

RESEARCH ARTICLE

Diagnosis and control of hypertension in the elderly populations of Japan and the United States

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Abstract: The Japanese have the highest life expectancy in the world while the United States (U.S.) has relatively low life expectancy. Furthermore, the Americans have relatively poorer health compared to the Japanese. Examination of the treatment of specific conditions such as hypertension in these two countries may provide insights into how the health care system contributes to the relative health in these two countries. In this study, we focus on the treatment of hypertension, as this is the most common condition requiring therapeutic interventions in seniors. This study examines hypertension diagnoses and controls in nationally representative samples of the older populations (68 years old or older) of Japan and the U.S. Data come from two nationally representative samples: the Nihon University Japanese Longitudinal Study of Aging (NUJLSOA) ($n = 2,309$) and the U.S. Health and Retirement (HRS) Study ($n = 3,517$). The overall prevalence of hypertension is higher in Japan than the U.S. Undiagnosed hypertension is about four times higher in Japan than in the U.S., while the control of blood pressure is more than four times higher in the U.S. than in Japan. Thus, the use of antihypertensive medication is much more frequent and more effective in the U.S. The medical care system seems to be more effective in controlling hypertension in the U.S. than in Japan. This may be due to the more aggressive diagnosis and treatment of hypertension in the U.S.

Keywords: control, diagnosis, hypertension, public health, older adults

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1. Introduction

Studies conducted throughout the world have shown that prolonged hypertension leads to an increased risk of heart disease, stroke, kidney disease, and death (Benetos, Safar, Rud-nichi *et al.*, 1997; Coresh, Selvin, Steven *et al.*, 2007; Digiovanna, 1999; Franklin, Larson, Khan *et al.*, 2001; MacMahon, Peto, Cutler *et al.*, 1990). Hypertension is one of the major controllable risk factors for poor health outcomes in old age. The number of older persons around the world using medication to lower blood pressure is growing. National differences in the effectiveness of hypertension diagnosis and treatment should relate to overall differences in population health and mortality. Japan is a world leader in life expectancy while the United States (US) lags behind Japan and many other advanced countries. These differences lead to questions about how Japan does so well in promoting long life and why the United States does so poorly. It has been suggested that Japan's public health emphasizing on hypertension treatment has been an important factor in reducing stroke mortality and raising life expectancy (Murray, 2011). A detailed comparison of how hypertension diagnosis, treatment, and control differ between the two countries could provide some insights into overall health differences. Furthermore, the diagnosis and the control of hypertension among the elderly provide insights into the overall quality of national health care systems in caring for their elderly populations.

Paradoxically, the incidence of hypertension in Japan is known to be relatively high; while that in the US is relatively low (Crimmins, Vasunilashorn, Kim *et al.*, 2008; Marmot, Syme, Kagan *et al.*, 1975; Crimmins, Garcia, and Kim, 2010). National levels of hypertension may reflect differences in culture, social factors, epidemiological history, and health care policies as well differences in various dietary styles and genetic components at individual level. One important factor in national differences in the prevalence of high blood pressure is the use of antihypertensive medication which has resulted in lowered levels of hypertension among older persons in Japan and in the U.S. (Ikeda, Gakidou, Hasegawa *et al.*, 2008). Antihypertensive medication usage increased earlier and remains higher in the U.S. than Japan (Crimmins, Garcia, Kim *et al.*, 2010; Ikeda, Gakidou, Hasegawa *et al.*, 2008).

This study is unique in using individual level data from two nationally-representative studies to examine hypertension among those 68 years of age and older in the U.S. and Japan. Many studies of hypertension are based on local or regional samples and are not representative of the entire country. In addition, this study utilizes both self-report and measured blood pressure so that a more complete picture of hypertension in the elderly population is provided. This results from the comparisons not only of measured high blood pressure but also of undiagnosed, controlled and uncontrolled high blood pressure. This is possible because measured blood pressure has recently been added to the U.S. Health and Retirement Study (HRS) and the Nihon University Japanese Longitudinal Study of Aging (NUJLSOA), providing an opportunity for a comparative analysis between national samples of these two countries. These longitudinal studies already included self-reports of hypertension and use of antihypertensives. This is the first cross-national comparison using measured blood pressure indicators based on individual level data for these two countries. This allows us to examine the associations between demographic factors and the prevalence, diagnosis, and control of hypertension in the two countries.

The questions that will be addressed in this paper are: (i) how do levels of overall hypertension, and diagnosed and undiagnosed hypertension differ among older persons in Japan and the U.S.; (ii) how does antihypertensive medication use and control of hypertension differ by country; and (iii) how are these measures of hypertension and control of hypertension associated with measured systolic blood pressure.

2. Data and Methods

2.1 Data Sources

This study used data from the 2006 (fourth wave) of the Nihon University Japanese Longitudinal Study of Aging (NUJLSOA), and data from the 2006 Health and Retirement Study (HRS). The NUJLSOA is a nationally representative sample of the Japanese population aged 65 and older at baseline collected by researchers at Nihon University. The fourth wave contains data from participants aged 68 years and older. Complete information on the design and methods of the study can be found on the website of the survey (Nihon University Japanese Longitudinal Study of Aging).

The fourth wave of the survey includes 3,403 participants, of whom approximately 68% participated in the collection of blood pressure measurements ($n = 2,330$). Our sample consists of the 2,309 cases for whom both measured and self-reports of hypertension are available. The average age of the sample was 76.1 years, of whom 54.9% were female. The participants who were missing on measured blood pressure differed from those included in the analysis in that they were older (1.01 years, $p < 0.01$) and had lower rates of antihypertensive medication usage (9%, $p < 0.01$).

The Health and Retirement Study (HRS) surveys more than 22,000 Americans over the age of 50 every two years. Data for the eighth wave of HRS used in this study were collected in 2006, the same time as the fourth wave of NUJLSOA. A detailed description of the study is provided at a website hosted by the University of Michigan. Half of the HRS 2006 sample was randomly chosen to participate in an enhanced face-to-face interview where blood pressure was measured. Respondents who used a proxy or who resided in a nursing home did not have measured blood pressure. The total number of the respondents who participated in the enhanced face-to-face interviews and who were 68 years of age and over was 4,730; of these 1,137 did not have blood pressure measurements and were not included in this study. The sample of 3,517 with information on both measured and self-reported hypertension used for this study was quite similar in composition to the Japanese sample and included 58.8% females and had an average age of 76.7. Relative to those included in the analysis, the participants who were missing on blood pressure measurements were older (3.21 years, $p < 0.01$). There was no significant difference in antihypertensive medication usage ($p = 0.97$) between those included in the study and those who were missing on blood pressure measurements.

2.2 Measurements

Protocols for blood pressure recordings were almost identical between HRS and NUJLSOA except that the measurements were taken during the midst of an interview for HRS and at the end of an interview for NUJLSOA. The blood pressure monitor used in NUJLSOA was OMRON HEM-762 (OMRON, Kyoto, Japan) and for HRS it was OMRON HEM-780N (OMRON, Kyoto, Japan); the device has been validated in independent studies (Shirasaki, Asou and Takahashi, 2007). Blood pressure was measured three times with approximately one minute between each measurement and the average of the available readings was used for analysis. If fewer than three readings were recorded, then the average of those readings was included. The participant was generally in a seated position and the recording was generally performed on the left arm for both surveys.

Measured hypertension is a binary variable that indicates a person had an average systolic measurement of 140 mmHg or greater and/or a diastolic measurement of 90 mmHg or greater. Use of antihypertensive medication was reported in the same way in both surveys. Respondents who responded affirmatively to ever having been diagnosed or having

experienced hypertension were then asked if they used medication for the condition. Overall hypertension is indicated by either having measured hypertension or using medication. [Table 1](#) presents descriptive measures on the sample and for the hypertension measures.

By utilizing measured hypertension and diagnosed hypertension, we are able to divide the total population into four hypertension categories: healthy, undiagnosed hypertension, controlled hypertension, and uncontrolled hypertension. Healthy was defined as not having measured hypertension and reporting that one has never been diagnosed with or experienced hypertension. Undiagnosed hypertension was defined as having measured hypertension but reporting that one has never been diagnosed with or experienced hypertension. Uncontrolled hypertension was defined as having measured hypertension and reporting hypertension. Controlled hypertension was defined as having been diagnosed with or experiencing hypertension and having measured systolic blood pressure of less than 140 mmHg and diastolic blood pressure of less than 90 mmHg.

2.3 Statistical Methods

All analyses were weighted and conducted on Statistical Analysis System (SAS) 9.2 (SAS Institute Inc. Cary, NC). To account for missing data on measured blood pressure, an adjusted weight was created for NUJLSOA by multiplying the normalized weight of the sample which accounted for the lack of survey response and differential selection by age by the inverse of the predicted probability that each participant would have a blood pressure measurement. The predicted probability was based on age, sex, and level of education. It was used in all analyses. For the HRS, sample weights which accounted for survey non-response, nonresponse to the blood pressure measurement, and initial probability of selection were provided by the survey and were used for all analyses.

3. Results

3.1 Descriptive Results

[Table 1](#) indicates that Japanese over age 68 are almost twice as likely as their American counterparts to be measured as hypertensive (74.3% versus 39.5%). By contrast, Japanese persons are significantly less likely to report that they have been diagnosed with hypertension (37.9% in Japan vs 64.1% in the U.S.). Older Japanese are also much less likely to use antihypertensive medication than their American counterparts (36.0% vs 59.7%). The overall prevalence of hypertension, which includes either measured hypertension or use of medication, is also significantly higher in Japan than in the U.S. (82.0% vs 74.1%).

We then integrated self-reports and measured levels to examine the prevalence of diagnosis and control. We find that there are much higher rates of undiagnosed hypertension in Japan (44.3%) than in the U.S. (11.9%) for this older age group ([Table 2](#)). In addition, the

Table 1. Measured, self-reported hypertension, use of hypertensives, overall hypertension by country

	Japan Percent of total sample	United States Percent of total sample
Measured Hypertension	74.3 (72.5–76.1)	39.5 (37.8–41.1)
Self-Reported Hypertension	37.9 (35.3–40.0)	64.1 (62.5–65.7)
Use of Antihypertensives	36.0 (34.0–38.0)	59.7 (58.1–61.4)
Overall Hypertension	82.0 (80.4–83.6)	74.1 (72.6–75.5)
<i>n</i>	2309	3517

Table 2. Hypertensive states: healthy, undiagnosed, controlled, uncontrolled by country

	Japan Percent	United States Percent
Healthy	17.8 (16.1–19.3)	24.0 (22.6–25.4)
Undiagnosed	44.3 (42.2–46.4)	11.9 (10.8–12.9)
Controlled	8.0 (6.8–9.1)	36.5 (34.9–38.1)
Uncontrolled	29.9 (28.1–31.9)	27.6 (26.1–29.5)
Total	100.0	100.0
<i>n</i>	2309	3517

Japanese also experience much lower levels of controlled hypertension (8.0%) compared to the U.S. (36.5%). However, uncontrolled blood pressure is not significantly different in the U.S. (27.6%) and Japan (29.9%). The proportion healthy (without any hypertension) is somewhat higher in the U.S. (24.0% vs 17.8%).

3.2 Blood Pressure Values in the U.S. and Japan

In order to increase our understanding of the reasons for the large differences reported above, we examined the distribution of systolic and diastolic blood pressure levels in the total samples (Figure 1) and systolic pressure among those who are classified as having no hypertension, undiagnosed hypertension, controlled, and those with uncontrolled hypertension who are taking medications (Figure 2). This detail indicates the sources of the differences in hypertension as well as providing some idea of how much blood pressure needs to be changed to achieve control. The modes of the distributions of systolic and diastolic blood pressure for the Japanese sample are 20 and 10 percentage points higher than those for the American sample (Figure 1). The Japanese group also has a higher level of systolic blood pressure in each of the subcategories (Figure 2). In those with no hypertension, 53% of Japanese have systolic blood pressures between 130 and 139, more than twice as many as that of Americans (24%). This group is considered pre-hypertensive and at high risk of developing hypertension. Many clinicians would consider recommending lifestyle adjustments to these pre-hypertensive individuals to lower blood pressure. Among those who have uncontrolled systolic hypertension, more Japanese than Americans have a level of blood pressure higher than 160 mmHg. Among those with controlled systolic hypertension the levels of blood pressure are also considerably higher among Japanese, with 64% of Japanese in the 130–140 range, and just 31% of Americans in that category. This indicates that treating blood pressure is much less effective in controlling blood pressure in Japan. This could be the result of differences in aggressiveness of treatment,

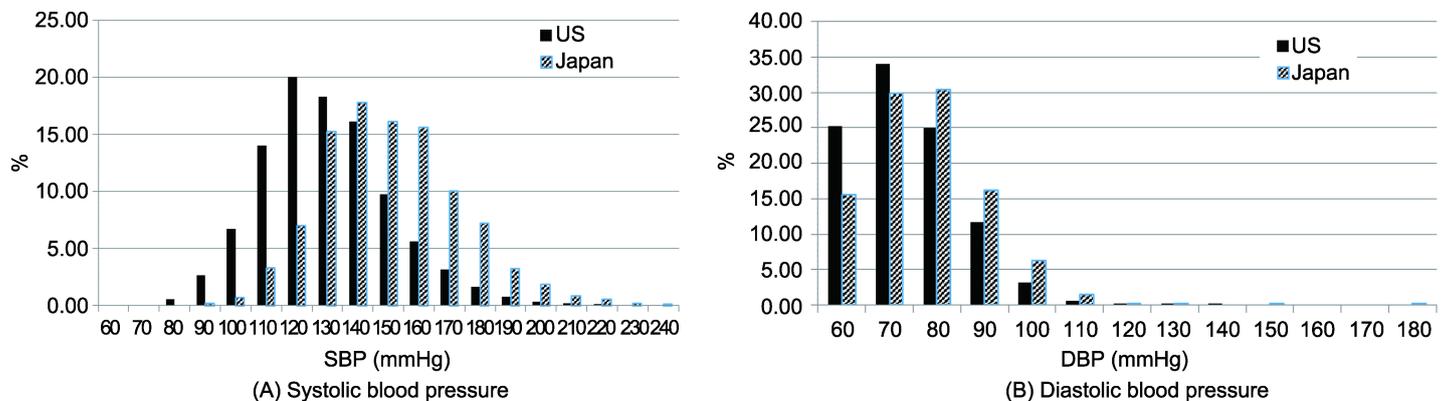


Figure 1. Distribution of (A) systolic blood pressure (SBP) and (B) diastolic blood pressure (DBP) measurement: Japan and U.S.

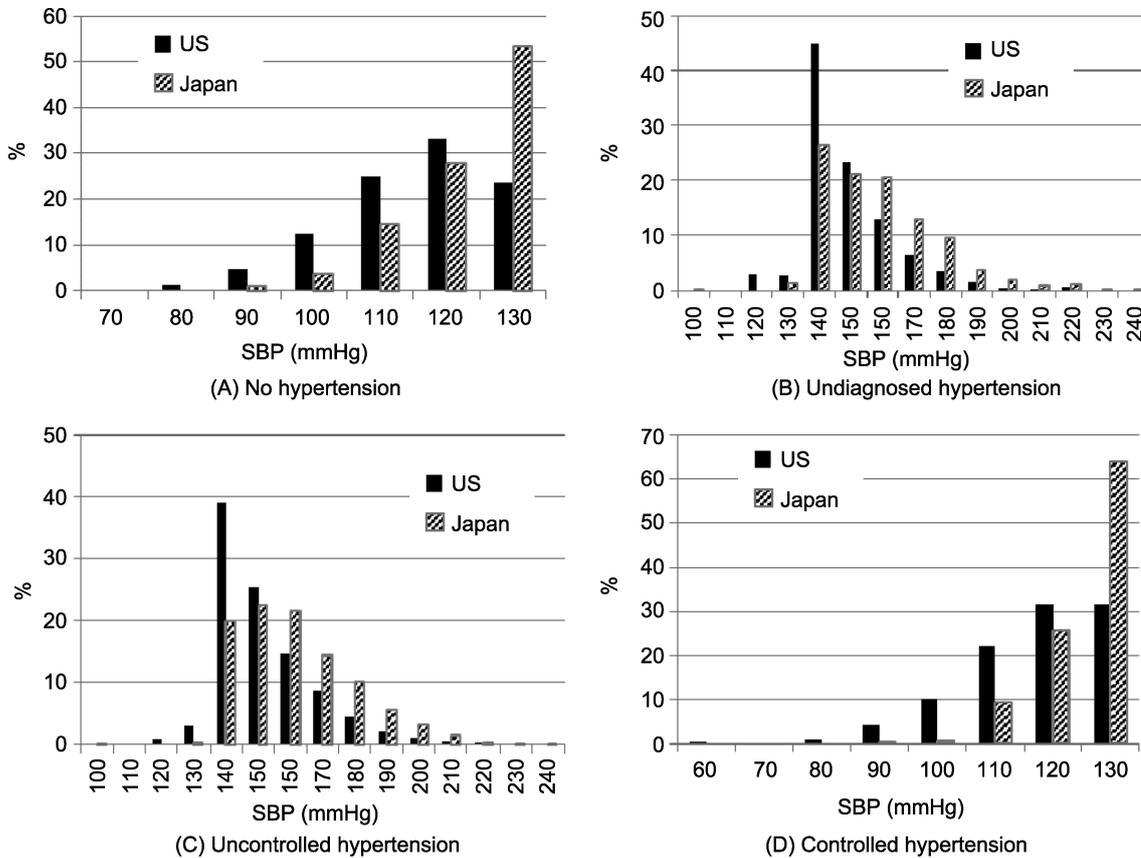


Figure 2. Distribution of measured systolic blood pressure (SBP) by hypertensive state.

different drug regimens (Singer, Izhar and Black, 2002), drug titration, patient compliance with medication (Cushman and Basile, 2006), physician compliance with recommended blood pressure levels (Oliveria, Lapuerta and McCarthy *et al.*, 2002), or resistance of hypertension to treatment (Singer, Izhar and Black, 2002).

4. Discussion

This study examined differences in hypertensive states and the levels of blood pressure among older persons in Japan and the U.S. Older Japanese persons have more hypertension arising from higher levels of both systolic and diastolic blood pressure. We find Japan has more undiagnosed hypertension and less controlled hypertension among those who take medications. The lower level of diagnosis, treatment, and effective control of blood pressure in Japan is somewhat surprising given the impressively high life expectancy and universal health care. However, previous studies in Japan had indicated that 80% to 90% of hypertensives aged 30 to 40 were not treated (Ministry of Health, Labor and Welfare, 2009). Other studies in Japan have reported a lack of control for about half of those taking antihypertensive medication (Hozawa, Ohkubo, Kikuya *et al.*, 2002; Ohkubo, Obara, and Funahashi, 2004). There are two sources of published data on measured hypertension in the Japanese population 70 years of age and older. Both of these indicate lower levels of measured hypertension than found here. The Fifth Japanese National Survey of Circulatory Disorders in 2000 reports 67% of those aged 70 and older have measured hypertension (Ministry of Health, Labor and Welfare, 2009); in the National Health and Nutrition Survey (NHNS) for 2006 the figure is 55% (Ministry of Health, Labor and Welfare, 2009); we report 74% among those aged over 68. We should note that in the NUJLSOA, blood pres-

sure was measured as part of a home interview; while both the survey of circulatory disorders and the NHNS required measurement at a site away from home. The need to leave home in order to be included in a study is one cause of underrepresentation of the oldest and most frail; only 7.0% of the NHNS sample was 85 years or older and only 1.4% was 90 years or older, compared to 11.9% and 3.3% in the NUJLSOA. On the other hand, younger people are more represented in the NHNS, 18.1% of the sample persons aged 68 and older is 68 and 69 years of age, whereas only 12.6 % of the NUJLSOA is in these two ages. People who are sicker and frailer are also less represented in the NHNS. The proportion of the sample aged 68 and older with a lot of difficulty in performing activities of daily living is almost twice as high as (1.81 times) in the NUJLSOA. Because the NUJLSOA is an ongoing longitudinal study, sicker people are more likely to continue to participate than if they were being newly recruited to a study. In addition, measurement at home, as is done in the NUJLSOA, could raise measured blood pressure because of a “reverse white coat” syndrome. Blood pressure measurement at home has been reported to exceed measurement in clinics in Japan (Liu, Roman, Pini *et al.*, 1999; Selenta, Hogan and Linden, 2000; Wing, Brown and Beilin, 2002). Comparison of home versus clinic measurement in one Japanese study among hypertensives indicated an increase of 12% in those measured as uncontrolled at home (Obara, Ohkubo, Funahashi *et al.*, 2005). Because both the Japanese study and the U.S. study were conducted at home with similar instruments and because both are weighted to represent the population aged 68 and older, they should be comparable in measured hypertension; however, the differential timing of the blood pressure measurement in the two studies could have potentially resulted in a relative increase in Japanese blood pressure.

The lack of hypertension diagnosis and lack of hypertension control is unlikely to be explained by a lack of contact with the medical system in either Japan or the U.S. Japan is a country where the population has very high medical contacts. The average reported number of physician visits in the year prior to survey for this Japanese sample was 20.9 and this does not vary much by hypertensive state. Even the undiagnosed and the uncontrolled hypertensives average 21 and 20 doctor visits in the past year, respectively. Older Americans in the HRS reported many fewer doctor visits, e.g., who were over age 68 reported an average of 5.5 visits in the year prior to survey, those with undiagnosed hypertension having 3.5 visits and those with uncontrolled hypertension having 5.3 visits. There are few people in both countries who reported not seeing a physician at all in the year prior to survey. In Japan, no one reported not having had a doctor’s visit in the year prior to survey, whereas this was true of only 7.1% of the Americans. However, this value was higher among Americans with undiagnosed hypertension, 17.4%. Thus, it does not appear that medical exposure is responsible for the lack of hypertension diagnosis or control in Japan; instead it could be a factor in the lack of diagnosis in the U.S.

The high frequency of medical visits in Japan is in part due to the practice of providing prescriptions for short time periods. In 2006, most drugs could only be prescribed for a thirty-day period and selected drugs for only a fourteen-day period in Japan. Renewing a prescription required another doctor visit. By contrast, prescriptions can be renewed for 3 months or even longer time periods in the U.S. and renewal can also be done by phone. This practice of required physician visits could also result in patients in Japan being more likely to be non-compliant with anti-hypertensive medication regimens.

An explanation for why more people might remain undiagnosed in Japan than the U.S. is that some specialists in Japan do not routinely measure blood pressure as part of a doctor visit. For instance, departments in hospitals for treatment of eyes, ears, and orthopedics, do not routinely perform blood pressure measurement in Japan. A second potential explanation for differences in hypertension control is the difference in the pattern of prescribed

antihypertensives. The improvement of blood pressure control in the U.S. in recent years (Crimmins, Garcia, and Kim, 2010; Cutler, Sorlie, Wolz *et al.*, 2008; Hajjar and Kotchen, 2003) is generally credited to the increasing use of polytherapy (concomitant prescription of multiple classes of antihypertensive medications). In 2004, approximately 60% of anti-hypertension drug treatment regimens involved multiple drugs (Ma, Lee, and Stafford, 2006). In 2002 a large study of Japanese treatment of hypertensives found that combination therapy occurred in only 35.3% of patients (Mori, Ukai, Yamamoto *et al.*, 2006). Another possible explanation for the observed differences could be goal-oriented management of hypertension which is more common in the U.S. while a fixed drug treatment algorithm is more common in Japan (Cushman and Basile, 2006).

All of these factors point to interventions in clinical practice to reach optimal blood pressure control. Regular monitoring, providing diagnoses, prescribing medications so that they can be easily obtained, and titration of drug regimens are all crucial to control of hypertension. However, underlying differences in the level of blood pressure between societies may still have an effect on outcomes.

The results of our study reveal the complexities of looking at international differences in health. Given their increased life expectancy and universal health care access, one would have expected the Japanese diagnosis and control of hypertension to be superior to that in the U.S. We find that the U.S. is relatively effective in diagnosing and treating hypertension. However, hypertensive treatment may not reflect other medical treatments. Lastly, hypertensive related mortality is primarily linked to stroke, which is not the leading or even second leading cause of death in both countries and may therefore not contribute as much as cancer or cardiovascular mortality to overall life expectancy (Glei, Mesle, and Vallin, 2010). Mortality from stroke has dropped markedly in Japan in recent years; although it remains somewhat higher in Japanese men and women than in Americans.

We should note some limitations of our study. We were only able to compare national samples for 2006 and hypertensive state and the use of medications are changing rapidly in both countries so that future research should examine changes after 2006. In addition we do not consider all the determinants of hypertensive state in this analysis. For instance, there are life style factors that may be related to hypertension such as obesity and smoking (Davarian, Crimmins, Takahashi *et al.*, 2013). Further investigation of these in comparative analyses may provide greater insights into the root of these differences.

Conflict of Interest and Funding

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The author contributions are as follows:

- Yasuhiko Saito: Collected data, performed data analysis, drafted and revised article
- Shieva Davarian: Performed initial data analysis and contributed to drafting and revising
- Atsuhiko Takahashi: Collected data, contributed to revising article
- Edward Schneider: Drafted and revised article
- Eileen M. Crimmins: Conceptualized article, performed analysis, drafted and revised article

Ethics Statement

The study procedure was approved by the Ethics Committees of the School of Medicine, Nihon University and the University of Southern California.

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