Abstract

Purpose of the Study: A great deal of research deals with the relationships between macro-level socioeconomic indicators and health expectancy measures across the world. Relatively little is known, however, about factors associated with the health expectancy of the Japanese population.

Design and Methods: We estimated disability-free life expectancy (DFLE) at 65 years of age by gender and prefecture using the Sullivan method. Data on disability prevalence are drawn from the Comprehensive Survey of Living Conditions of the People on Health and Welfare of 2010. Regression analyses are performed to investigate the association of DFLE at 65 with variables representing a prefecture's wealth, labor, and welfare characteristics.

Results: Our results show close relationships between socioeconomic factors and prefecture-level DFLE at 65. Income per capita, the proportion of workers older than 65, and welfare expenditures are positively related to DFLE at 65, whereas unemployment and Long-Term Care Insurance (LTCI) expenditures are inversely associated with DFLE at 65 for both genders, controlling for the rate of the elderly population. The proportion of the elderly relying on public assistance is related only to women's DFLE.

Implications: The present study provides strong evidence suggesting that a prefecture's wealth, labor, and welfare conditions are related to the well-being of Japanese elders. Our findings suggest that narrowing socioeconomic disparities contributes to the health status of the Japanese population. Reducing regional health disparities therefore requires policy makers to take into account the socioeconomic conditions of each prefecture.

Introduction

The Japanese population is aging at an extraordinary pace. In 2014, those who were older than 65 years of age formed 26.0% of the entire population, and this group is projected to reach 39.9% by 2060 (Cabinet Office, 2014). The proportion of the oldest old (i.e., those older than 75 years of age) is also growing fast, leading to the top-heavy population pyramid (Muramatsu and Akiyama, 2011). The growing share of the elderly has important implications for social policy in Japan, where fertility rates have long been below the replacement level. A continued expansion of the older population is likely to increase the demand for medical and health care and pension provisions, further raising the financial burden for the working-age population (Reynolds et al., 2003). With the arrival of a "super-aging" society (Muramatsu and Akiyama, 2011), growing research and policy attention has been directed toward the health status of the elderly, since an older population in good health could lessen future medical and care requirements (Jagger et al. 2008). Health expectancy decomposes life expectancy (LE) into different states of health, allowing for the investigation of health-related quality of life at any given age (Robine et al., 2003). In 2012, the Japanese government included health expectancy, precisely disability-free life expectancy (DFLE), in the national health-promotion program, the second phase of Healthy Japan 21 (Ministry of Health, Labour, and Welfare, 2013). The program aims to achieve the following two objectives for the period between 2013 and 2022: (1) to increase DFLE at a faster rate than growth in LE, and (2) to reduce regional inequalities in DFLE.

It is widely recognized that Japanese people enjoy phenomenal health, but evidence suggests emerging health differentials in the country. In 2010, for example, the gap in men's LE at birth was 3.60 years (from 77.28 years in Aomori to 80.88

years in Nagano), whereas women's LE had a range of 1.84 years (from 85.34 years in Aomori to 87.18 years in Nagano) (Ministry of Health, Labour, and Welfare, 2010). In addition, Robine et al. (2012) revealed differences in the probability of reaching age 100 across Japanese prefectures. In 2005, Okinawa had by far the highest centenarian rate at age 70 (men 196 per 10,000 people aged 70; women 801) compared to the country's average values of 65 (for men) and 209 (for women). Importantly, health expectancy varies between prefectures as well. The difference in DFLE at birth was larger than that for LE at birth for women in 2010: the gap in female DFLE was 2.95 years (from 72.37 years in Shiga to 75.32 years in Shizuoka), and the range of male DFLE was 2.79 years (from 68.95 years in Aomori to 71.74 years in Nagano) (Ministry of Health, Labour, and Welfare, 2013). These findings elucidate substantial inequalities in both longevity and health status within Japan.

As health inequalities persist, researchers have begun to analyze the ways through which disparities in health-related quality of life are produced. A 2005 cross-national analysis by Jagger et al. (2008), which included 25 European countries, recorded close relationships between healthy life years (HLYs) at 50 years of age and various socioeconomic indicators. In their study, GDP per capita and expenditure on elderly care were positively related to HLYs for both men and women, whereas long-term unemployment had negative impacts on men's HLYs. Recently, Fouweather and his colleagues (2015) repeated the same analyses and found material deprivation as an important predictor of HLYs at 50 in 2005 and 2010. This point adds to the extant literature on negative impacts of economic strain on the well-being of individuals (Mirowsky and Ross, 2001). Further, the unemployment rate was predictive of lower levels of DFLE in Great Britain (Wohland et al., 2014) and Spain (Gutierrez-Fisac et al., 2000), while per-capita GDP was linked to increases in DFLE across 31

administrative divisions of China (Liu et al., 2010). Overall, these research findings indicate a strong association between a country's wealth, labor, and welfare characteristics and the health-related quality of life of its population.

Studies examining the relationship between socioeconomic factors and health expectancy abound in many parts of the world, but few studies to date have focused on Japan. One exception is the 1999 ecological study by Kondo et al. (2005), which documents significant associations between prefecture-level DFLE at 65 and the proportion of older workers, self-rated health status, and number of nurses. There are important limitations to their study, however. First, a total of 181 variables were included in the analysis, such as climate conditions (e.g., the average differences between maximum and minimum temperatures in a day), social relationships (e.g., the percentage of people who have worries but do not know with whom to consult), and the number of deaths due to traffic accidents per 100,000 people. The rationale for choosing these factors, however, is unclear. This point is of particular relevance to public health policy in Japan, since the second phase of Healthy Japan 21 aims to narrow regional variations in DFLE. It is therefore important to suggest a framework to effectively address the problem of health inequalities in the country.

Second, the relationship between health and longevity remains to be explored. This is primarily due to the fact that the study only uses previously published values of DFLE (Hashimoto et al., 1999) and neglects information on LE. Given that DFLE is a part of LE, it is important to interpret health in relation to longevity. Finally, since the results come from 1999 data, there may be new indicators associated with area variation in health expectancy. One important factor to consider is the long-term care insurance (LTCI) policy. It was implemented in April 2000 to provide every Japanese person older than 65 years of age with in-home and institutional long-term care

services (Campbell and Ikegami, 2000; Tamiya et al., 2011; Yong and Saito, 2012). The program determines the level of care requirements on the basis of difficulties in activities of daily living (Tsutsui and Muramatsu, 2005), suggesting that the new policy might have an important bearing on the health expectancy outcomes of Japanese people.

The purpose of this research is to investigate factors associated with DFLE at 65 across 47 Japanese prefectures in 2010. Guided by previous studies on this topic (Fouweather et al., 2015; Gutierrez-Fisac et al., 2000; Jagger et al., 2008; Liu et al., 2010; Wohland et al., 2014), we pay particular attention to a prefecture's wealth, labor, and welfare characteristics. By analyzing the role of these factors in producing DFLE differentials, the present study seeks to contribute to the goal of the second phase of Healthy Japan 21: to reduce regional inequalities in DFLE for the period between 2013 and 2022. Moreover, this work focuses on DFLE at older ages, which allows us to identify the key determinants of health-related quality of life among Japanese elders. The discussion that follows is divided into three sections. We begin by describing our data, methods, and analytical strategy. We then conduct regression analyses to examine factors associated with prefecture-level DFLE at 65. In the final section, we discuss the implications for public policy and future research.

Design and Methods

Data

DFLE at 65, denoting the number of expected years without disability at 65 years of age, by gender and prefecture, are computed by the Sullivan (1964) method. This method requires data on mortality and the age- and gender-specific prevalence of health conditions. Mortality data for this study come from prefecture-specific life

tables published in 2010. The Japanese government publishes age-abridged life tables for each prefecture every five years. The current work uses the latest data of 2010. We focus on the prevalence of disability as a measurement of health. Data on disability are drawn from *Kokumin Seikatsu Kiso Chosa* (Comprehensive Survey of Living Conditions of the People on Health and Welfare) of 2010. Our research uses the 2010 data, because the most recent prefecture-level life tables are from 2010. This study defines disability to be applicable to either of the following two questions: (1) Are you currently institutionalized in hospitals, clinics, or long-term care facilities? (2) Do you have any limitations in carrying out normal activities due to health problems? We estimate the proportion of respondents who answered "yes" to either question in each prefecture, and then combine it with the information about mortality taken from the life tables.

Prefecture-level socioeconomic indicators

To investigate factors associated with DFLE at 65 across 47 Japanese prefectures, we follow previous studies (Fouweather et al., 2015; Gutierrez-Fisac et al., 2000; Jagger et al., 2008; Liu et al., 2010; Wohland et al., 2014) and focus on the following three domains of a prefecture's socioeconomic conditions that might be relevant to health: wealth (i.e., annual income per capita), labor (i.e., the unemployment rate and the proportion of workers older than 65 years of age), and welfare (i.e., the rate of welfare expenditures, expenditures on the LTCI program per capita, and the proportion of the elderly protected by public assistance). We estimate LTCI expenditures per capita by dividing the total amount of LTCI expenditures by the number of LTCI recipients older than 65 years of age in each prefecture. We use information on public assistance as a proxy for material deprivation. Note that since the number of recipients of public assistance is heavily influenced by the population

size of the prefecture, we estimate the proportion of elders who receive public assistance by dividing the number of older people (65 and above) protected by public assistance by the number of individuals older than 65 years of age. Details about each indicator, including definitions, coding strategy, and data sources, are provided in Table 1. All information is collected for 2010.

Analytical strategy

The unit of analysis in the present study is a prefecture, and there are in total 47 prefectures in Japan. To investigate the relationship between prefecture-level DFLE at 65 and a set of socioeconomic indicators, we conduct variance-weighted least-squares regression analyses. This strategy takes into account varying degrees of precision around the dependent variable (here prefecture-specific DFLE at 65) by using inverse-variance as a statistical weight. Prefecture-specific DFLE at 65 is the dependent variable in all models. We first test bivariate relationships between DFLE at 65 and each socioeconomic indicator (model 1), and we then add the rate of the population older than 65 years of age as a control (model 2). Prior to estimating the models, we plotted the relationships between DFLE at 65 and each independent variable to identify influential data points. We present results from the regression models without adjusting for influential observations, because doing so did not alter our results. All analyses are performed separately for men and women.

[Table 1, about here]

Results

Descriptive statistics

Table 2 provides descriptive information for all the variables included in the analysis. In 2010, 65-year-old Japanese men on average could expect to live an

additional 12.3 years without disability (ranging from 11.4 years in Nagasaki to 13.4 years in Ibaraki). The average for women was 14.3 years, ranging from 13.2 years in Tokushima to 16.0 years in Shizuoka. The spread in DFLE at 65 is larger for women than for men (2.8 years and 2.0 years, respectively).

In addition, levels of socioeconomic development vary greatly by prefecture. In 2010, annual income level ranged from 2,025,000 yen in Okinawa (approximately 16,300 USD, 1 USD=120 yen) to 4,306,000 yen in Tokyo (34,600 USD) per person, suggesting that Okinawans earned less than half of individuals in Tokyo. Large disparities are observed for the rest of the variables, but differences in welfare characteristics are of particular importance. LTCI-related expenditures per capita ranged from 192,000 yen (16,000 USD) in Saitama to 314,000 yen (26,200 USD) in Okinawa. Further, the proportion of elders who rely on public assistance reached more than 4.5% of the older population in Tokyo (for men) and Okinawa (for women), while only 0.3% of older men and women in Toyama lived on public assistance in 2010. These results show that between-prefecture variations in wealth, labor, and welfare characteristics remain quite large, challenging the traditional notion that Japan is a uniquely homogeneous society (Nakane, 1970). Our next task is to investigate to what extent these differences in socioeconomic conditions translate into health status.

Regression analyses

Table 3 presents the results of regression analyses, which assess the importance of a prefecture's wealth, labor, and welfare characteristics on health expectancy. Income per capita, unemployment levels, the rate of workers older than 65 years of age, welfare expenditures, and LTCI-related expenditures are strongly related to DFLE at 65 for men and women (model 1). The association between these variables and DFLE at 65 remains significant for both genders even when the rate of

the elderly population is adjusted for (model 2). Here, it is important to note that the estimated effects of these variables are in the expected direction: Higher levels of a prefecture's wealth and welfare are positively related to the duration of disability-free life at age 65, while the rise in unemployment is inversely associated with DFLE at 65 for men and women. Importantly, the larger the LTCI-related expenditures, the shorter the length of disability-free life at 65. The variable with the largest impact is income per capita. A one-percent increase in income per capita is associated with an improvement of DFLE at 65 of 1.41 years (about 17 months) for men and 1.46 years (about 18 months) for women (model 1). Although the relationship of income to DFLE at 65 is slightly attenuated with the addition of the control variable, results remain statistically significant at the 0.01 level for both genders (model 2). The impact of public assistance greatly differs by gender. The proportion of older people who receive public assistance is strongly and negatively related to DFLE at 65 for women only.

[Tables 2 and 3, about here]

Discussion

Our results indicate associations between a prefecture's wealth, labor, and welfare characteristics and health, as measured by DFLE at 65. Although it has been suggested that Japan is a homogeneous society with little internal variation (Nakane, 1970), the findings of the present study reveal wide disparities in socioeconomic development levels across prefectures and further demonstrate how these differences translate into health inequalities across prefectures. Our findings add to the existing literature on the structural determinants of population health and have important social policy implications.

First, we found a positive relationship between income per capita and DFLE at 65. Income has the highest impact on DFLE at 65, and its effect remains significant in all models for both men and women. A diverse literature suggests that higher income contributes to health (Backlund et al., 2007; Kawachi and Kennedy, 1997), helping individuals have access to health-related resources, such as a healthy diet, medication, and a less stressful living environment (Link and Phelan 1995; Phelan et al., 2010). Our results offer strong support for these patterns. A one-unit increase in per-person income represents an increase in DFLE at 65 of more than 15 months for Japanese men and women. In contrast, material deprivation, measured by the proportion of the elderly who receive public assistance, is associated with a reduction in DFLE at 65, although the impact is observed only for women. This is in line with previous research findings about a link between poverty and poor health (Mirowsky and Ross, 2001). Recently, the number of individuals who rely on public assistance has been increasing in Japan, and older people account for the large proportion of recipients (Ministry of Health, Labour, and Welfare, 2014). Indeed, a large number of women, particularly independent-living older women, live on public assistance, which might explain the significant effect of public assistance on female DFLE. Overall, these findings raise the possibility that welfare programs, particularly those targeted at improving the living conditions of older adults, may have important consequences for their health status. In fact, our results further support this point by showing a positive impact of welfare expenditure levels on DFLE at 65 for both men and women.

Second, labor conditions are important for Japanese men's and women's health. Unemployment is inversely related to DFLE at 65: a one-unit increase in the unemployment rate is associated with a reduction of 1.4 disability-free months for men and 3.7 months for women. Although information on unemployment in this study

is not restricted to the older population, we recorded a negative relationship between the overall unemployment rate and the well-being of the elderly. On the other hand, active labor participation is related to increases in disability-free life for both genders: higher levels of elderly workers are predictive of longer DFLE at 65. It has been suggested that levels of later-life labor force participation are higher in Japan (Raymo et al., 2004). Older men and women in Japan, for example, had the highest labor force participation rates of the OECD countries in 2009 (29.4% and 13.1%, respectively) (OECD, 2010). This may be due to efforts on the part of both the public and private sectors to retain employees past the retirement age and to promote re-employment of retirees as temporary workers. The Silver Human Resources Centers (SHRCs), for instance, help older people continue to work after retirement within temporary employment. A great deal of research suggests that continued participation in society helps older individuals to stay physically and mentally healthy (Minagawa and Saito, 2014; 2015). Shirai et al. (Shirai et al., 2006), indeed, found that participation in SHRC activities is predictive of improved well-being, known as *ikigai*, among SHRC members in Osaka. Our findings lend further support for the beneficial health consequences of active social participation among older men and women in Japan.

Finally, the impact of the LTCI policy deserves special note. Our work showed a negative relationship between per-capita LTCI expenditures and DFLE at 65 for both genders. A large number of older people with disabling conditions may increase the demands for care services under the LTCI scheme, leading to higher levels of LTCI expenditures. The program provides older adults with various types of care services, such as bathing and toileting, care management counseling, and financial assistance for purchasing aiding devices, and these services are made available through tax revenues, income-tested premiums, and co-payments. Debate

continues regarding the feasibility of the LTCI program in the face of large increases in LTCI-related expenditures (Tsutsui and Muramatsu, 2007). Our results show that higher levels of LTCI expenditures are related to reductions in disability-free life at 65. The Japanese government has focused on active aging as the key to achieving successful aging. The present findings raise the possibility that improving the health of older people through active aging could have important implications for the financial status of local governments.

This study has several strengths. We utilized the most recent prefecture-level life tables and estimated DFLE at 65 for each prefecture in 2010. Estimates of prefecture-specific DFLE were published in 2010, but results are available only for DFLE at birth. The present findings advance our understanding of the distribution of health expectancy at older ages across prefectures. Further, this work offers a systematic study of the socioeconomic factors associated with DFLE. Prior research on the structural determinants of health expectancy (Fouweather et al., 2015; Gutierrez-Fisac et al., 2000; Jagger et al., 2008; Liu et al., 2010; Wohland et al., 2014) provided the conceptual framework for this study and helped to formulate our analyses. While past work included a wide range of economic, social, physical, and demographic variables (Kondo et al., 2005), we narrowed the focus of the investigation down to a prefecture's wealth, labor, and welfare characteristics, and we demonstrated how health disparities are manifested through differences in macro-level socioeconomic conditions.

Despite these strengths, this research has some limitations. Our first limitation has to do with the independent variables. Drawing on prior research findings, we focused only on macro-level socioeconomic indicators, thereby ignoring the influences of individual-level factors. This is known as ecological fallacy. A growing

body of work shows how macro- and individual-level factors interact and jointly produce health inequalities at the country level (Eikemo et al., 2008; Olsen et al., 2007). Further, in addition to wealth, labor, and welfare, there might be other factors influencing population health. Guitierrez-Fisac et al.'s (2000) study reported a negative association between the percentage of smokers in the population and DFLE at birth across Spanish provinces. Information on health behaviors might help us to capture the potential impacts of individual characteristics on health outcomes. Overall, extending the present results to incorporate other macro- and micro-level indicators is an important direction for future research. Another limitation is that those who are residing in elderly nursing homes are excluded from the computation of DFLE at 65. Although our disability measure accounts for institutionalization in hospitals, clinics, or long-term care facilities, information on elderly nursing homes is missing. Recently, substantial efforts have been made to understand the health of institutionalized individuals (Yong and Saito, 2009). Future studies will benefit from incorporating data on institutionalization and produce more precise estimates of health expectancy. Also, it is important to note that, like many studies in this area, our work has been limited by reliance on cross-sectional data. Although our results suggest the importance of a prefecture's wealth, labor, and welfare conditions in determining health, these results are not definitive in their inference of causality.

Taken together, our results suggest what may work in reducing inequalities in health expectancy in the Japanese context. Efforts toward expanding income and welfare expenditures, encouraging labor force participation after retirement, and combating unemployment and poverty at the prefecture level have the potential to contribute to the narrowing of the regional gap in elderly well-being. A prolonged economic recession since the late 1990s has generated public discourse regarding the

fact that Japan has become a country with social disparities and large class differences (Ishida and Slater, 2011). Our results indicate that emerging socioeconomic inequalities may have significant impacts on the health status of the population. The second phase of Healthy Japan 21 aims to decrease DFLE differences, but achieving this goal may require policymakers to address much broader issues currently facing Japanese society.

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Table 1. Socioeconomic factors included in the analysis.

Measures	Definitions	Coding
Wealth		
Income per capita	Income per person (annul)	logged
Labor		
Unemployment	Unemployment rate for each gender	in percentage
65+ worker rate	Proportion of employees (65+)	in percentage
Welfare		
Welfare expenditures	Proportion of social welfare expenditure in prefectural budget	in percentage
LTCI expenditures per capita	Per capita LTCI-related expenditures March 2010 to February 2011	in 10,000 yen
65+ recipients of public assistance	Proportion of older people protected by public assistance (65+)	in percentage

Note: Information on income per capita, unemployment, the elderly worker rate, and welfare expenditures comes from Social Indicators by Prefecture, 2014. Data on the elderly who receive public assistance are constructed from Overview of the Report on Welfare, 2010. Data on LTCI expenditures are taken from the Report on LTCI Activities, 2010.

Table 2. Descriptive statistics.

	Mean	Min.	Max.
Dependent variables			
Male DFLE at 65	12.3	11.4	13.4
Female DFLE at 65	14.3	13.2	16.0
Independent variables			
Income per capita (in 1,000 yen)	2,654.8	2,025.0	4,306.0
Unemployment rate (%)			
- Men	7.7	5.6	13.1
- Women	4.9	3.2	8.2
65+ worker rate (%)	20.2	15.2	26.7
Welfare expenditures (%)	3.9	2.7	5.5
Per-capita LTCI expenditures per capita (in 10,000 yen)	26.5	19.2	31.4
65+ recipients of public assistance (%)			
- Men	1.2	0.3	4.7
- Women	1.3	0.3	4.9
Control variable			
The rate of 65+population (%)	24.6	17.4	29.6

Table 3. Estimated relationships between DFLE at 65 and prefecture-level socioeconomic factors, 2010.

	Men		Women	
	Model 1	Model 2	Model 1	Model 2
Wealth				
Income per capita (ln)	1.41***	0.82**	1.46***	1.45***
Labor				
Unemployment rate (%)	-0.13***	-0.12***	-0.34***	-0.31***
65+ worker rate (%)	0.08***	0.08***	0.16***	0.16***
Welfare				
Welfare expenditures (%)	0.29***	0.17***	0.18***	0.11***
Per-capita LTCI expenditures (10,000 yen)	-0.08***	-0.06***	-0.08***	-0.08***
65+recipients of public assistance (%)	-0.003	-0.01	-0.29***	-0.30***

Note: Model 1 estimates bivariate relationships between DFLE at 65 and each indicator. Model 2 adjusts for the rate of the population older than 65.
***p<0.001; **p<0.01

Appendix 1. Distribution of disability-free life expectancy (DFLE) at 65 across 47 prefectures, 2010

	Men	Women
	DFLE 65	DFLE 65
Hokkaido	12.2	14.4
Aomori	11.8	13.6
Iwate	11.7	13.9
Miyagi	12.3	14.4
Akita	12.4	14.3
Yamagata	12.2	14.3
Fukushima	12.2	13.8
Ibaraki	13.4	14.7
Tochigi	12.4	14.5
Gunma	12.6	15.2
Saitama	12.5	14.0
Chiba	13.3	14.4
Tokyo	12.6	14.6
Kanagawa	12.9	15.2
Niigata	12.1	14.6
Toyama	12.1	14.5
Ishikawa	12.8	14.6
Fukui	12.3	14.6
Yamanashi	12.5	15.3
Nagano	12.6	14.5
Gifu	12.4	14.6
Shizuoka	13.2	16.0
Aichi	12.9	15.2
Mie	12.6	14.0
Shiga	12.5	13.7
Kyoto	12.9	14.4
Osaka	11.7	13.5
Hyogo	11.8	13.9
Nara	12.1	13.6
Wakayama	12.3	13.9
Tottori	12.1	14.4
Shimane	12.4	15.0
Okayama	11.5	13.7
Hiroshima	12.2	13.4
Yamaguchi	12.1	14.7
Tokushima	12.2	13.2
Kagawa	12.2	14.1
Ehime	11.9	14.0
Kochi	11.6	14.3
Fukuoka	12.0	13.5
Saga	11.6	13.9
Nagasaki	11.4	13.3
Kumamoto	12.4	14.4
Oita	11.7	13.6
Miyazaki	12.9	15.1
Kagoshima	12.5	14.8
Okinawa	12.9	15.5