Risk Factors for Hip Fracture in Japanese Older Adults

Takashi Yamashita¹ and A. John Bailer²

Abstract
Risk factors for hip fracture in Japanese older populations are understudied compared with Western countries arguably due to the relatively lower prevalence rates in Japan. Nationally representative data from the Nihon University Japanese Longitudinal Study of Aging were analyzed using logistic regression to examine possible risk factors of hip fractures, separately for older women (n = 2,859) and older men (n = 2,108). Results showed that older Japanese women with difficulty bending their knees (OR = 1.9), with diabetes (OR = 1.7 times), and/or with more activity of daily living limitations (OR = 1.1) had higher risks of hip fracture. Older Japanese men with difficulty bending their knees (OR = 2.6), who use more external prescription drugs (OR = 1.9), and with cancer (OR = 2.0 times) had higher risks of hip fracture. Further considerations of gender- and culture-specific factors along with the identified risk factors may provide insights into future intervention programs for hip fracture in Japanese older populations.

Keywords
falls, gender-specific risk factors, injury, geriatrics

Introduction
Older adults experiencing hip fractures may find their lives irrevocably changed. The estimated number of new cases of hip fracture in Japan was 117,900 in 2002, doubling from the 53,000 cases reported in 1987. Hip fracture is the third leading cause of becoming bedridden following stroke and frailty due to advanced old age in Japan (Ministry of Health Labour and Welfare, 2005). Furthermore, the risk of mortality increases due to the severe injury and complications after hip fracture (Hasegawa, Suzuki, & Wingstrand, 2007). Even in cases of successful recovery, increased needs for extensive care and institutionalization are often reported (Alexander, Rivara, & Wolf, 1992; Yoshimura, Suzuki, Hosoi, & Orimo, 2005).

Preventing hip fracture is a public health priority in the Japanese society given the ongoing transition to the super-aging society. By 2050, the population age 65 years and older is expected to reach 40% of the total Japanese population (Cabinet Office, 2007). Even if the age-specific incidence rates of hip fractures stay constant, the total number of individuals experiencing hip fracture is likely to follow the number of older adults (Cummings & Melton, 2002). Hip fracture is known to be an expensive injury due to intensive medical treatment and follow-up care (Cummings & Melton, 2002; Rizzo et al., 1998). In addition to the current pension budget crisis, further medical expense would be tremendous burden on the Japanese society (Kunieda, 2002).

More than 90% of hip fractures are attributable to falls in the older population (Youm, Koval, Kummer, & Zuckerman, 1999). Constructing hip fracture prevention strategies requires an understanding of the risk factors for falls. Thus, sources of potential risk factors for hip fracture will be identified from the literature about falls risk factors. Many studies have identified risk factors of hip fracture in Western countries (Otaka, Riu, Uzawa, & Chino, 2003). Given the known gender differences in hip fracture risk factors (Cummings et al., 1995), this study conducts analyses of risk factors separately for women and men. Although some Japanese studies investigated risk factors of hip fracture using the large samples (Suzuki et al., 1997), further population-level research is necessary for developing higher quality intervention programs from public health perspectives. The purpose of this study is to identify the risk factors of hip fracture in the relatively understudied population of Japanese older adults using nationally representative data.

Materials and Method
Study Population
This study used data from the first wave of the Nihon University Japanese Longitudinal Study of Aging (NUJLSOA)
initiated by the Nihon University Center for Information Networking in 1999. NUJLSOA used a multistage probability sampling method to collect nationally representative data of Japanese older adults age 65 and older. Trained interviewers conducted face-to-face interviews using a structured questionnaire. Those who were 75 years and older were oversampled for the purpose of detailed analysis of the oldest old population. The NUJLSOA survey included a wide range of questions such as demographic information, socioeconomic status, medical history, lifestyle, and health/disability status of Japanese older adults. For this study, only community-dwelling older adults (N = 4,967) were analyzed after excluding those who were institutionalized (n = 30).

Response Variable
The respondents who answered yes to the question, “Have you ever experienced or are currently experiencing fractures (femur, hips)?” were coded 1 and others were coded 0 for the variable hip fracture.

Predictor Variables
Risk factors of falls and hip fracture were selected as predictor variables. A collection of potential risk factors along with relevant references are displayed in Table 1. Potentially related factors and available variables in the NUJLSOA Wave 1 including demographic and socioeconomic factors, medical conditions, functional limitations and physical health, and environmental factors are also identified in this table.

Demographic and socioeconomic factors. Age and education were included in the analyses. Age is a continuous variable. Education was reported as the respondent’s last education level completed and has six levels: (a) junior high school, (b) high school, (c) schools for specialized studies, (d) junior college, (e) university, and (f) graduate school. The education variables were dichotomized into (0) less than high school or (1) higher than high school education due to the highly skewed distribution showing that the majority of respondents had high school or less education completed.

Medical conditions and history. The indicators of dementia, heart problem, cancer, diabetes, cataracts, glaucoma, arthritis, osteoporosis, and back pain were included in the analysis. Each variable was coded whether the respondents had the condition (1) or not (0). For medication use, the total number of internal prescribed medications and non-prescribed medications used were separately taken into account. The external prescribed medications variable was dichotomized into the respondents who used at least one external prescribed medication (1) and those who did not (0) given the highly skewed distribution. When female respondents gave birth to more than five children, they were coded 1 and others 0.

Functional limitation and physical health characteristic. Activity of daily living (ADL) and instrumental activity of daily living (IADL) were included as variables to assess functional limitations. The ADL variable corresponded to the number of ADL problems associated with eating, dressing, showering, getting out of bed, walking across room, going outside of house, and toileting experienced by an individual. The IADL variable corresponded to the number of IADL problems, including difficulty with preparing meals, shopping, taking care of bills, using telephone, cleaning, taking a bus, and managing medications. Body mass index (BMI) was calculated as weight (kg)/height (m)^2. The variable height (cm) was also taken into account. Variables measuring physical ability included walking 200 to 300 m; grasping with fingers and bending knee were coded 1 if the respondents had difficulty performing or 0 if they did not, respectively. A self-rated variable of overall health was coded 1 if the respondents reported positive health as very healthy, healthier than average, or average health, and the other was coded 0.

Environmental factor. The variable rural was coded 1 if the respondents reported living in farming or fishing village and was coded 0 if they reported living in city or suburb areas. This variable accounts for the geographical difference in diet. Japanese people living in rural areas are more likely to have higher salt intake than those in urban areas (Yamaguchi, 1995). Higher salt intake is associated with lower bone density among postmenopausal women (Devine, Criddle, Dick, Kerr, & Prince, 1995); therefore, it may be a relevant factor of hip fracture (Suzuki et al., 1997).

Statistical Methods
Summary statistics for the predictor variables were computed for the respondents with hip fracture and those without hip fracture, separately for women and men. Means and standard deviations for continuous variables, and percentages for dichotomous variables were computed. Independent t tests were used to test differences in means between those with hip fracture and those without for continuous variables, and chi-square tests were used to test differences for categorical variables. Logistic regression was used to model the odds of hip fracture on demographic and socioeconomic factors, medical condition, functional limitation and physical health, lifestyle, and environmental factors (Hosmer & Lemeshow, 2004). All analyses were performed with the Statistical Analysis System (SAS) software version 9.1 (SAS Institute, Cary, North Carolina).

Results
Table 2 shows a comparison of predictor variables between individuals with and without hip fracture stratified by gender: women (n = 2,859) and men (n = 2,108). Overall, 349 out of 4,967 or 7% of the respondents had at least one hip
The respondents with hip fracture were, on average, 1 year older than individuals not experiencing a hip fracture (76.6 vs. 75.3), and their prevalence rates of diabetes (13% vs. 8%), osteoporosis (13% vs. 7%), the number of internal prescription drugs (2.5 vs. 2.1), and use of external prescription drugs (37% vs. 25%) were higher compared with those without. In addition, the respondents with hip fracture reported more difficulty bending their knee (45% vs. 24%), higher mean number of difficulty with ADLs (1.0 vs. 0.4) or IADLs (1.4 vs. 0.90), and lower self-rated health (54% vs. 67% for positive self-rated health) compared with those without, respectively.

Table 1. Risk Factors of Falls and Hip Fractures in Older Population

| Category                          | Fall and fracture risk factors                                                                 | Reference                                                                 |
|-----------------------------------|-------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------|
| Demographic and socioeconomic     | Age                                                                                             | Wei, Hu, Wang, and Hwang, 2001<sup>a</sup>; Tromp et al., 2001<sup>b</sup> |
|                                   | Female gender                                                                                    | Tromp et al., 2001<sup>b</sup>                                             |
|                                   | Education                                                                                       | Pluijm et al., 2006<sup>b,c</sup>                                         |
| Medical conditions                | Stroke                                                                                          | Suzuki et al., 1997<sup>a</sup>; Lau et al., 2001<sup>b</sup>; Wei et al., 2001<sup>a</sup> |
|                                   | Dementia                                                                                        | Rubenstein and Josephson, 2002<sup>b</sup>                                |
|                                   | Cataract                                                                                        | Wei et al., 2001<sup>a</sup>                                               |
|                                   | Osteoporosis                                                                                    | Lau, Woo, Leung, and Swaminthan, 1993<sup>b</sup>; Kanis, Johnell et al., 1999<sup>b,c</sup> |
|                                   | Use of medication                                                                                | Lau et al., 2001<sup>b,c</sup>; Grisso et al., 1997<sup>a</sup>           |
|                                   | Sleep disturbance                                                                               | Suzuki et al., 1997<sup>a</sup>                                           |
|                                   | Hormone therapy                                                                                 | Cummings et al., 1995<sup>a</sup>                                         |
|                                   | History of falls                                                                                 | Lau et al., 2001<sup>b</sup>; Cummings et al., 1995<sup>b</sup>; Tromp et al., 2001<sup>b</sup>; Pluijm et al., 2006<sup>b</sup> |
|                                   | History of fracture                                                                             | Fujiwara, Kasagi, Yamada, and Kodama, 1997<sup>a</sup>; Wei et al., 2001<sup>a</sup> |
|                                   | Knee osteoarthritis                                                                             | Wei et al., 2001<sup>b</sup>                                               |
| Functional limitation and physical health | Lower body weight                                                                               | Suzuki et al., 1997<sup>a</sup>                                           |
|                                   | BMI                                                                                            | Suzuki et al., 1997<sup>b,c</sup>; Fujiwara et al., 1997<sup>b,c</sup>; Kanis et al., 1999<sup>b,c</sup>; Wei et al., 2001<sup>a</sup> |
|                                   | Alcohol intake                                                                                  | Suzuki et al., 1997<sup>b,c</sup>; Fujiwara et al., 1997<sup>b</sup>; Lau et al., 2001<sup>b,c</sup>; Cummings et al., 1995<sup>b,c</sup>; Pluijm et al., 2006<sup>b,c</sup> |
|                                   | Visual impairment                                                                                | Tromp et al., 2001<sup>b</sup>; Dargent-Molina and Favier, 1996<sup>b</sup> |
|                                   | Giving birth to five or more children A                                                         | Fujiwara et al., 1997<sup>b,c</sup>                                      |
|                                   | Weight                                                                                         | Grisso et al., 1997<sup>b,c</sup>; Cummings et al., 1995<sup>b,c</sup>     |
|                                   | Height                                                                                         | Grisso et al., 1997<sup>b</sup>; Tromp et al., 2001<sup>b</sup>           |
|                                   | Lower limb dysfunction                                                                         | Grisso et al., 1997<sup>b</sup>                                           |
|                                   | Functional limitations                                                                         | Cummings et al., 1995<sup>b</sup>; Tromp et al., 2001<sup>b</sup>; Dargent-Molina and Favier, 1996<sup>b</sup> |
| Lifestyle                          | Calcium intake                                                                                  | Lau et al., 2001<sup>b,c</sup>; Kanis et al., 1999<sup>b,c</sup>        |
|                                   | Coffee/tea consumption                                                                          | Suzuki et al., 1997<sup>a</sup>; Kanis et al., 1999<sup>a</sup>          |
|                                   | Eating fish                                                                                    | Suzuki et al., 1997<sup>b,c</sup>                                         |
|                                   | Milk intake                                                                                    | Fujiwara et al., 1997<sup>b,c</sup>                                       |
|                                   | Physical activity                                                                               | Lau et al., 2001<sup>b,c</sup>; Grisso et al., 1997<sup>b,c</sup>; Kanis et al., 1999<sup>b,c</sup> |
|                                   | Smoking                                                                                       | Lau et al., 2001<sup>b</sup>; Kanis et al., 1999<sup>a</sup>; Cummings et al., 1995<sup>a</sup> |
|                                   | Alcohol intake                                                                                 | Suzuki et al., 1997<sup>b,c</sup>; Fujiwara et al., 1997<sup>b</sup>; Lau et al., 2001<sup>b,c</sup>; Kanis et al., 1999<sup>b</sup> |
| Environment                       | Living in rural areas                                                                           | Suzuki et al., 1997<sup>a</sup>                                           |
|                                   | Use of Western style bed                                                                       | Suzuki et al., 1997<sup>a</sup>                                           |
|                                   | Direct hip impact when fall                                                                     | Wei et al., 2001<sup>a</sup>                                               |
|                                   | Presence of dogs/cats in the house                                                               | Pluijm et al., 2006                                                        |

Note: BMI = body mass index. This table included the risk factors only from major Japanese studies and comparatively recent studies.

<sup>a</sup>Risk factors of falls/recurrent falls.

<sup>b</sup>Risk factor of fracture.

<sup>c</sup>Protective factors.
Among older women, those with hip fracture were older (77.4 vs. 75.8) and reported higher prevalence of diabetes (15% vs. 7%), back pain (25% vs. 17%), osteoporosis (20% vs. 11%), higher average number of internal (2.7 vs. 2.1) prescription drugs, and more use of external prescription drugs (42% vs. 29%) than those without. In addition, women who had a hip fracture were more likely to report difficulty with grasping with fingers (9% vs. 5%), bending their knee (54% vs. 29%), along with more ADL (1.3 vs. 0.5) and IADL (1.7 vs. 0.9) difficulties, and lower self-rated health (46% vs. 65%) compared with those without, respectively.

Among older men, those who had hip fracture were older (75.6 vs. 74.5) and had higher prevalence rates of cancer (13% vs. 8%) and use of external prescribed drugs (32% vs. 19%) when compared with those men without hip fracture. In addition, older men who had a hip fracture were more likely to report difficulty to bend knee (33% vs. 15%).

Table 3 shows the results of logistic regression analyses for women and men. Among older Japanese women, diabetics had 1.7 times the odds of hip fracture (95% confidence interval [CI] = [1.1, 2.6]) than those nondiabetics holding all other risk factors constant. Whereas older women with difficulty bending their knee and more difficulty with ADLs
had 1.9 (95% CI = [1.3, 2.7]) times and 1.2 (95% CI = [1.1, 1.4]) times the odds of hip fracture than those without, respectively. Women with difficulty grasping with their fingers had 47% lower odds of hip fracture than those without.

Among older Japanese men, individuals who used at least one external prescription medication had 1.9 (95% CI = [1.3, 3.0]) times the odds of hip fracture than those who did not. Those with cancer had 2.0 (95% CI = [1.04, 3.8]) times the odds of hip fracture than those without. Older men with difficulty bending their knee had 2.6 (95% CI = [1.7, 4.1]) times the odds of hip fracture than those who did not. However, the individuals with back pain had 43% lower odds of hip fracture than those without.

### Discussion

This study examined the risk factors of hip fracture for older Japanese women and men separately using the nationally representative Japanese data set, NUJLSOA. In older Japanese women, diabetes, difficulty bending their knee, and more ADL limitations were associated with increased risk of hip fracture, whereas difficulty to grasp with fingers was associated with lower risk. In addition, in older Japanese men, cancer, use of external prescription drugs, and difficulty bending their knee were associated with increased risk of hip fracture, whereas back pain was associated with lower risk.

In this study, age and education were not associated with hip fracture unlike some of the past studies (Wei, Hu, Wang, & Hwang, 2001). However, one Japanese study reported that age was not a risk factor of hip fracture (Yamanashi et al., 2005). Although age was not independently associated with risk of hip fracture in this study, a number of factors that tend to increase with age seemed to be associated with increased risk of hip fracture. For example, ADL limitations, back pain, and use of prescription drugs generally increase with...
or lower bone mineral density is a definitive indicator of risk of hip fracture in this study. In general, osteoporosis was not associated with risk of hip fracture in the current study. Education may influence the variables considered in this study but did not seem to be a direct risk factor of hip fracture.

Two chronic illnesses, diabetes and cancer, were associated with increased risk of hip fracture in women and men, respectively. This finding supports some of the previous studies. Schwartz et al. (2001) found that diabetics had a greater risk of hip and proximal humerus fracture after adjusting for bone mineral density and demographic factors. In addition, Mexican American older adults with diabetes were at higher risks of hip fracture after adjusting for covariates such as demographic factors and BMI (Ottenbacher, Ostr, Peek, Goodwin, & Markides, 2002). Although the occurrence mechanism of how particular chronic illnesses influence hip fracture risk is still unclear, complications from diabetes such as diabetes-related visual impairment, and/or cancer treatments including hormone therapy and androgen deprivation therapy for particular cancers seem to indirectly increase risk of hip fracture (Kanis, McCloskey, et al., 1999; Lopez et al., 2005; Ottenbacher et al., 2002; Schwartz et al., 2001). On a relevant note, more attention should be paid to other drugs (e.g., benzodiazepine) known to be associated with fall risks, which may reflect existence of illnesses or other physical conditions along with particular chronic illnesses in addition to those examined in this study (Cummings et al., 1995; Grisso et al., 1997).

Difficulty bending a knee was associated with increased risk of hip fracture among older Japanese women and men. There are two potential mechanisms that might explain this association. First, difficulty bending the knee presumably works as a mediator of the relationship between falls and hip fracture (Nguyen, Pongchayakul, Center, Eisman, & Nguyen, 2005). That is to say, not being able to bend the knee comfortably could result in instability of posture that may lead to falls (Lord et al., 1994). Second, difficulty bending a knee may have an influence on the trauma of one’s hip when a fall occurs. Indeed, hitting the knee first on the ground and changing direction of the fall can alleviate the impact on hip and avoid hip fracture (Pinilla, Boardman, Bouxsein, Myers, & Hayes, 1996; Runge, Rehfeld, & Resnicek, 2000). This finding suggests that educating older adults about how to fall safely along with potential consequences of hip fracture may be a reasonable strategy as a future public health intervention. In addition, such findings could help understand possible etiological explanations about the associations between ADL, physical fitness, and falls (Lau, Woo, Leung, & Swaminthan, 1993). Two protective factors, difficulty grasping with fingers in women and back pain in men, are arguably related to lower activities levels, which may indicate lower risk of falls and, in turn, hip fracture.

It should be noted that osteoporosis was not associated with risk of hip fracture in this study. In general, osteoporosis or lower bone mineral density is a definitive indicator of bone fragility (Cummings & Melton, 2002). Whereas osteoporosis is reported as a risk factor of hip fracture (Lau et al., 2001; Lau et al., 1993), it is a protective factor in other studies (Kanis, Johnell, et al., 1999). It may be possible that osteoporosis would be a risk factor only when there was a significant impact on one’s hip like when one falls.

There are several important contributions from the findings in this study. First, this study examined hip fracture risk factors in the understudied older Japanese population. Given the lower prevalence of hip fracture comparing with Western nations, only a few studies have focused on hip fracture at the population level in Japan while it still is a serious public health problem. Second, this study identified different risk factors of hip fracture for older Japanese women and men. Most previous studies considered gender as a risk factor or focused only on either women or men. Last, no previous study examined risk factors of hip fracture with NUJLSOA, which is one of a few publicly available large data sets of Japanese older adults. Secondary data analysis using nationally representative data in aging population is not yet common in Japanese hip fracture studies.

Some limitations in this study should be noted. First, Japanese specific cultural aspects were not taken into account. Although not examined in this study, typical but distinctive Japanese diets such as fish, tofu, and natto (fermented soybeans), and use of Japanese traditional futon are possible protective factors of fracture (Suzuki et al., 1997). Second, although we identified risk factors for hip fracture, the predictive accuracy of logistic regression models in this study may not be sufficient for routine use. Follow-up analyses using the area under the receiver operating characteristic curve (AUC) showed the moderate predictive accuracy; AUC (women, men) = (0.71, 0.67); the models could improve by incorporating omitted risk factors of hip fracture (DeMaris, 2004; Swets, 1988). Third, the finding regarding back pain requires caution as the estimated odds ratio was small although statistically significant. Finally, the NUJLSOA does not include information about timing of hip fracture and possible consequences (e.g., functional limitations). Therefore, any causal inference or examination of hip fracture treatment outcomes was not possible. However, the respondents were community-dwelling older adults who are still at risk of hip fracture. In this regard, identification of risk factors regardless of previous hip fracture experience is meaningful. Although this study included a single wave of data, as further consecutive waves of NUJLSOA become available, longitudinal analyses may allow for the inclusion of additional risk factors including a previous history of falls.

In conclusion, this study identified risk factors of hip fracture by developing hip fracture prediction models separately for older Japanese women and men using the nationally representative data. Diabetes, difficulty to bend knee, difficulty to grasp with fingers (protective factor), and ADL limitations were associated with risk of hip fracture among older adults. Indeed, these factors were independently associated with risk of hip fracture in the current study. Education may influence the variables considered in this study but did not seem to be a direct risk factor of hip fracture.
Japanese women. Cancer, use of external prescribed drugs, back pain (protective factor), and difficulty to bend knee were associated with increased risk of hip fracture among older Japanese men. These identified risk factors including physical impairments and functional limitations, and their causal pathways to hip fracture need to be further examined with consideration of gender difference and specific cultural aspects of study populations in future research.

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Bios

Takashi Yamashita, Ph.D is assistant professor of sociology at University of Nevada, Las Vegas, USA. His primary research focus is on social determinants of health, health resource access and health literacy. He completed his post-doctoral training (2011-2012) at the Scripps Gerontology Center, Miami University in Oxford, Ohio, USA.

A. John Bailer, Ph.D is University Distinguished Professor and Chair of the Department of Statistics at Miami University in Oxford, Ohio, USA. He also serves as a Scripps Research Fellow in the Scripps Gerontology Center and as an affiliate member of the Department of Sociology and Gerontology, both at Miami University. He joined Miami University in 1988 after completing a PhD in biostatistics from the University of North Carolina and a staff fellowship at the National Institute of Environmental Health Sciences.