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Calculation of prefectural disability-adjusted life expectancy (DALE) using long-term care prevalence and its socioeconomic correlates in Japan

Sugako Kurimori, Yoshiharu Fukuda*, Keiko Nakamura, Masafumi Watanabe, Takehito Takano

Health Promotion/International Health, Division of Public Health, Graduate School of Tokyo Medical and Dental University, 1-5-45 Yushima, Bunkyo-ku, Tokyo 113-8519, Japan

Abstract

Objectives: The objectives of this study were: (1) to determine the disability weight, "utility", for calculation of disability-adjusted life expectancy (DALE) using the prevalence of long-term care; (2) to calculate prefectural DALE; and (3) to clarify the relation between DALE and area socioeconomic conditions in Japan.
Methods: Disability utility by care level (support and levels I–V) of long-term care insurance was determined by a survey of 236 professionals with four standard utility measures: EuroQol-5D, time trade-off, standard gamble, and visual analogue scale. DALE at age 65 (DALE65) and age-adjusted weighted disability prevalence (WDP) of 47 prefectures were calculated using the determined utilities, prevalence of long-term care, and life tables. The relationships of DALE and WDP to mortality from major causes and socioeconomic indicators were examined by correlation analysis.
Results: The determined utilities were: support, 0.78; level I, 0.68; level II, 0.64; level III, 0.44; level IV, 0.34; and level V, 0.21. The prefectural DALE65 ranged from 17.11 to 15.29 years for men and from 20.21 to 18.42 years for women. Strong correlations were found between DALE65 and mortality for both sexes. Male DALE65 was correlated with no socioeconomic indicators, while female DALE65 was correlated with some indicators. WDP was positively associated with indicators representing socioeconomic disadvantage, such as unemployment rate and percentage of elderly single households.
Conclusions: The socioeconomic correlates of DALE and WDP suggested that favorable socioeconomic policies, in addition to a decrease in mortality from major causes, will contribute to significant extension of the independence period in the elderly. The method proposed here encourages the practical use of health expectancy in health policy, especially at local and regional levels.

Keywords: Health expectancy; Disability-adjusted life expectancy; Disability prevalence; Socioeconomic factor; Long-term care

1. Introduction

Health expectancy is a population-based measure of the proportion of expected life span estimated to be healthful and fulfilling, or free of illness, disease,

* Corresponding author. Tel.: +81 3 5803 5189; fax: +81 3 3818 7176.
E-mail address: fukuda.hlth@tmd.ac.jp (Y. Fukuda).

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and disability [1]. Several health expectancy indicators have been developed, including disability-free life expectancy (DFLE) and disability-adjusted life expectancy (DALE) [2–7]. DFLE is the expected period of life lived without a given disability, and DALE measures the equivalent number of years of life expected to be lived in full health, taking account of the degree of disability [8–11].

Similar to other health indicators, health expectancy has two main practical uses in health policy. First, it is used for health policy making and evaluation by periodic monitoring or comparison among nations and regions [12]. Second, it is useful for evidence-based decision-making in health policy through identifying the relations between health indicators and possible health determinants, including socioeconomic factors [13].

One objective of the present study was to propose a method of DALE calculation suitable for periodic monitoring even at local and regional levels, such as the prefecture or municipality (Japan consists of almost 2400 municipalities nested in 47 prefectures at April, 2005). A new national health promotion policy, "Health Japan 21", aims to extend health expectancy, accompanied by prefectural and municipal health promotion plans [14]. Health expectancy feasible at the local and regional levels would be useful for planning and evaluation of these health policies. Although earlier studies estimated prefectural DFLE and DALE using various data sources for the disability prevalence [9,15], such data are not routinely available at the municipal level. Recent studies have calculated prefectural and municipal DFLE using disability prevalence based on long-term care insurance (LTCI) data [16–19]. LTCI was introduced for the elderly requiring nursing care in Japan in 2000, and certificated people are classified into one of six care levels according to the severity of their disability and care needs [20]. As municipal governments manage LTCI, LTCI data are routinely available at the municipal as well as prefectural level, and are used as a source of disability prevalence.

In addition to the disability prevalence, DALE calculation requires disability weight, "utility", which is the value of a particular health state, usually expressed on a scale from 1 as perfect health to 0 as a state equivalent to death [2]. It is useful not only for calculation of DALE, quality-adjusted life years (QALY), disability-adjusted life years (DALY), and other indicators, but also for cost-effectiveness analysis in clinical studies [2,21]. The utility of a specific health state is determined by several methods, including EuroQol-5D (EQ-5D), time trade-off (TTO), standard gamble (SG), and visual analogue scale (VAS) [22,23].

If appropriate utilities corresponding to the care levels of LTCI are available, the combination of these utilities and care level-specific prevalence of long-term care enables DALE calculation. Although several previous studies have determined the utilities by disease and disability [21,22,24], linkage between these utilities and LTCI data is impossible. In the present study, we first determined the utility by LTCI care levels using an original survey with standard utility measures. Then, we calculated DALE and weighted disability prevalence (WDP) of 47 prefectures using the LTCI data and the determined utilities.

An additional objective of this study was to clarify possible determinants of DALE, focusing on whether disease-oriented approaches to prevent major causes of death or social determinant-oriented approaches to intervene in socioeconomic factors have an effect on the length of the period of independence of the elderly. For this purpose, we examined the relations of DALE and WDP to mortality from major causes and socioeconomic indicators. "Health Japan 21" aims mainly to prevent chronic diseases, such as cancer, heart disease, and stroke, to extend health expectancy [14]. Although prevention of these diseases will lead to a decline in mortality, the effects on the number of elderly people with disabilities or requiring long-term care are unknown. On the other hand, socioeconomic factors are known to be associated with health levels in the population [13,25], and thus approaches relating to social determinants of health are required for improvement of the health of the population [26]. However, much less is known about the socioeconomic determinants of health expectancy and the length of the period of independence in elderly Japanese people.

2. Methods

2.1. Survey of utility measurement

2.1.1. Care levels of LTCI

The basic unit of insurance in LTCI is the municipality, although the system including certification

procedure, criteria of certification, fee schedule, and qualification of caregiver is universal across the country. Eligible people are those aged 65 and over who require sustained nursing care for partial or total activities of daily living, such as feeding, toileting, and bathing, and those aged 40–64 with 15 specified diseases [20]. As shown in Appendix A, certificated people are classified into one of six care levels ("*Yokaigodo*"): support and care levels I–V. The care levels are mainly derived from care time estimated as required nursing care time. After application of care requirements, a care manager assigned to a particular case conducts an assessment of the client's disability, using an 85-item instrument developed by the Ministry of Health, Labour, and Welfare. The assessment forms are processed using a government computer program that will automatically, although tentatively, classify individuals into six levels. The municipal certification committee finally makes judgment of the care level based on computer-generated classification and the opinion from the client's primary care physician. Then, the certificated client can receive benefits, such as home-care services by home-helpers and nurses, within the maximum amount according to the care level with 10% co-payment.

2.1.2. Study subjects

A survey to determine the utility by care level of LTCI was carried out among professionals engaged in LTCI services. Eleven LTCI service providers were selected at random from one organization with 49 providers in the Tokyo area. Persons who had at least one kind of qualification related to LTCI (care manager, home-helper, nurse, or certified care worker) and had more than one year's experience were eligible as subjects.

Our research staff visited the selected LTCI service providers to explain the purposes and context of the survey to representatives of the providers. The representatives nominated eligible study subjects among the employees, and distributed and collected the questionnaires. A total of 236 professionals from 11 providers were nominated as study subjects, and agreement to participate in the survey was given in writing by each subject. The survey was carried out over the period from 1 October to 30 November 2003.

To calculate the sample size, we conducted a pilot study ($n = 62$). Based on the standard deviation of 0.16 in the pilot study, an assumed least difference of utilities between care levels of 0.10, α (error) of 0.05, and $1 - \beta$ (power) of 0.90, the required sample size was estimated to be 324 [27]. As the utilities of two care levels were assessed for each study subject, the required number of subjects was $324/2 = 162$.

2.1.3. Utility measurement

Each subject was asked about the general health state of certificated persons of two care levels. The combination of two care levels was assigned randomly. The questionnaire included four standard utility measures: EuroQol-5D (EQ-5D), time trade-off (TTO), standard gamble (SG), and visual analogue scale (VAS) [22,23]. According to the established procedure, the utility of each measure was quantified from 1 (perfect health) to 0 (equivalent to death). EQ-5D consisted of questionnaires on five health dimensions (mobility, self-care, usual activities, pain/discomfort, and anxiety/depression) with three possible responses, and the utility was assigned according to the combination of responses using a conversion table [28]. The instruments of TTO and SG are shown in Appendix B. VAS was used to assess health state on a scale from 100 (perfect health) to 0 (equivalent to death) at intervals of 5, and converted to utility from 1 to 0.

The reproducibility of the four measures was examined by determining test-retest reliability for one service provider ($n = 15$) within an interval of one month. A significant correlation for each measure was found: correlation coefficients were EQ-5D 0.63, TTO 0.73, SG 0.82, and VAS 0.87.

2.1.4. Determination of utility

Determination of utility was based on the validity and reliability of measurement, and the measure with the highest reliability and validity was adopted for the determined utility. To evaluate reliability, discrimination of utility among care levels by the measure was examined using one-way ANOVA, assuming that a reliable measurement showed a significant difference in utility among care levels. Convergent validity [29] was examined by determining the significance of differences in utility among the four measures using paired *t*-test, under the assumption that the utility of a valid measure was consistent with the utility of other measures.

2.2. WDP and DALE calculation

Sex- and age group-specific WDP by prefecture was calculated using the determined utilities and prevalence of long-term care. LTCI data, obtained from a database published by the Ministry of Health, Labour, and Welfare in 2002 [30], and population data were based on resident registration records from 2002 [31]. As there was a difference in age categories between the population data and the LTCI data (with oldest age groups of 80 and over, and 95 and over, respectively), the populations in the 80–84, 85–89, 90–94, and 95 and over categories were estimated using the ratio of the population in these categories reported in the 2000 census by prefecture [32].

WDP was calculated for the population aged 65 and over, as 96% of LTCI-certificated persons were aged 65 and over [30]. Age-specific WDP was calculated using the following formula:

$$\mathrm{WDP}_x = \sum_i \left(\frac{N_{ix} U_{ix}}{P_x} \right)$$

where WDP_x is age-specific WDP, N_{ix} the number of certificated persons of care level i, U_{ix} the determined utility of care level i, and P_x the population size in age category x (aged x to $x+5$). Then, age-adjusted WDP was computed by the direct age-standardization method with the national population in 2002.

Sex-specific DALE at ages 65, 70, 75, 80, 85, and 90 years was calculated by prefecture using WDP and the 2000 life table [33] according to the method of Sullivan [34]. DALE was calculated using the following formula:

$$\mathrm{DALE}_x = \frac{\sum (L_x (1 - \mathrm{WDP}_x))}{l_x}$$

where L_x is the total number of person-years lived between ages x and $x+5$, and l_x the number of persons surviving at age x in the life table.

In addition to prefectural data, WDP and DALE for the entire Japanese population were calculated using national figures from the 2000 life table [33] and LTCI data from 2002 [30].

2.3. Correlation analysis

The relationships of life expectancy (LE), DALE, and WDP to mortality and socioeconomic indicators were examined by correlation analysis. We used LE and DALE at age 65 years (DALE65), age-adjusted WDP, and age-adjusted mortality rates from all causes and major causes (cancer, heart disease, and stroke). Socioeconomic indicators included per capita income, unemployment rate, percentage of people with four-year college degree or higher, percentage of elderly single households, percentage of elderly couple households, percentage of households with elderly, number of household members, and number of physicians per 100,000 population. These indicators were drawn from the data sources of governmental surveys around 2000 [35–37].

SPSS 11.0J was used for all statistical analyses in the present study.

3. Results

The total number of respondents was 228 (response rate, 96.6%), which consisted of 26 men and 202 women, with a mean age (standard deviation) of 45.2 years (10.7). Their qualifications (multiple answers) were as follows: care manager, 49.1%; grade I home-helper, 10.5%; grade II home-helper, 36.0%; nurse, 12.3%; and certified care worker, 34.6%. Most (89.5%) had more than two years' experience in LTCI services.

In the EQ-5D, the utility could be converted when all five health dimensions were answered completely. If the utilities of two care levels obtained by the measure in each study subject were inversed (a high level showed high utility), these utilities were excluded from analysis as we considered that the subject did not understand the questions. As a result, the numbers of utilities used in the analyses were: EQ-5D, 421; TTO, 414; SG, 418; and VAS, 412.

Table 1 shows the results of utility measured by the four methods. Including the differences between consecutive pairs shown in Table 1, the numbers of pairs with significant differences in utility among all 15 pairs of care levels were as follows: EQ-5D, 13; TTO, 12; SG, 9; and VAS, 13. These results suggested that the discrimination of utility among care levels was lowest for SG. With regard to validity, EQ-5D showed significantly ($p < 0.05$) lower utility, while SG showed significantly higher utility than the other three measures. TTO and VAS were not significantly different

Table 1
Utility by care level of long-term care insurance measured by four methods

Method[a]	*N*	Support		Level I		Level II		Level III		Level IV		Level V	
		Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
EQ-5D	421	0.68	0.14	0.61	0.11	0.55	0.08	0.43	0.18*	0.14	0.24*	−0.02	0.11*
TTO	414	0.77	0.19	0.65	0.20	0.61	0.22	0.44	0.20*	0.39	0.24	0.23	0.23*
SG	418	0.90	0.15	0.84	0.18	0.84	0.18	0.73	0.22	0.61	0.28	0.47	0.29*
VAS	412	0.80	0.15	0.73	0.15	0.67	0.14	0.46	0.15*	0.30	0.14*	0.19	0.12*
(TTO + VAS)/2	385	0.78	0.13	0.68	0.14*	0.64	0.15	0.44	0.14*	0.34	0.16*	0.21	0.14*

* Significant ($p < 0.05$) difference from lower care level: e.g. level III vs. level II.
[a] EuroQol (EQ-5D), time trade-off (TTO), standard gamble (SG) and visual analogue scale (VAS).

from one another. These results implied that the convergent validity of EQ-5D and SG was lower than that of TTO and VAS. Thus, TTO and VAS showed similarly higher validity and reliability, and we then calculated the mean of TTO and VAS. The results indicated a significant difference among all pairs of care levels, except for the pair of levels I and II. Consequently, the mean of TTO and VAS ($n = 385$) was determined as the most appropriate utility: support, 0.78; care level I, 0.68; care level II, 0.64; care level III, 0.44; care level IV, 0.34; and care level V, 0.21.

Table 2
Weighted disability prevalence (WDP) of 47 prefectures in Japan

Age group (years)	Male		Female	
	Mean	S.D.	Mean	S.D.
65–69	0.014	0.002	0.015	0.002
70–74	0.029	0.004	0.036	0.007
75–79	0.054	0.007	0.084	0.016
80–84	0.119	0.017	0.165	0.028
85–89	0.167	0.020	0.249	0.031
>90	0.206	0.020	0.340	0.026

Table 2 shows a summary of prefectural WDP for the population aged 65 and over. WDP at age 65–69 years (WDP65) ranged from 0.010 to 0.019 for men and 0.010 to 0.020 for women. Age-adjusted WDP ranged from 0.041 to 0.068 for men and 0.055 to 0.105 for women.

Table 3 shows a summary of prefectural LE65 and DALE65. LE65 ranged from 18.45 to 16.52 years for men and 24.10 to 21.87 years for women. DALE65 ranged from 17.11 to 15.29 years for men and 20.21 to 18.42 years for women. The correlation coefficients of LE65 and DALE65 were 0.91 ($p < 0.001$) for men and 0.49 ($p < 0.001$) for women. For age-adjusted WDP, the correlation coefficients with LE65 were −0.12 ($p = 0.41$) for men and 0.12 ($p = 0.41$) for women, and those with DALE65 were –0.49 ($p = 0.001$) for men and −0.78 ($p < 0.001$) for women.

Table 3
Life expectancy (LE) and disability-adjusted life expectancy (DALE) of 47 prefectures in Japan

Age (years)	Male				Female			
	LE (years)		DALE (years)		LE (years)		DALE (years)	
	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
65	17.57	0.33	16.28	0.31	22.57	0.42	19.39	0.39
70	13.99	0.29	12.65	0.26	18.32	0.40	15.10	0.37
75	10.77	0.26	9.37	0.22	14.31	0.38	11.07	0.34
80	7.96	0.24	6.50	0.19	10.71	0.36	7.52	0.27
85	5.78	0.22	4.31	0.14	7.71	0.30	4.67	0.17
90	4.20	0.21	2.48	0.09	5.45	0.25	2.38	0.09

Table 4
Correlation coefficients of life expectancy at age 65 (LE65), disability-adjusted life expectancy at age 65 (DALE65), and age-adjusted weighted disability prevalence (WDP) with mortality and socioeconomic indicators

Variable	Male			Female		
	LE 65	DALE 65	WDP	LE 65	DALE 65	WDP
Age-adjusted mortality rate						
All causes (male)	−0.79**	−0.86**	0.37**	−0.36*	−0.55**	0.44**
All causes (female)	−0.73**	−0.67**	0.05	−0.87**	−0.61**	0.13
Cancer	−0.71**	−0.77**	0.39**	−0.65**	−0.52**	0.13
Heart disease	−0.37*	−0.33*	−0.07	−0.74**	−0.30*	−0.09
Stroke	−0.45**	−0.31*	−0.20	−0.56**	−0.04	−0.36*
Socioeconomic indicators						
Per capita income	0.09	0.24	−0.39**	−0.37*	0.12	−0.43**
Unemployment rate	0.26	0.08	0.40**	0.37**	−0.07	0.30*
Percentage of four year college degree or higher	0.17	0.17	−0.05	−0.24	0.17	−0.10
Percentage of elderly single households	−0.03	−0.28	0.64**	0.26	−0.36*	0.65**
Percentage of elderly couple households	0.04	−0.14	0.50**	0.24	−0.23	0.50**
Percentage of households with elderly	−0.06	−0.02	−0.04	0.19	0.22	−0.03
Number of household members	−0.02	0.17	−0.48**	0.05	0.43**	−0.45**
Number of physicians per population	0.07	−0.18	0.59**	0.28	−0.30*	0.58**

* $p < 0.05$.
** $p < 0.01$.

For the entire Japanese population, WDP for groups aged 65–69 to 90 years old were 0.014, 0.028, 0.054, 0.117, 0.169, and 0.207 in men; and 0.014, 0.036, 0.084, 0.0164, 0.247, and 0.341 in women. In addition, LE65 [33] and DALE65 for the entire population were 17.56 and 16.26 in men and 22.46 and 19.32 in women, respectively.

The correlation coefficients of LE65, DALE65, and age-adjusted WDP with mortality and socioeconomic indicators are shown in Table 4. LE65 and DALE65 were negatively correlated with mortality, except for female DALE and stroke mortality. Male WDP was positively correlated with male mortality from all causes and cancer. Female WDP was positively correlated with male all-cause mortality and negatively correlated with stroke mortality.

None of the socioeconomic indicators examined showed significant correlations with male LE65 or DALE65. For women, several indicators showed significant correlations with LE65 and DALE65, such as the negative correlations with per capita income for LE65 and with elderly single households for DALE65, and positive correlations with unemployment rate for LE65 and with number of household members for DALE65. WDP was positively correlated with unemployment rate, elderly single households, and elderly couple households, while negatively correlated with per capita income and number of household members.

4. Discussion

4.1. Summary of findings

In the present study, we presented an estimation of DALE that was feasible at the local and regional levels using LTCI data. To estimate DALE, we determined the utility by LTCI care level through a survey of professionals and comparison of validity and reliability among four standard utility measures. Then, using the determined utility, we calculated prefectural DALE, which ranged from 17.11 to 15.29 years for men and 20.21 to 18.42 years for women. In addition, the correlations of LE, DALE, and WDP with mortality and socioeconomic indicators were examined. The correlation with mortality was substantial for LE and DALE, but not for WDP. Conversely, a strong correlation with indicators of socioeconomic disadvantage was found for WDP, but not for LE or DALE.

4.2. Methodological considerations

We first discuss methodological issues regarding utility measurement and disability prevalence, focusing on both the strengths and drawbacks of the present study.

The utilities for LTCI care levels were determined through an original survey that was unique in two respects. First, utility was measured by four standard methods, and their validity and reliability were assessed. The results of reliability assessment indicated that SG was less reliable because of the lower discriminability for utilities among care levels. Validity assessment indicated that EQ-5D and SG showed significantly lower and higher utility as compared to other measures, respectively. The mean of the remaining measures, TTO and VAS, indicated the utility with the most reliability: all pairs, except for care levels I and II, showed significant differences in utility. There is no single standard method of utility measurement, and different methods have been used depending on the setting [38]. Among the four measures applied in the present study, only EQ-5D can theoretically show utilities less than 0 [28], and previous studies suggested that SG is likely to show higher utility than other measures [23,39]. These intrinsic features might be related to the differences in utility among measures observed in the present study. In addition, as there have been few studies applying utility measures in the Japanese population, it remains possible that social and cultural aspects in Japan influence the answers to the questions used for these utility measures.

The validity of LTCI certification, especially classification of care levels, has been discussed as one of the critical problems in the current LTCI [40,41]. No measures showed significant differences in utility between levels I and II. Considering the relatively small difference in maximum benefits between these two levels as shown in Appendix A, it is possible that the judge of disability by professionals in the present study may have been influenced by actually provided services in addition to disability severity, and consequently they could not accurately discriminate the utilities between these two levels.

Test–retest showed a significant, although not strong, correlation in particular for EQ-5D ($r = 0.63$). The questionnaires using in the present study were self-administered and simpler than those used in previous studies, in which complicated instruments, such as series of questions and computer-based tools, were applied [21,22,24]. The development of more sophisticated instruments and more experience with utility measurements in the Japanese population will result in expansion of utility application in fields of health policy and health economics.

The other unique point of utility measurement in the present study is related to the study subjects. Utility measurements were mainly performed in patients, professionals, and general populations [42,43], and utility is often elicited directly from those who have investigated health problems [42]. If our questionnaires were applied to certificated individuals, those of lower care levels may be able to respond to the questionnaire. However, certificated individuals of higher care levels, including bedridden and demented elderly, may have difficulty in understanding and responding to the questionnaire, and surrogates, such as family members and care-givers, may be respondents. Previous studies confirmed that different types of respondents lead to inconsistent utilities [42]. To avoid this inconsistency, we selected professionals as study subjects for the measurement of utility.

As a limitation regarding study subjects, the samples were restricted to those in the Tokyo area, and thus the results obtained could be generalized based on the assumption that the study subjects represent the entire country. This assumption was drawn from the fact that the criteria for certification and qualifications of caregivers are uniform throughout the country [44]. In addition, the study subjects were chosen from those who had sufficient experience in long-term care services. The utility of disability is critical for the DALE estimate. For practical use of DALE with LTCI data, comparative data from different samples including certificated persons should be obtained and further discussion is therefore required.

The second methodological issue regards the disability prevalence. In the present study, the disability prevalence was estimated from the data of certificated people of LTCI. The certificated people do not represent the disabled per se, and the certification and use of LTCI services may be influenced by various factors, such as individual socioeconomic

status, availability of alternative care, and social and cultural features in the residential region. In fact, a previous study of LTCI in Japan showed the significant influence of income and availability of informal care on use of long-term care utilization [45].

In addition to LTCI data, there are several possible sources for the prevalence of disability: Patient Survey conducted every three years to estimate the numbers of outpatients and inpatients for sampled hospitals and clinics; Survey on Health Services Facilities for the aged for an annual report of the number of institutionalized elderly in health service facilities; Survey on Social Welfare Institutions for an annual report of the number of institutionalized persons in social welfare institutions; and the Comprehensive Survey of the Living Conditions of People on Health and Welfare which is an annual sampling survey to estimate morbidity, including disability and care requiring at home. DFLE estimated in a previous study was based on aggregation of these sources as the disability prevalence [15]. As the correlation coefficient of prefectural disability prevalence between this previous study and the present study was moderate (0.51 in men and 0.69 in women), it seems that the disability prevalence is dependent on data sources. The data rather than LTCI have the limitation regarding periodic use and availability at the prefectural level and especially at the municipal level. As a consequence, the LTCI data are the sole source for periodic estimation of DFLE and DALE at the local and regional levels, even though there is some bias as the disability prevalence, in particular due to the arbitrary application and the certification procedure.

4.3. Health determinants of the elderly

Correlation analysis of LE, DALE, and WDP with mortality and socioeconomic indicators showed some interesting results.

LE and DALE did not show strong relations with socioeconomic indicators. In general, lower socioeconomic status is related to poor health, even in health expectancy and in the elderly population [12,25,46]. A previous study demonstrated that the relation between lower socioeconomic area indicators and higher mortality was moderate for mortality in the elderly as compared to premature mortality in Japan [47], as well as in other countries [48]. There are several possible explanations for this finding. First, vulnerable people are likely to die before aging, and thus the elderly are less vulnerable survivors [47]. Second, the socioeconomic indicators, especially income and unemployment, used in the present study seem to represent the socioeconomic status of work-aged people but not the elderly population. In addition, the egalitarian system in Japan, which includes a health system where the elderly can gain universal access to health care with small co-payment across the country [44] and finance adjustment policy, which has eliminated the health gap throughout the country [49], appear to contribute to the small degree of significance of this relationship. This study was an ecological study, and thus the low level of significance of the relation between area indicators and mortality does not necessarily represent a poor relation at the individual level. Although individual-level studies are very limited in Japan, a previous study showed a significant but relatively weak relation between mortality and socioeconomic status measured by educational attainment at the individual level [50].

Second, for women, not female but male all-cause mortality was significantly positively correlated with WDP. It has been confirmed in previous studies that spouse's death is one of the risks for decreased physical health, including mortality and disability [51,52]. Spouse's death possibly decreases social support and increases household of single elderly, and hence increases the need for formal care services [45]. The combination of these physical and social consequents from spouse's death appears to explain the relation between female WDP and male mortality.

Indicators representing socioeconomic disadvantage were strongly correlated with WDP. The association between health and social indicators in a population-based study suggested two possible effects: compositional and contextual effects. Compositional effects reflect individual-level causation [53]. A previous study demonstrated a relation between higher long-term care prevalence and lower household income at the individual level in Japan [54]. With regard to contextual effects, ecological or area characteristics influence residents' health in a manner independent of individual factors [47]. Recent studies have high-

lighted contextual effects and demonstrated the effects on mortality, morbidity, self-rated health, and health-related behavior [55]. Although the present study could not distinguish between these two effects, individual or area socioeconomic disadvantage, characterized by increased unemployment and elderly one-person households and other indicators, seemed to contribute to the increase in elderly with disabilities or requiring long-term care.

4.4. Implications and conclusions

Previous studies using LTCI data have estimated prefectural health expectancy, not DALE but DFLE [16–19]. With regard to DFLE, the criteria for disability are critical. Some studies defined disability for all care levels of LTCI [16,18], while another defined disability for care level II and over [17]. This inconsistency would lead to different figures of health expectancy and consequent misevaluation of population health. DALE is estimated using the utility according to care levels, and thus it is independent of the disability criteria, while it depends on the utility figures. Trend analysis of DFLE and DALE showed that a decrease in the number of years of moderate and severe disabilities and an increase in that of minor disabilities caused the decline of DFLE and an increase in DALE [56]. If valid data regarding disability (or disease) prevalence by level of severity and corresponding utilities are available, the combined use of DFLE and DALE will accurately indicate the health level of the population, and contribute to health policy making.

DALE65 and LE65 were negatively associated with mortality. These associations implied that prevention of major causes of death will prolong DALE due to increased LE. In contrast, the relation between WDP and mortality was uncertain. A sound relation (higher mortality and higher WDP) was found only in male all-cause and cancer mortality for male WDP, and in male all-cause mortality for female WDP. These findings were in agreement with those of a previous study demonstrating that the elimination of highly fatal disease, such as cancer, leads to an increase in the number of years and the proportion of life with disability [57], and suggested that prevention of major causes of death has a limited contribution to decreasing the disability prevalence. As mentioned above, the positive relation between female WDP and male mortality suggested that prolonging the healthy life of female elderly subjects would be contributed to by the decrease in male mortality, as well as decreases in female mortality and disability.

With regard to socioeconomic conditions and elderly health, our results did not show a substantial relation between socioeconomic disadvantage and lower life expectancy. These findings should not be interpreted to mean that socioeconomic conditions are not important determinants of mortality in elderly populations, but that efforts to eliminate socioeconomic inequalities resulted in less relationship between socioeconomic conditions and mortality. On the other hand, the finding of strong relations between WDP and socioeconomic indicators suggested that socioeconomically disadvantaged conditions substantially influence non-fatal disease and disability, even if the influence of fatal diseases might be modest. Hence, health policies for the elderly with socioeconomic disadvantages, such as living in underprivileged areas and living alone, will contribute to an increase in healthy longevity.

In conclusion, we determined utility corresponding to LTCI data for DALE calculation feasible at local and regional levels, and then calculated prefectural DALE and WDP. As an example of the use of these indicators, the correlation with mortality and socioeconomic indicators was examined. The significant associations with socioeconomic indicators, especially for WDP, suggested that a favorable socioeconomic policy, in addition to disease prevention strategies, could contribute to significant extension of the period of independence in the elderly.

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Appendix A. Outlines of states and maximum benefits according to care level in long-term care insurance

See Table A1.

Table A1

Care level	Severity of disability	Outline of state	Estimated nursing time (min/day)	Maximum benefits (thousand yen/month)
Support	Frailty, slight impairment	Require partial assistance (supervision or help) for personal care, including cleaning rooms Sometimes require partial assistance for complex movements, such as standing and maintaining a standing position on one foot Able to do toileting and feed at meals mostly by oneself	25–30	61.5
Level I	ADL difficulties	Require partial care for personal care, such as grooming and cleaning rooms Require some support for complex movements, such as standing and maintaining a standing position on one foot Require some support for locomotion, such as walking and maintaining a standing position on both feet Able to do toileting and feed at meals mostly by oneself Sometimes have troublesome behavior and/or decline of understanding	30–50	165.8
Level II	Moderate impairment	Require partial care for personal care, such as grooming and cleaning rooms Require some support for complex movements, such as standing and maintaining a standing position on one foot Require some support for locomotion, such as walking and maintaining a standing position on both feet Sometimes require partial assistance (supervision or help) for toileting and feeding at meals Sometimes have troublesome behavior and/or decline of understanding	50–70	194.8
Level III	Severe impairment	Unable to do personal care, such as grooming and cleaning rooms by oneself Unable to do complex movements, such as standing and maintaining a standing position on one foot by oneself Unable to do locomotion, such as walking and maintaining a standing position on both feet by oneself Unable to do toileting by oneself Sometimes have several troublesome behavior and/or decline of understanding	70–90	267.5
Level IV	Severe impairment with special needs	Require full assistance for personal care, such as grooming and cleaning rooms Require full assistance for complex movements, such as standing and maintaining a standing position on one foot Unable to do locomotion, such as walking and maintaining a standing position on both feet by oneself	90–110	306.0

Table A1 (*Continued*)

Care level	Severity of disability	Outline of state	Estimated nursing time (min/day)	Maximum benefits (thousand yen/month)
		Require full assistance for toileting Sometimes have many troublesome behaviors and decline of general understanding		
Level V	Bedridden with special needs	Require full assistance for personal care, such as grooming and cleaning rooms Require full assistance for complex movements, such as standing and maintaining a standing position on one foot Require full assistance for locomotion, such as walking and maintaining a standing position on both feet Require full assistance for toileting and feeding at meals Sometimes have many troublesome behaviors and decline of general understanding	>110	358.3

One thousand yen = 9.2 US dollar and 7.5 Euro (June 2005). *Sources*: Ministry of Health, Labour and Welfare, http://www.mhlw.go.jp/topics/kaigo/ (June 2005); Study Group of Long-term Care Insurance, Laws for Long-term Care Insurance, Tokyo, Tyuohoki, 2002; and Shimanouchi S, et al., editors, Glossary of nursing/care terminology, Tokyo Horei Publishing, 2000.

Appendix B. Instruments for utility measurement of time trade-off (TTO) and standard gamble (SG)

We asked about the general state of people certificated at care level *i* of long-term care insurance.

Time trade-off (TTO)

In cases in which the state of care level *i* continues for 10 years, how many years in this health state would you consider to be equivalent to perfect health?

Standard gamble (SG)

Suppose there is a medical treatment causing a state of care level *i* to recover to perfect health. If the treatment fails, you die. What success rate would be needed for you to receive this treatment?

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