19, 20], cognitive vulnerability and self-rated health [21–23], and social connections [24] are statistically significantly related to survival in older adults. However, except for a few studies [25, 26], no studies have clarified causal structures associated with three health aspects, survival and socioeconomic status.

The fundamental hypothesis model is shown in **Figure 1**. This model indicates that healthy survival days and not-bedridden status would be determined by healthy dietary and lifestyle habits and three health-related dimensions based on socioeconomic status as a structural and causal relationship.

Therefore, the objectives of this chapter were to clarify the causal relationships among healthy dietary and lifestyle habits, socioeconomic status, and three health-related dimensions related to healthy longevity among Japanese elderly suburban dwellers. Covariance structure analysis clarified how large and causally each latent variable shown in **Figure 1** has a causal relationship with healthy longevity, a latent dependent variable.

It has become clear that it is essential to live satisfactorily in terms of health and the amount of annual income influenced by individual educational background.

What is the income threshold required to maintain survival? The relationship between per capita national product and average life expectancy for each country and its income threshold for longevity are reported. Here, a connection is shown in which

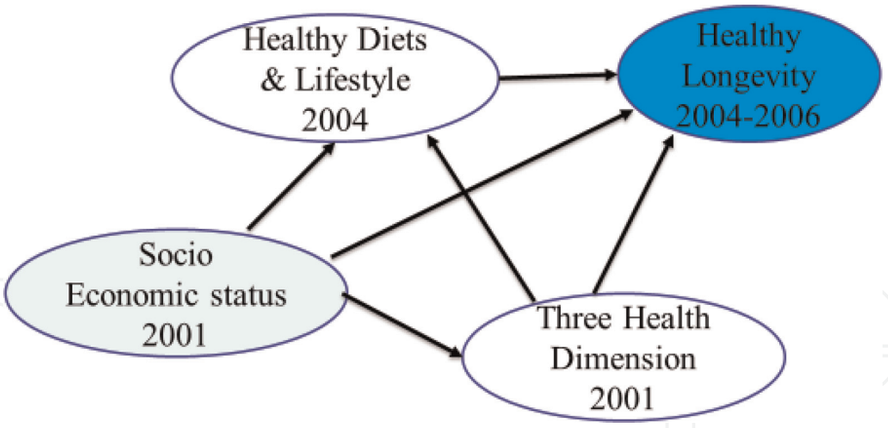

Figure 1.
Causal structural relationships to the healthy longevity as a hypothesis model.

the higher the per capita national product of a country, the longer the average life expectancy. When it exceeded more than 4.500 US $, almost no extension of life expectancy was seen, and it occupied a practically constant level [27].

Costa Rica's average life expectancy, which is less than 10% of the per capita national product of the United States of America, was almost at the same level as that of the United States. In this way, along with the relationship between the value of national production and average life expectancy, the national product threshold has been clarified to ensure a certain average life expectancy [27].

However, no studies have been reported that clarify the annual income on an individual basis and the income threshold for maintaining a certain number of survival days, except in the six-year follow-up studies in urban suburbs and areas reported by the authors [25, 26].

Therefore, in this study, we will discuss the relationship between marital annual income and survival days in older people living at home in urban suburbs, citing a part of a previous study that also aimed to clarify the family yearly income threshold to ensure a certain number of survival days.

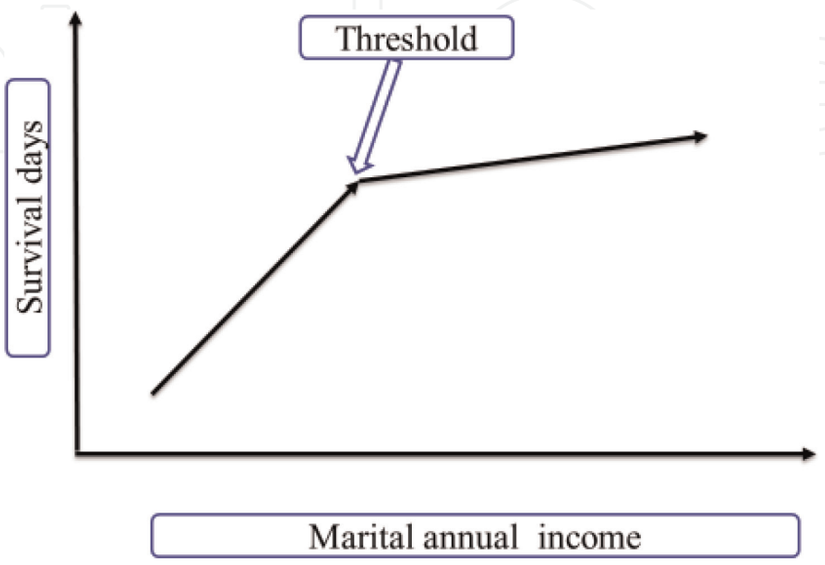

Figure 2.
Relationship between marital annual income and survival days and the threshold as a hypothesis model.

In the case of achieving the research purpose, the support method by health education specialists who support health is expected to be linked to new health support based on the process of taking into account the significance of the underlying income and enabling people to live positively against the background of a certain income, and as a result, specific desirable lifestyle habit might be maintained.

In addition to the significance of income, which is particularly important as a socioeconomic factor, it is expected that scientific income criteria regarding how much income can be used to maintain a certain level of survival can be presented.

We hypothesized that there is a significant relationship between annual marital income and survival days and that there is a threshold in this association. The hypothetical model is shown in **Figure 2**.

However, no studies have been reported that clarify the annual income on an individual basis and the income threshold for maintaining a certain number of survival days, except in the six-year follow-up studies in urban suburbs and areas reported by the authors [25].

2. Methods

2.1 Participants and study setting

Details of the survey method were shown in previous studies [25, 26]. Here, only the main survey methods are shown.

In September 2001, we surveyed all elderly people (65 years and older) living in their homes in a municipality near Tokyo. Of the 16,462 participants, 13,195 (80.2% of respondents) gave informed consent to participate in the study and returned a self-administered questionnaire by mail. A second questionnaire was mailed to respondents in September 2004. As a result, 8,558 people responded. There were 505 relocations, 914 deaths, and 3218 no responses. The survey respondents were all elderly people living in their homes over 65. We tracked all participants until August 31, 2007, and obtained personal data using IDs for 8,162 deaths and survivals through the City Hall Resident Registry.

The municipalities studied are urban suburbs that partially developed as suburban cities from the 1970s to the 1990s, including the period of high economic growth, to accommodate the increase in workers and their families in the metropolitan area. The total population of the cities surveyed was about 140,000 as of 2001, and 9.6% of the population was over 65 years old, almost half of the national average (17.3%) in 2000.

2.2 Observed measurement variables

Many observed variables and latent variables were used to clarify the causal structure using different factors in the survey year. The latent variables were determined by exploratory factor analysis, as shown in section 3.2. The question methods, options, and survey methods of the observed variables used in the survey are shown in the literature of previous studies [25, 26].

Socioeconomic status in 2001 was assessed via educational attainment and annual income. Levels of educational attainment were categorized into four groups; graduation from junior high school, graduation from high school, those achieving a higher academic level than junior college, and those who did not want to respond. Annual income levels fell into four categories; less than one million Japanese yen(equivalent to less than US $7,400), less than three million yen, less than five million yen, and more than seven million yen in 2001.

Healthy dietary and lifestyle habits in 2004 were assessed by the dietary health score and the healthy lifestyle score, respectively [25, 26]. The three health-related dimensions examined in our study consisted of physical, mental, and social health components [25, 26].

2.3 Analyses

Detailed analysis of analytical methods, methods, and fitness was described in previous studies [25, 26]. Respondents aged 80 and older and those with more than a moderate degree of long-term care in the 2001 survey were excluded from the analyses due to an increased and indispensable deviation in their measurement variables. All data obtained were evaluated by degree to examine differences between males and females using Kendall's tau rank correlation coefficient. Exploratory factor analysis was used to fit all observed variables to corresponding latent variables.

The most important research method of this research is structural equation modeling (SEM). The analysis software used AMOS ver.28 for Windows (IBM). The analysis data used longitudinal follow-up data over seven years. Based on data from the 2001 survey, the 2004 survey investigated the three factors of a healthy diet, lifestyle, and health, as well as the degree of care required. We also clarified the number of days lived from 2004 to 2007. For causal structures, we used all combinations of four latent variables to find the model with the best fit.

Estimating the best-fitting model was carried out by the maximum likelihood method of SEM. The optimization algorithm was implemented with no-missing-data parameters. The direct, indirect, and total standardized effects of different latent variables on the endogenous health and life condition variable were measured by gender. The models employed indices criteria for assessing model fitness. Goodness-of-fit was approved by the chi-square goodness-of-fit test ($\chi 2$, degree of freedom, P value), NFI (Normed fit index), 1FI (Incremental fit index), RMSEA (Root mean square error of approximation) for the structural relationship model. Results were considered statistically significant if the p-value was less than 0.05.

A mutual agreement was signed between the city and local governments and Tokyo Metropolitan University regarding protecting individual privacy during the entire survey process. In this agreement, the confidentiality obligation was confirmed, and personal information handled by the university was limited to IDs. In September 2004 and September 2007, consent was obtained from the Tokyo Metropolitan University Graduate School Ethics Committee for a follow-up survey on manufacturing.

3. Results

3.1 Measurement variables

Of 8,162 eligible participants, included in the analysis were 7,066 individuals (male, 3,409; female, 3,657) aged lower than 80 years and with either no long-term care or the mildest degree of long-term care utilized in September 2001.

Previous studies detailed the critical results of the observed variables [25, 26]. The mean survival days between September 1, 2004, and August 31, 2007, were fewer in males than in females. 2.3 percent of male and 3.0 percent of female participants had degenerated to either the middle or severest degrees of long-term care in 2004 compared to 2001.

Compared with males, females displayed significantly lower educational attendance and annual income, deemed a gender disparity (Kendall's tau rank correlation coefficients were − 0.376, $p < 0.001$ and − 0.236, $p < 0.001$, respectively).

Regarding the dietary health score, most participants were distributed below seven points, while in the healthy lifestyle category, most participants scored above two points. The results indicated that many people enjoyed healthy lifestyles, although many later older people had an unhealthy diet.

3.2 Results of exploratory factor analysis

We use the latent variables obtained through exploratory factor analysis for a hypothesized model. Factor 1 indicated high loadings, particularly for self-rated health variables, and displayed a high confidence coefficient. Self-rated health and daily life satisfaction, except for the number of comorbid conditions, were termed "mental health factors" related to the three health-related dimensions. The number of comorbid conditions was a negative factor by itself. It is considered considerably associated with the physical condition since the comorbidities tended to include more common diseases such as hypertension, diabetes, and cardiovascular disease, apart from mental disorders among the target population.

Along with the number of comorbid conditions, BADL and IADL, excluding the frequency of going outside, informed the labeling of factor 2 as "physical health." We emphasized the social aspect of the frequency of going outside over the physical part. Therefore, factor 3 was identified as "social health" and included communication with the neighborhood, hobby-related activities, and frequency of going outside.

Factor 4 was termed "Healthy Dietary and Lifestyle habit" and involved healthy dietary and lifestyle habit variables. Finally, factor 5 was "Socioeconomic Status" and indicated educational attainment and annual income. The cumulative contribution proportion of the above five factors was 40.5 percent.

3.3 Causal relationship "Healthy Dietary and Lifestyle" and "healthy longevity" model

Figure 3 shows the causal relationship between "Healthy Dietary and Lifestyle", and "Healthy Longevity" for both sexes. The models fit the data well with the following fit indices: NFI = 0.995, IFI = 0.997, and RMSEA = 0.008. R-squared values also fit well: 19 percent for males and 13 percent for females.

Based on this model, "Healthy and Longevity" were significantly affected by "Healthy Dietary and Lifestyles" for both sexes significantly. And we observed a relatively significant direct effect of the "Healthy Diet and Lifestyles" on "Healthy Longevity", with a 0.48 standardized path coefficient for males and 0.36 for females. In this model, we are not concerned about socioeconomic status and three health dimensions as confounding factors.

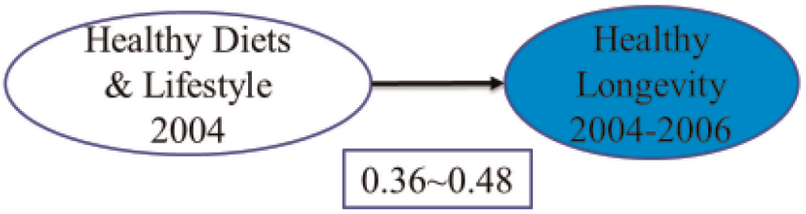

Figure 3.
Causal relationship between "Healthy Diet and Lifestyle" and "healthy longevity" model for men and female.

If only the causal structure of the two latent variables shown in **Figure 3** is analyzed, the more desirable the latent variables of "Healthy diet and Lifestyle." The more desirable the similarly dependent latent variables, the degree of care required. Then, it will be interpreted that "Healthy longevity," a long survival day with a low degree of care needed, becomes statistically significant.

3.4 Structure relationships with "socioeconomic status," "Healthy Diet and Lifestyle," "Three Health-related Dimensions," and "healthy longevity"

We adopted and analyzed the statistically best-fitting models by sex using SEM. **Figure 4** shows the models for male and female participants presenting causal relationships among the latent variables. The models fit the data well with the following fit indices: NFI = 0.861, IFI = 0.872, and RMSEA = 0.025. R-squared values also work well: 81 percent for males and 71 percent for females.

The models depict the pathways from "Socioeconomic Status" in 2001 via "Three Health-related Dimensions" in 2001 and "Healthy Diet and Lifestyle" in 2004, leading to both sexes' "Healthy Longevity" from 2004 to 2006.

In addition, the paths from "Three Health-related Dimensions" approached the "Healthy Diet and Lifestyle." We observed a relatively significant direct effect of the "Three Health-related Dimensions" on "Healthy Longevity," with a 0.90 standardized path coefficient (SPC) for males and 0.84 SPC for females. On the other hand, the direct effect of "Healthy diet and Lifestyle" on "Healthy Longevity" was nearly zero (0.00 ~ 0.02).

The total effect of "Three Health-related Dimensions" and "Healthy Diet and Lifestyle" supported by "Socioeconomic Status" on "Healthy Longevity" indicated considerably large SPCs for males (0.444) and females (0.580) as a total effect.

3.5 Marital annual income threshold to ensure a certain number of survival days

We used a one-way analysis of variance to analyze the threshold marital annual income to secure a certain number of survival days. A significant difference was tested

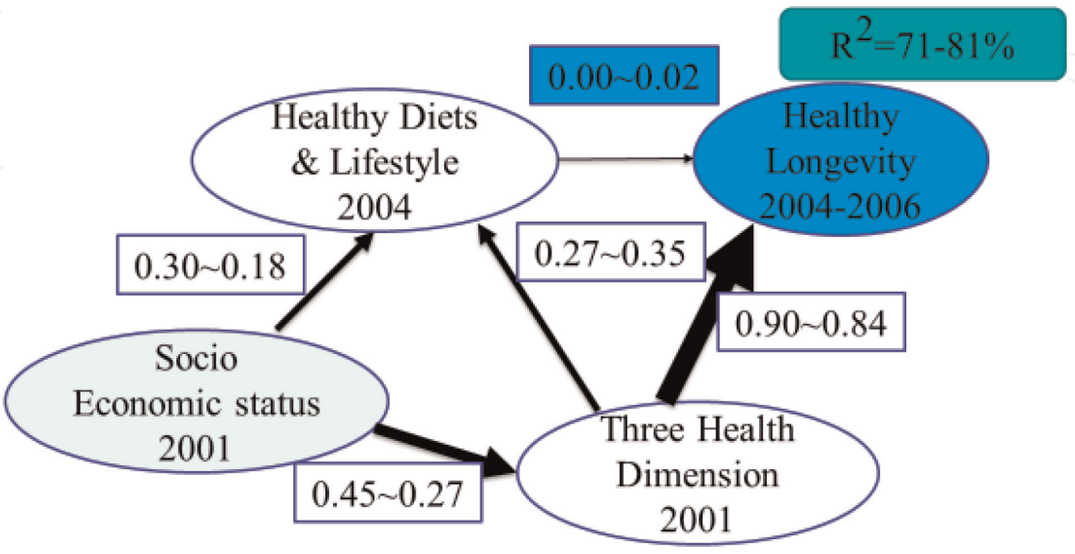

Figure 4.
Causal relationship between "socioeconomic status," "Three Health Dimensions," "Healthy Diet and Lifestyle," and "healthy longevity" model for men and female.

for all combinations of annual income classes by Tamhane's test, which does not assume equal variances [25].

In addition to showing a statistically significant relationship between income and survival days, we clarified that there is a threshold for income to maintain a certain number of survival days.

In the group of 4 million yen or more but less than 5 million yen, there was no significant difference compared to the survival days of the group with more than that. Therefore, 4.5 million yen, the group's median value of 4 million yen to less than 5 million yen, was regarded as the income threshold for maintaining a certain number of survival days (**Table 1**).

The X-axis shown in **Figure 5** is the average income, and the Y-axis indicates the number of days an individual lives. The analysis of older people in suburban cities shows that an income threshold can be seen to ensure a certain number of survival

Sex	(I) Marital annual income	(J) Marital annual income	(I-J)	Standard error	p value	95% Confidential interval	
Men	less than 1 million	less than 2 million	−74.9	47.0	0.917	−218.3	68.4
		less than 3 million	−128.3	44.0	0.078	−262.9	6.3
		less than 4 million	−156.4	43.5	**0.008**	−289.5	−23.3
		less than 5 million	−191.2	44.7	**0.001**	−327.9	−54.5
		more than 7 million	−228.9	44.7	**0.000**	−365.5	−92.3
		more than 7 million	−245.2	44.0	**0.000**	−379.8	−110.6
	less than 2 million	less than 3 million	−53.4	26.6	0.620	−134.1	27.4
		less than 4 million	−81.5	25.7	0.033	−159.7	−3.3
		less than 5 million	−116.3	27.8	**0.001**	−200.6	−32.0
		less than 7 million	−154.0	27.7	**0.000**	−238.2	−69.7
		more than 7 million	−170.3	26.6	**0.000**	−251.1	−89.5
	less than 3 million	less than 4 million	−28.1	19.8	0.972	−88.3	32.0
		less than 5 million	−62.9	22.4	0.100	−130.0	5.0
		less than 7 million	−100.6	22.3	0.000	−168.4	−32.7
		more than 7million	−116.9	20.9	0.000	−180.4	−53.4
	less than 4 million	less than 5 million	−34.8	21.4	0.899	−99.6	30.0
		less than 7 million	−72.5	21.3	0.015	−137.2	−7.7
		more than 7 million	−88.8	19.8	**0.000**	−149.0	−28.6
	less than 5 million	less than 7 million	−37.7	23.7	0.918	−109.7	34.3
		more than 7 million	−54.0	22.4	0.287	−122.0	14.0
	less than 7 million	more than 7 million	−16.3	22.3	1.000	−84.2	51.6
Female	less than 1 million	less than 2 million	−48.1	20.8	0.358	−111.2	15.0
		less than 3 million	−103.5	20.0	**0.000**	−164.3	−42.7
		less than 4 million	−131.8	19.7	**0.000**	−191.6	−72.0
		less than 5 million	−180.7	18.9	**0.000**	−238.1	−123.3

Sex	(I) Marital annual income	(J) Marital annual income	(I-J)	Standard error	p value	95% Confidential interval	
		more than 7 million	−155.0	22.4	**0.000**	−222.9	−87.0
		more than 7 million	−140.9	24.3	**0.000**	−2 l4.6	−67.1
	less than 2 million	less than 3 million	−55.4	16.8	0.021	−106.5	−4.4
		less than 4 million	−83.7	16.4	**0.000**	−133.6	−33.8
		less than 5 million	−132.6	15.5	**0.000**	−179.6	−85.6
		less than 7 million	−106.9	19.6	**0.000**	−166.3	−47.4
		more than 7 million	−92.8	21.7	**0.000**	−158.8	−26.8
	less than 3 million	less than 4 million	−28.3	15.4	0.769	−75.1	18.6
		less than 5 million	−77.2	14.1	**0.000**	−120.9	−33.4
		less than 7 million	−51.5	18.7	0.121	−108.4	5.5
		more than 7 million	−37.3	20.9	0.806	−101.1	26.4
	less than 4 million	less than 5 million	−48.9	14.0	**0.010**	−91.3	−6.5
		less than 7 million	−23.2	18.4	0.992	−79.1	32.7
		more than 7 million	−9.1	20.6	1.000	−71.9	53.8
	less than 5 million	less than 7 million	25.7	17.5	0.960	−27.6	79.1
		more than 7 million	39.8	19.9	0.625	−20.7	100.4
	less than 7 million	more than 7 million	14.1	23.2	1.000	−56.5	84.7

Table 1.
One-way ANOVA of survival days by marital annual income.

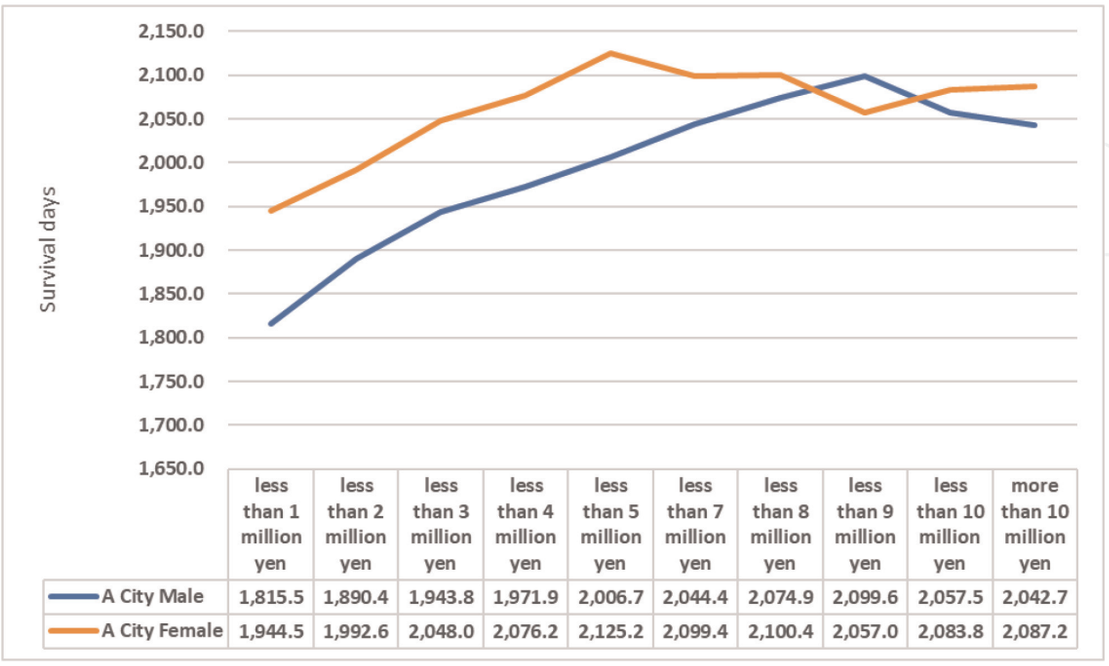

Figure 5.
Annual income threshold for survival days among suburban elderly people for both sexes.

days. These results suggest that older adults living in the suburbs need a certain amount of income to provide a certain number of survival days.

4. Discussion

4.1 Socioeconomic status, dietary and lifestyle habits, three health-related dimensions, and healthy survival days

Until now, a vast amount of health education has been targeted at elderly populations to foster diet and healthy behavioral change attempts. The underlying evidence supported these aims demonstrating that a healthy diet and lifestyle habits improve individual healthy longevity [6–12].

In contrast, our study revealed that current dietary and lifestyle habits did not determine healthy longevity among the suburban Japanese elderly but by the three health-related dimensions observed three years prior and indirectly by their educational attainment and previous annual income.

This original scientific evidence suggests that it might be of great importance for older people to particularly emphasize the maintenance of mental well-being, physical activity, and social communication/participation based on income rather than urging an improvement of their diet or other health-related behaviors.

It should be noted that this unique scientific evidence suggests the need to maintain mental health, physical activity, and social health for older adults to develop desirable diets and lifestyles. At the same time, they suggested that socioeconomic foundations are essential for the three sensual three health dimension.

It might be incorrect to understand that healthy longevity has become due to advantageous lifestyles. Based on our original causal structure analyses, it should be noted that older people with secured income that allows them to have favorable lifestyle habits may have healthy longevity. In this case, attention should also be paid to the income threshold, which requires a certain amount of income to be secured to maintain certain survival days. These findings should be considered concerning the following three points of argument.

First, most theories calling for a healthy diet and lifestyle changes were derived from previous investigations targeting adults over a wide range of ages [28, 29]. Many studies that identified significant associations between healthy lifestyles and health outcomes incorporated people in early, middle, and later adulthood [30, 31].

As a result, much evidence-based health education has also been assumed to be fully applicable to older people. Thus, we should distinguish between healthy aging led by healthy life habits during younger life periods influenced by their parents.

Second, several reports have addressed a significant association between healthy habits and health outcomes among elderly populations [32–35]. These studies focused on the relationship between healthy habits and health outcomes adjusted only for individual essential demographic variables without any attention to the confounding factors.

In comparison, our study analyzed associations between healthy habits and outcomes embedded in a model with a broader spectrum involving socioeconomic and health-related dimensional compartments resulting in control over as many potential confounds as possible for the first time until now [25, 26, 36].

Reproducibility by covariance structure analysis is expected by utilizing the results of three surveys of the same person every three years and data that clarify the survival and degree of care required after three years.

Our findings suggest, therefore, that the described associations between healthy habits and elderly healthy survival (showed **Figure 3**) might be confounded with socioeconomic status and health-related dimensional factors.

Third, although chronological analysis can reveal causal relationships among different latent variables, up until now, there have been few studies using this analysis in the gerontology research area. The current studies were the first trial to investigate causal associations by the SEM method using longitudinal data following the same subjects across six years, including survival days [25, 26, 36].

According to the standardized effects, we have been shown that dietary health and lifestyle habits did not cause healthy longevity. Longevity without bedridden status was the effect of physical, mental, and social health supported by socioeconomic status rather than a healthy diet and lifestyle (**Figure 4**).

Our study verified a solid causal association from three years earlier of three health-related dimensions toward the degree of nursing care and survival rate. Other studies have presented the expected consequence that mortality among older people is significantly associated with their physical health [19, 28], mental health [22, 35], and social health [28].

The current study incorporated the three health states into one latent variable using data from the same year (the three health-rated dimensions), as our previous reports suggest [26]. However, the reciprocal correlation among variables of the three health states does not coincidentally occur. Still, rather social health may be affected by mental health directly and by physical health indirectly in different chronological periods [36, 37].

Figure 4 shows the nearly null effect of healthy diet and lifestyle habits on healthy longevity. This finding opposed previous studies [6–12], as discussed above. However, these results are supported by the study of Diehr et al. [32] in those older adults aged 65 years and over who were overweight or obese had no worse and sometimes better outcomes in categories such as the activity of daily living, years of healthy life and active life expectancy compared to individuals of average weight.

From our perspective, it is assumed that overweight or obese conditions resulting from dietary health and lifestyle habits may have little influence on elderly health and living conditions.

Using covariance structure analysis, we analyzed the relationship between educational attainment, annual marital income, and health, namely physical, mental, and social health. As a result, it is clarified that educational attainment about half a century ago determined the annual income of married couples and that socioeconomic factors have a more decisive influence on both mental health and social health, subsequently support physical health, and ultimately affect social health.

The standardized estimate, which indicates the direct effect of socioeconomic factors on physical health, was tiny at 0.04. Forty-three percentage of social health could be explained. Analyses by gender showed almost similar results (**Figure 5**).

This new evidence would be completely new knowledge from an international perspective, and reproducibility is required.

Our research shows that the effects of educational attainment and income on healthy longevity are not direct but may have indirect effects through the three health factors (**Figure 4**). Several studies support our work. Based on the multivariate analysis, an extensive census data analysis of Estonia showed that educational differences in mortality were observed between men and women. Specifically, we showed that people with a more extended education period than those with the lowest education level were more likely to live 13.1 years longer for men and 8.6 years longer for women [38].

Manox et al. clarified through covariance variance structure analysis that educational attainment does not directly affect health but leads to health maintenance as a more indirect and distal end effect of entering a desirable occupation and maintaining income [39].

Similarly, Wardle et al. [40] reported that indexed status by occupational social class was significantly associated with favorable attitudes underlying various health behaviors and their health-sustaining effects, regardless of age or gender.

Our study shows that socioeconomic status may increase awareness, and the three desirable health factors may favor eating and lifestyle habits. In other words, favorable eating habits and lifestyle habits may not ultimately determine healthy longevity.

Instead, it was shown that economically sound groups that can maintain good eating habits and lifestyles based on desirable socioeconomic factors, especially those with sensual mental health, may be linked to healthy longevity, which is the final effect. Thus, as Manox et al. [39] pointed out, the achievement of higher education supported that it could have a distal impact on health outcomes through the expansion of social status, the type of occupation, and the potential for increased income.

This study had some limitations. In September 2001, the initial response rate was as high as 80.2%, but in the second round in September 2004, it fell to 52.0%. In particular, older people may have been missing more due to increased institutional admissions and deaths in hospitals and long-term care homes. This increase in the exclusion ratio of the target population could lead to random error and selection bias. Therefore, since excluding data with missing values would improve the fit of the model using SEM, the final analysis excluded data with one or more missing observed variables.

However, the exclusion of missing data did not change the study results. Therefore, the selection bias was insignificant even in this study, which shows missing values. It is unclear which of the three health factors indicated by the WHO has a more substantial impact on healthy longevity. As shown in **Figure 6**, socioeconomic factors can primarily strongly affect mental health and social health. However, it is entirely unclear which physical, mental, and social health factors contribute the most to healthy life expectancy. These hypotheses are our following research topics. More detailed follow-up is needed.

A review of our research yielded the following conclusions: It was revealed that healthy older people in the physical, mental, and social spheres were more likely to practice healthy eating habits and lifestyle habits. On the other hand, it was shown that a healthy diet and lifestyle might not directly affect healthy longevity, which is not required for long-term care but has a long survival day. Instead, healthy longevity could be directly affected by the three favorable health factors indicated by the WHO, which are socioeconomically supported. However, to make promising eating habits and lifestyle habits, it is necessary to maintain the three health factors supported by socioeconomic factors. Therefore, it is required to pay attention to the three health factors supported by economic independence and a healthy lifestyle strongly influenced by the three health factors.

It should be noted that socioeconomic factors are the essential foundation for the elderly to maintain healthy longevity, even if the continuation of undesirable lifestyle habits hinders healthy longevity.

As a result, attention should not be paid to the individual's only responsibility. Much more attention should be paid to public commitment to creating a supportive environment.

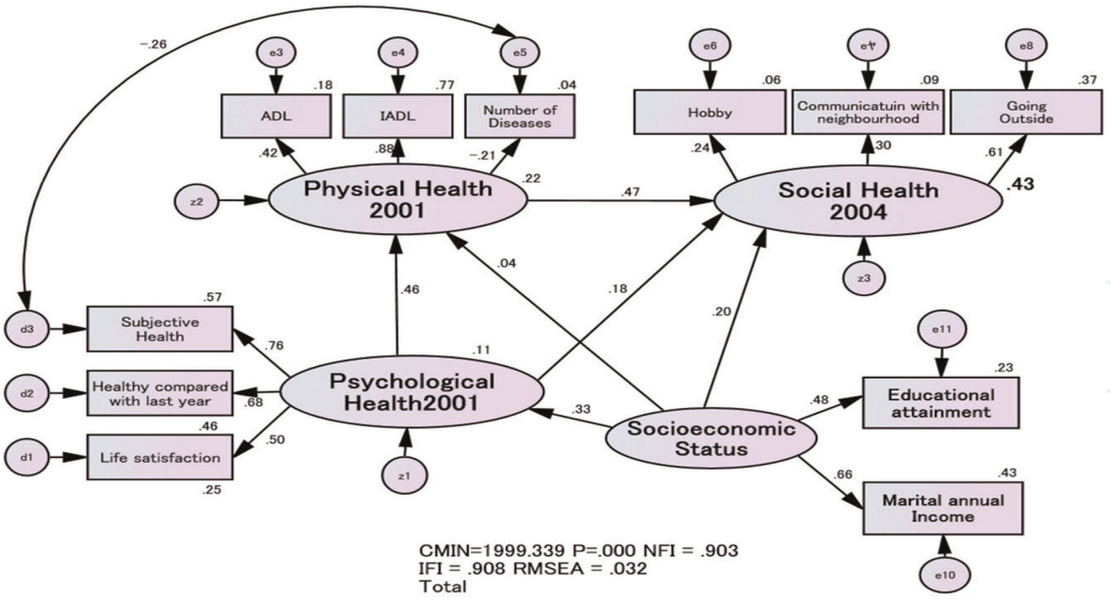

Figure 6.
Social health is a causal structure based on socioeconomic factors to support mental health and is determined through subsequent physical health for both sexes.

4.2 Marital annual income threshold to maintain survival

One of the leading scientific findings revealed by this study is that the marital yearly income threshold required to keep the number of survival days has been clarified.

In addition to showing a statistically significant relationship between income and survival days, we clarified that there is a threshold for income to maintain a certain number of survival days. For the elderly, it was4.5 million yen(0.0346 million US $) for both sexes as a marital yearly income.

In future research, it will be necessary to conduct an analysis based on equivalent income that considers family members, as some people live alone without a spouse. In addition, this survey did not implement survey items such as living conditions. These are a topic for future research.

Other than our previous study [25], no further research has been reported in Japan that has tracked survival concerning the amount of annual income that determines the number of survival days of individual life. Therefore, to improve the validity, additional tests are required, and reproducibility is required.

According to the 2021 Wage Structure Basic Statistical Survey [27], Japan's Ministry of Health, Labor and Welfare reported the average monthly income for full-time workers in 2021 was 0.037 million Japanese yen. Twenty years ago, in 2001, the average monthly salary was 0.036 million yen. In this way, changes in the amount of personal income in Japan over time have remained almost constant over the past 20 years, making it one of the countries with a minor increase in revenue among the advanced G7 countries.

Although the increase in average life expectancy in Japan slowed down, it continued to increase to the same level as in developed countries where personal income is rising. This suggests that income alone cannot explain the factors determining extending life expectancy. This fact can also reveal that Okinawa Prefecture, which has the lowest income in Japan, had the longest average life expectancy and that

Tokyo, which has the highest income city, does not have the longest average life expectancy.

The authors [42] have clarified that the average life expectancy of municipalities with a large population in Japan increases significantly with the elevation of latitude in the municipality location. This fact suggests that even if medical care in high-altitude provincial cities is not better than in urban areas, unpolluted water sources are secured, and the natural environment surrounded by abundant greenery contributes to the extension of the lifespan of living organisms.

Therefore, it is presumed that the community's natural environment and social networks are favorable factors for extending the average life expectancy, assuming that a constant income is secured and relative poverty is low.

It has been reported that other factors that determine the survival day and heredity are reflected in survival in old age about half a century later. For example, it explains the causal relationship that growth is retarded and short stature increases the mortality rate in the period when the height increases [43]. Regarding the mechanism, Davey et al. [44] reported that the socioeconomic factors of the parents in childhood reflected the nutritional status of the family, and the child's significant organs reached a level where they could fully demonstrate their functions.

Hasegawa et al. [45] reported the causal relationship between socioeconomic factors and lifestyle habits on the survival rate of urban older adults, following the survival of 8,285 people for three years. Socioeconomic factors indirectly affect healthy life maintenance via the three health factors and report the possibility that socioeconomic status is the basis of survival.

The results of this research followed previous research [12, 17, 40] that it is necessary to secure a certain level of income to maintain survival days. In the future, it will be required to verify the effects of social security policy interventions to correct health disparities.

Our studies suggest that there may be a threshold for the number of years alive and related annual income. However, the research method had limitations. In addition, many issues can be pointed out to improve the research results' validity.

As for the annual income question, objective information such as equivalent income and whole-life income should be added to consider equivalent disposable income. In addition, The next research topic is to add survey items such as subjective questions such as economic living conditions and satisfaction with health [46], which are reported to be related to survival.

A future research subject is to increase the results' internal and external validity by random sampling.

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Conflict of interest

There is no conflict of interest status to be disclosed in this study.

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References

[1] Mathers CD, Murray CJ, Salomon JA, Sadana R, Tandon A, Lopez AD, et al. Healthy life expectancy: Comparison of OECD countries in 2001. Australian and New Zealand Journal of Public Health. 2003;**27**:5-11

[2] Marmot MG, Smith GD. Why are the Japanese living longer? BMJ. 1989;**299**: 1547-1551

[3] Overview of the 2018 Ministry of Health, Labor and Welfare Abridged Life Tables. https://www.mhlw.go.jp/toukei/saikin/hw/life/life18/index.html (Review: 25 February 2022)

[4] Asiskovitch S. Gender and health outcomes: The impact of healthcare systems and their financing on life expectancies of women and men. Social Science & Medicine. 2010;**70**:886-895

[5] Kondo N, Mizutani T, Minai J, Kazama M, et al. Factors explaining disability-free life expectancy in Japan: The proportion of older workers, self-reported health status, and the number of public health nurses. Journal of Epidemiology. 2005;**15**:219-227

[6] A new perspective on the health of Canadians; A working document. Available from: http://www.phac-aspc.gc.ca/ph-sp/pdf/perspect-eng.pdf

[7] Healthy People; The surgeon general's report on health promotion and disease prevention. Available from: http://profiles.nlm.nih.gov/ps/access/NNBBGK.pdf

[8] Bronnum-Hansen H, Juel K, Davidsen M, Sorensen J. Impact of selected risk factors on quality-adjusted life expectancy in Denmark. Scandinavian Journal of Public Health. 2007;**35**:510-515

[9] Willcox BJ, He Q, Chen R, Yano K, Masaki KH, Grove JS, et al. Midlife risk factors and healthy survival in men. Journal of the American Medical Association. 2006;**296**:2343-2350

[10] Enstrom JE, Breslow L. Lifestyle and reduced mortality among active California Mormons, 1980-2004. Preventive Medicine. 2008;**46**:133-136

[11] Nothlings U, Ford ES, Kroger J, Boeing H. Lifestyle factors and mortality among adults with diabetes: Findings from the European prospective investigation into Cancer and nutrition-Potsdam study. Journal of Diabetes. 2010;**2**:112-117

[12] Tamakoshi A, Kawado M, Ozasa K, Tamakoshi K, Lin Y, Yagyu K, et al. Impact of smoking and other lifestyle factors on life expectancy among japanese: Findings from the Japan collaborative cohort (JACC) study. Journal of Epidemiology. 2010;**20**: 370-376

[13] Hoi le V, Phuc HD, Dung TV, Chuc NT, Lindholm L. Remaining life expectancy among older people in a rural area of Vietnam: Trends and socioeconomic inequalities during a period of multiple transitions. BMC Public Health. 2009;**9**:471

[14] Matthews RJ, Jagger C, Hancock RM. Does socio-economic advantage lead to a longer, healthier old age? Social Science & Medicine. 2006;**62**:2489-2499

[15] Jagger C, Gillies C, Moscone F, Cambois E, Van Oyen H, Nusselder W, et al. Inequalities in healthy life years in the 25 countries of the European Union in 2005: A cross-national meta-regression analysis. Lancet. 2008;**372**: 2124-2131

[16] Sugiura Y, Ju YS, Yasuoka J, Jimba M. Rapid increase in Japanese life expectancy after world war II. Bioscience Trends. 2010;**4**:9-16

[17] Kagamimori S, Gaina A, Nasermoaddeli A. Socioeconomic status and health in the Japanese population. Social Science & Medicine. 2009;**68**: 2152-2160

[18] International Health Conference: The Constitution of the World Health Organization. New York; 1946

[19] Byberg L, Melhus H, Gedeborg R, Sundstrom J, et al. Total mortality after changes in leisure time physical activity in 50 year old men: 35 year follow-up of population based cohort. British Journal of Sports Medicine. 2009;**43**:482

[20] Donaldson LJ, Jagger C. Survival and functional capacity: Three year follow up of an elderly population in hospitals and homes. Journal of Epidemiology and Community Health. 1983;**37**:176-179

[21] Eplov LF, Jorgensen T, Birket-Smith M, Segel S, et al. Mental vulnerability as a predictor of early mortality. Epidemiology. 2005;**16**:226-232

[22] Kaplan GA, Goldberg DE, Everson SA, Cohen RD, et al. Perceived health status and morbidity and mortality: Evidence from the Kuopio ischaemic heart disease risk factor study. International Journal of Epidemiology. 1996;**25**:259-265

[23] Khaw KT, Wareham N, Bingham S, Welch A, et al. Combined impact of health behaviours and mortality in men and women: The EPIC-Norfolk prospective population study. PLoS Medicine. 2008;**5**:12

[24] Seeman TE, Kaplan GA, Knudsen L, Cohen R, Guralnik J. Social network ties and mortality among the elderly in the Alameda County study. American Journal of Epidemiology. 1987;**126**: 714-723

[25] Hoshi T, Kodama S, Kurimori S, Fujita K. Married annual income threshold for survival days among. Both elderly suburban and rural dwellers. Fortune Journal of Health Sciences. 2022; **5**(3):529-541

[26] Hoshi T. SES. Dietary and lifestyle habits, three health-related dimensions, and healthy survival days. In: Hoshi T, Kodama S, editors. The Structure of Healthy Life Determinants: Lessons from the Japanese Aging Cohort Studies. Singapore: Springer; 2018. pp. 134-189

[27] World development report 2006. Equity and Development. The World Bank Oxdord University Press. World Bank Group Open Knowledge Repository. Available from: https://openknowledge.worldbank.org/handle/10986/5988 [Review: 11 July 2022]

[28] Berkman LF, Breslow L. Health and Ways on Living; the Alameda County Study. New York: Oxford University Press; 1983

[29] Ford ES, Zhao G, Tsai J, Li C. Low-risk lifestyle Behaviors and all-cause mortality: Findings from the National Health and nutrition examination survey III mortality study. American Journal of Public Health. 2011;**101**(10):1922-1929. DOI: 10.2105/AJPH.2011.300167

[30] Millen BE, Quatromoni PA, Pencina M, Kimokoti R, et al. Unique dietary patterns and chronic disease risk profiles of adult men: The Framingham nutrition studies. Journal of the American Dietetic Association. 2005;**105**:1723-1734

[31] Dam RM, Li T, Spiegelman D, Franco OH, et al. Combined impact of lifestyle factors on mortality: Prospective

cohort study in US women. BMJ. 2008; **337**:a1440

[32] Diehr P, O'Meara ES, Fitzpatrick A, Newman AB, et al. Weight, mortality, years of healthy life, and active life expectancy in older adults. Journal of the American Geriatrics Society. 2008;**56**: 76-83

[33] Iestra J, Knoops K, Kromhout D, de Groot L, et al. Lifestyle, Mediterranean diet and survival in European post-myocardial infarction patients. European Journal of Cardiovascular Prevention and Rehabilitation. 2006;**13**:894-900

[34] Knoops KT, de Groot LC, Kromhout D, Perrin AE, et al. Mediterranean diet, lifestyle factors, and 10-year mortality in elderly European men and women: The HALE project. Journal of the American Medical Association. 2004;**292**:1433-1439

[35] Spiers N, Jagger C, Clarke M, Arthur A. Are gender differences in the relationship between self-rated health and mortality enduring? Results from three birth cohorts in Melton Mowbray, United Kingdom. The Gerontologist. 2003;**43**:406-411 discussion 372-405

[36] Hoshi T, Ryu S, Fujiwara Y. Urban health and determinant factors for longer life for the elderly urban dwellers in Tokyo. In: Proceedings of the International Symposium on Sustainable Urban Environment. Tokiyo: Metropolitan University; 2007. pp. 61-66

[37] Hoshi T, Takagi C, Bosako Y, Nakayama N, et al. Chronological evaluation of physical, psychological and social health of urban elderly dwellers over 6 years and assesment of cuasal inter-relationships. Nihon Koshu Eisei Zasshi. 2011;**58**:491-500

[38] Leinsalu M, Vagero D, Kunst AE. Estonia 1989-2000: Enormous increase in mortality differences by education. International Journal of Epidemiology. 2003;**32**:1081-1087

[39] Singh-Manoux A, Clarke P, Marmot M. Multiple measures of socio-economic position and psychosocial health: Proximal and distal measures. International Journal of Epidemiology. 2002;**31**:1192-1199 discussion 1199-1200

[40] Wardle J, Steptoe A. Socioeconomic differences in attitudes and beliefs about healthy lifestyles. Journal of Epidemiology and Community Health. 2003;**57**:440-443

[41] 2021 Wage Structure Basic Statistics Survey Ministry of Health, Labor and Welfare. Available from: https://news.yahoo.co.jp/articles/226d8885b45364a7c4b0399e522182c6a82f2a28

[42] Hoshi T, Taniguchi R. A study on the relationship between average life expectancy and altitude in municipalities nationwide. Proceedings of the Annual Meeting of the Japanese Society of Public Health. 2003;**62**:183

[43] Flegal KM, Graubard BI, Williamson DF, et al. Excess deaths associated with underweight, overweight, and obesity. JAMA. 2005; **293**:1861-1867

[44] Davey Smith G, Hart C, Upton M, Hole D. Height and risk of death among men and women: Aetiological implications of associations with cardiorespiratory disease and cancer mortality. Journal of Epidemiology and Community Health. 2000;**54**:97-113

[45] Hasegawa T, Takashi T, Hoshi T, et al. The effects of socioeconomic status and lifestyle on life expectancy: A structural analysis of an elderly Japanese population. International Medical Journal. 2011;**18**(4):261-264

[46] Montano D. Socioeconomic status, well-being and mortality: A comprehensive life course analysis of panel data, Germany, 1984-2016.Arch. Public Health. 2021;**79**(1):40. DOI: 10.1186/s13690-021-00559-7