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Local-Area Age Structure and Population Composition: Implications for Elderly Health in Japan

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Abstract

Objective—This study examines relationships between local-area age structure and health at older ages.

Method—We estimate random intercept models for two disability measures using four-waves of data from a national panel study of 3,580 Japanese older adults.

Results—Elderly living in relatively older areas reported more difficulties with activities of daily living compared to those living in an “average” age structure. Controlling for individual characteristics and time did little to change this relationship; while a similar relationship between older age structure and functional limitations emerged.

Discussion—Residents of relatively older areas are as tended to have lower socioeconomic status, but this “disadvantage” was offset by their higher rates of employment and marriage. These compositional differences highlight the role of local-area age structure in identifying and understanding elderly health variation between places.

Keywords

Population aging; environmental gerontology; age structure; Japan; disability

Introduction

The proportion of the world’s population aged 65 and over is projected to double between 2010 and 2040 (Kinsella & He, 2009). Scholars and policy makers have made substantial efforts to understand the implications of this rapid population aging at the global and national levels, but have paid little attention to potential consequences of differences in age structure or the pace of aging within countries. Research on the linkages between place and health has only recently begun to focus on health at older ages (Yen, Michael, & Perdue, 2009), despite strong theoretical reasons to believe that older individuals may be especially sensitive to environmental influences (Clarke & Nieuwenhuijsen, 2009). Studies in this line of research typically focus on a single characteristic of geographically defined areas that is theoretically related to both place and health—such as poverty at the neighborhood level. While mostly ignored in the literature, we posit that local *age structure* may be an

increasingly important correlate of elderly health for three reasons. First, elderly living in relatively older places may systematically differ from those living in areas characterized by a younger age structure. Second, an area's age structure may be related to other local attributes that influence elderly health outcomes. Third, the relevance of local-area age structure may increase over the coming decades as the pace of aging accelerates in most places and as regional heterogeneity in population aging becomes more pronounced. In this study, we examine how both disability at older ages and individual-level correlates of disability are associated with the age structure of municipalities in Japan—the world's oldest and most rapidly aging country (Kinsella & He, 2009).

Local Area Age Structure and Geography

Elderly health varies systematically by place. In the U.S., for example, disability rates at older ages are higher in many southeastern counties, even after accounting for regional differences in individual-level correlates of disability (Lin, 2000; Porell & Miltiades, 2002). If local-area age structure is related to health—either as a reflection of differences in population composition or via other mechanisms—then classification of geographic areas by age structure may be a useful tool for describing spatial health patterns and identifying specific locales for health interventions and related research.

In general, rural areas tend to have higher concentrations of elderly residents, a pattern that is at least partly attributable to trends in urbanization (Kinsella, 2001). At the same time, the relationship between age structure and place is not as simple as a rural/urban distinction. We know, for example, that there is considerable regional variation in the age structure of Russia's rural areas (Gavrilova & Gavrilov, 2009), and that some large global cities are noticeably younger (e.g. London, Los Angeles) or older (e.g. Montreal, Dublin) than the country as a whole (Kinsella & He, 2009). In the U.S., non-metro counties have a higher concentration of elderly than metro counties (Jones, Kandel, & Parker, 2007); while in Canada there is little association between the degree of urbanization and age structure (Malenfant, Milan, Charron, & Bélanger, 2007). Data from Japan indicate that population aging (and population decline) is affecting not only rural areas, but—increasingly—other urban cores that are not a part of the three major metropolitan regions of Tokyo, Osaka, and Nagoya (Murakami, Atterton, & Gilroy, 2008).

Local Area Age Structure and Composition

Compositional place “effects” reflect the tendency of similar individuals to live in a particular area and, consequently, to experience similar health outcomes (Cagney, 2006; Macintyre, Ellaway, & Cummins, 2002). For example, early studies of place and health (e.g., Robert, 1998; Sloggett & Joshi, 1998) often attempted to uncover the extent to which characteristics of the local population contributed to relationships between community-level SES and health. Identifying these compositional differences between places is important for three reasons. First, despite evidence of—and investigation into—“place effects” on health, it appears that the majority of health variation across space can be attributed to compositional differences (Kawachi & Berkman, 2003; Macintyre et al., 2002). Second, understanding regional variation in individual characteristics related to health can be useful for policies aimed at reducing health inequalities or improving residential infrastructure.

Third, accounting for compositional differences between places is a necessary first step in identifying mechanisms related to place and age structure that influence health.

We are not aware of any prior studies that investigate whether elderly living in areas with relatively older and younger age structures differ systematically with respect to individual characteristics associated with health. If residents of areas experiencing rapid population aging have lower average levels of SES (for example), we may observe worse health outcomes in these relatively older areas. Compositional differences may also work to suppress evidence of regional heterogeneity in health. For example, if marriage is associated with better health at older ages and is more prevalent in relatively older places, then relationships between residence in older places and worse health may be obscured in analyses that do not account for marital status.

Local Area Age Structure as a Correlate of Elderly Health

Even after accounting for individual-level correlates of health, population age structure may remain associated with elderly health outcomes. This would be the case if local-area age structure was related to other contextual influences on health such as environmental features, the availability of resources and amenities, or community structure and functioning (Cagney, 2006). For example, elderly health has been linked to environmental attributes such as good transportation, pedestrian-oriented designs, and access to recreational facilities (Clarke & Nieuwenhuijsen, 2009). Age structure may be one important predictor of whether or not an area has, needs, or can attract such amenities. The proportion elderly in an area may also be associated with larger social networks or greater collective efficacy among the elderly—both of which have been linked to better health. Lastly, the literature on response shifting and adaptive framing (Sprangers & Schwartz, 1999; Street & Burge, 2012) suggests that shifting residential context may lead to changes in the way elderly view and report their health.

Only a few studies have considered (neighborhood) age structure as a possible correlate of elderly health—none of which examined disability. One study found a positive relationship between a neighborhood's proportion elderly and mental health outcomes in New Haven, Connecticut (Kubzansky et al., 2005), and attributed this to greater social support. Another study in New Haven found that a higher percentage of elderly was associated with lower odds of reporting low self-rated health; possibly due to better services in those areas or a change in the respondent's frame of reference (Subramanian, Kubzansky, Berkman, Fay, & Kawachi, 2006). Lastly, a study of the 1995 Chicago heat wave found that the proportion elderly was associated with lower mortality (Browning, Wallace, Feinberg, & Cagney, 2006), perhaps as a result of having more elderly-related services. These studies are all somewhat limited by their narrow geographic focus—providing limited generalizability and not addressing the implications of heterogeneous age structures within countries.

Local Area Age Structure in Japan

As the world's oldest population, Japan is an ideal setting in which to study linkages between population aging at the local level and individual health outcomes. The proportion of Japan's elderly population (65 or older) doubled to 23 percent between 1990 and 2010. By 2035, it is projected that approximately one of every three Japanese will be age 65 or

older, with the proportion of seniors in some municipalities topping 65 percent (National Institute of Population and Social Security Research, 2009). Despite rapid population aging at the national level, there is significant heterogeneity in age structure across Japan's municipalities (the lowest level of local government). For example, in 1990 approximately fifteen percent of all Japanese municipalities were comprised of greater than 20% elderly residents (compared to the national average of 12%). These "oldest areas" were quite heterogeneous in that they included remote rural villages; towns just outside of large urban centers; and some cities with populations greater than 100,000.

Another advantage of focusing on Japanese elderly is their relatively limited geographic mobility, which minimizes some of the methodological problems that plague the "health and place" literature (e.g., multiple moves, endogeneity concerns). Cross-national studies of elderly migration provide little information on Japan (Bradley & Longino, 2009), but available data indicate that residential mobility among aged Japanese is substantially lower than that of their American counterparts. Approximately 23 percent of elderly in the United States moved between 1996 and 2000 (He & Schachter, 2003) whereas only about 12 percent of older Japanese residents moved during the period 2000–2005; more than half of whom moved within the same municipality (National Institute of Population and Social Security Research, 2008). For Japanese elderly who do move, there is some evidence that younger elderly (age 65–74) living in metropolitan areas may move to more sparsely populated areas; while the oldest old (age 75 and over) may move from rural areas to suburbs and major urban areas to access long-term care facilities and to live with their children (Kawase & Nakazawa, 2009).

Study Objectives

The goals of this study are to (A) evaluate the extent to which reported disability prevalence among elderly living in relatively older areas differs from those living in younger areas; and (B) assess the extent to which compositional differences may account for (or obscure) relationships between local-area age structure and disability. Given that the majority of older Japanese age in place and that migration flows of younger Japanese tend to be from smaller, rural areas to larger cities, we expect that relatively older municipalities are more likely to be rural and culturally "traditional." As a result, we also expect elderly living in these communities are more likely to still be working (i.e., farm work and small businesses), to be married, and to have lower levels of SES. After accounting for these characteristics, we expect there may be a positive relationship between age structure and disability, since relatively older are as may not have "age-friendly" infrastructure related active aging and an enabling life (United Nations Population Fund, 2012).

Methods

Data

We used data from the National Survey of Japanese Elderly (NSJE), a nationally representative longitudinal survey conducted jointly by the Institute of Gerontology at the University of Michigan and the Tokyo Metropolitan Institute of Gerontology. The original sample consisted of 2,200 non-institutionalized adults aged 60 and older, and we used the

four waves of data that are publicly available from the Inter-university Consortium for Political and Science Research (ICPSR) at the University of Michigan—1987, 1990, 1993, and 1996. The original sample, with a 69% response rate, was considered representative, and patterns of non-response were comparable to those found in similar U.S. surveys (Jay, Liang, Liu, & Sugisawa, 1993). Supplemental samples were added in wave 2 (n=404) and wave 4 (n=976) in an effort to maintain a representative sample of Japanese elderly age 60 and above. Substantially abridged proxy interviews (approximately 11% of all surveys between waves 2 and 4) were excluded from our analysis; while 607 individuals died between waves 1 and 4. Table 1 presents the pattern of survey responses at each wave.

Operationalization of Place

Most previous environmental gerontology studies operationalize area at the block, neighborhood, or census tract level. This use of “neighborhood” as the geographic level of analysis is often dependent on administrative or respondent classifications, and may not be appropriate for all types of health outcomes or explanations why place could influence health (Diez Roux, 2001). Certain services and amenities, (e.g., well-connected public transit) or social mechanisms (e.g., collective efficacy) theorized to influence elderly health often operate at geographic areas larger than a neighborhood (Gerstorf et al., 2010). A shared social, political and demographic history may also shape the characteristics of elderly people that live in a particular municipality. One limitation of gerontological “neighborhood” studies is that many imply a neighborhood’s features only affect the health of those living there, despite the fact that some neighborhood institutions (e.g. senior centers, hospitals) could provide health benefits for elderly throughout a town or city.

In this study, local areas are officially designated municipalities (i.e., cities, towns, villages). Although municipalities are administratively defined and may be comprised of heterogeneous neighborhoods, their borders are not in dispute and people who live one block away will almost always be considered as living in the same place. There were 3,253 municipalities in Japan in 1985, but the number decreased to 2,395 by 2005 as a result of federally-promoted municipal merges. To ensure comparability across waves, we use the most recent (and thus largest) municipality definitions for all residents across all waves. Respondents to the first four waves of this survey lived in 235 different municipalities.

Age Structure

The few studies examining relationships between age structure and elderly health operationalized age structure as a continuous variable (Browning et al., 2006; Kubzansky et al., 2005; Subramanian et al., 2006), but this may be problematic if the relationship between age structure and the health outcome of interest is not linear. The United Nations uses demarcations of 7 and 14 percent elderly to establish relatively older or younger countries (Kinsella & He, 2009), while one older environmental study employed neighborhood cut-points of 13 and 21 percent (Sherman, Ward, & Lagory, 1985). Since these classifications have little theoretical or empirical rationale, we employ a simple four-category measure representing relatively “young” areas (< 10% elderly), areas with an “average”, or modal, age structure (>10% and < 15% elderly), “older” areas (>15% and < 20% elderly), and a small group of “oldest” places experiencing the most extreme population aging (>20%

elderly). We placed individuals into these categories based upon their baseline residential municipality's average proportion population of age 65-plus across the four survey years. These data came from the Japanese census (1990), census bureau estimates (1996), or were interpolated from successive 5-year censuses (1987 and 1993). Across that time, NSJE respondents lived in municipalities that ranged from 5–38% elderly, with a mean of 13.8%. Our categories include significant representation in each group and allow us to examine potential non-linearities in the relationships between age structure and individual-level measures of disability. The modal (“average”) category included 46 percent of the analytic sample, while 21%, 26%, and 7% of respondents lived in “young”, “older” and “oldest” areas, respectively. This treatment of age structure assumes that individuals did not move subsequent to their first survey. The implications of this assumption are described in the Results section.

Although the proportion elderly and a municipality's population size were related, there is a great deal of variation—even at the age structure “extremes.” For example, the oldest areas ranged in population size from 7,213 to 65,606 (mean 28,904) and include villages with less than 20,000 people (38%); towns that have 20,000–50,000 people (36%), and small cities that have between 50,000–150,000 people (26%). Population size in the youngest municipalities ranged from 23,948 to 1,072,964 (mean 228,959), with approximately half (48%) of these areas being larger cities (>150,000 people) and the rest being towns and smaller cities.

Disability

As life expectancy in developed countries continues to rise, physical functioning and disability at older ages has become a central research focus (Lynch, Brown, & Taylor, 2009). We consider two disability measures—functional limitations and difficulties with basic and instrumental activities of daily living (ADL/IADL). Using the conceptual framework of the “disablement process” (Verbrugge & Jette, 1994) and Nagi's related *Disablement Model* (Nagi, 1991), functional limitations represent restrictions on specific physical tasks; while ADLs/IADLs incorporate physical undertakings that also capture social functioning and performances of socially-defined roles (Lynch et al., 2009). Although these two measures are not antecedents of one another, onset of functional limitations typically occurs before ADL/IADL difficulties. Our data are consistent with this—86% of elderly who report at least one ADL/IADL difficulty also report at least one physical functioning limitation; while only 33% of those who report at least one physical functioning limitation also report a ADL/IADL difficulty.

Because there is some variation across survey waves in the measurement of disabilities, we only use the 10 items that are measured consistently across survey waves, similar to previous analyses of these same data (Liang et al., 2007). For functional limitations, this includes six measures—crouching, reaching, grasping, lifting, climbing stairs, and walking 200–300 meters (or approximately one city block). For ADL/IADL difficulties, this includes four measures—shopping for personal items, using the telephone, taking a bath, and using public transportation. Difficulty in performing each of the various activities was assessed on a five-point scale, with values of zero indicating no difficulty. As in many studies of

disability (Lynch et al., 2009), we first dichotomized each measure so that any difficulty was coded as 1. A majority of respondents (71%) reported no difficulties with any of the ten disability measures. We then created two indices that measure whether or not a respondent reported at least some difficulty with any measure in the index. Across all observations, 28% reported at least one functional limitation, while only 11% reported an ADL/IADL difficulty.

Correlates of Disability

Our analyses include seven individual-level characteristics that have been linked with disability—education, income, work status, marital status, age, gender and co-residence with children. The negative association between socioeconomic status (SES) and disability is well established (Lynch et al., 2009), and lower-SES Japanese elderly have both a higher prevalence of disability and smaller disability improvements over time in comparison with higher-SES elderly (Schoeni et al., 2006). We operationalized education as a three-category variable (did not attend high school; at least some high school; and at least some college), reflecting the fact that the majority of the original sample only completed primary or middle school. Income is the total income of the respondent and his or her spouse (the average exchange rate across the four survey years was approximately ¥130=\$1).

Elderly who work beyond typical retirement age consistently report better health (Lindeboom & Kerkhofs, 2009), and previous research on Japan has found that employment is associated with slower health decline at older ages (Raymo, Liang, Kobayashi, Sugihara, & Fukaya, 2008). Marital status is associated with better elderly health outcomes, although this association may be larger for men than for women (Waite, 2009).

Co residence with an adult child may improve health outcomes for the elderly or, conversely, it may be an indicator of a life transition caused by poor health (Brown et al., 2002). Takagi and Silverstein (2006) found that elderly Japanese living with married children were older and more likely to believe in traditional intergenerational co-residence, while those living with unmarried children were more likely to be in poor health. Lastly, we include gender since it is well-established that elderly women consistently report more functional limitations than otherwise similar men (Leveille, Penninx, Melzer, Izmirlian, & Guralnik, 2000).

Table 2 presents descriptive statistics—in total, by survey sample, and by survey wave. This table illustrates how individual-level characteristics of respondents change over time, and how supplemental (younger) samples differed from the original sample. These differences reveal increases in disability prevalence as cohorts age; and that the younger supplemental samples had higher SES levels of education and income.

Analysis 1—Composition

Before ascertaining the role composition plays in accounting for or obscuring disability differences between relatively older and younger places (objective B), we must determine the extent to which our seven compositional characteristics differ across age-structure categories. We employ a simple bivariate analysis, combined with insights from existing disability research, in order to identify how individual characteristics vary by age structure.

Analysis 2—Disability

We estimate the following random intercept logistic regression models, nesting observations within respondents:

$$\log \left(\frac{p_{ij}}{1 - p_{ij}} \right) = \mu_i + \beta X_{ij} + \gamma Z_j + \alpha_{jk}$$

Here, p_{ij} is the probability of reporting a disability at time i for individual j , μ_i is the population mean at time i ; X represents a vector of time-varying variables; and Z represents a vector of time-constant variables (i.e., education, gender, residential age structure). α_{jk} is the random intercept that can vary by person or by municipality; has a mean of 0 and a constant variance. This random effect—assumed to be independent across individuals and across places—is one way to account for unobserved heterogeneity as well as dependence between multiple observations of the same person or place.

Model 1 regresses the two disability indices on the categorical measure of municipality age structure. Since this model does not include any other predictor variables, the estimated coefficients indicate only whether there are significant differences in disability across age structure categories (objective A). Models 2 through 4 assess the extent to which the compositional differences described in Table 1 account for (or obscure) the relationships between age structure and disability observed in Model 1 (objective B). Model 2 incorporates measures from *Analysis 1* that would likely contribute to higher rates of disability in older places. Similarly, Model 3 includes measures from *Analysis 1* that would likely account for lower rates of disability in older places. Model 4 includes age structure, all individual covariates of health and an indicator of time (measured in 3-year intervals) that accounts for possible period trends in disability reporting.

Results

Analysis 1

The results from the bivariate analysis can be found in Table 3. Our seven individual-level characteristics were separated into three groups. The first two of these (i.e., educational attainment and income) are those that suggest the possibility of higher levels of disability in relatively older and oldest areas. Elderly living in these places had significantly lower proportions of highly-educated elderly and significantly lower proportions in the highest income group. In addition, those living in older and oldest areas were more likely to report the lowest levels of income. These two SES characteristics are included in Model 2 of *Analysis 2*.

The distribution of the second group of individual characteristics—respondents' employment status and marital status—suggests the possibility of lower levels of disability in older areas. Table 3 shows a distinct linear relationship between the proportion elderly in a respondents' residential municipality and *both* the proportion of respondents who are employed and the proportion of respondents who are married. These two characteristics are included in Model 3 in *Analysis 2*.

The last group of characteristics—mean age, gender, and co-residence with children—displayed more ambiguous relationships with age structure; and are included in Model 4 in *Analysis 2*. Mean age varied by less than 1 year between categories and did so in a non-linear fashion; while gender did not significantly differ between relatively older and younger places. Although one of the three coresidential variables—“living with an unmarried child”—was negatively related to age structure, it is unclear what implications this should have for disability prevalence.

Analysis 2: Functional Limitations

Odds ratios for reporting any functional limitation are on the left side of Table 4, conditional upon random effects. The baseline model shows no statistically significant differences in disability prevalence between age structure categories. As expected, Model 2 shows that higher levels of education and income were associated with lower odds of reporting a disability, although their inclusion did not alter relationships between age structure and functional limitations. In Model 3, employment and marriage—both of which are positively associated with age structure—were related to lower odds of reporting a limitation (OR=0.19 and 0.25, respectively). Results from this model indicate that compositional differences due to these two characteristics help suppress evidence of higher relative odds of reporting a limitation in older (OR=1.35) and oldest (OR=1.37, at the 0.10 level of significance) areas. After including age, gender, living arrangements, and time in Model 4, the odds of reporting a limitation in “older” areas were significantly higher than for residents of the modal age structure (OR=1.27). This set of models thus provides some evidence that higher rates of work and marriage obscure a higher “risk” of reporting a functional limitation for those living in relatively older areas.

Analysis 2: ADL/IADL

Odds ratios for reporting any ADL/IADL difficulty, conditional upon random effects, are on the right side of Table 4. Results from Model 1 indicate that those living in older areas have higher relative odds of reporting any difficulty (OR=1.40). After accounting for SES in Model 2, this relationship was no longer statistically significant. In Model 3, the inclusion of marriage and employment reveals a stronger association between ADL/IADL prevalence and age structure for both older (OR=1.62) and oldest (OR=1.78) areas. These relationships are largely unchanged in Model 4. The random effects parameters in our models indicate that the unexplained variation between individuals is greater for ADL/IADL difficulties than that for physical functioning limitations. In addition, there was no evidence of any random effect at the municipality level.

Sensitivity Analyses

There were few missing items at baseline (Liang et al., 2002), and with the exception of income (for which missing values are treated as a separate category), education (1%) and gender (5 individuals), no covariates had missing data. At least one functional limitation measure or ADL/IADL measure was missing in 2.9% and 1.4% of surveys, respectively. Because there were so few missing values on independent variables, we did not employ multiple imputation for our main analysis (Von Hippel, 2007).

We performed a supplemental set of analyses to assess the sensitivity of our results due to missing data resulting from proxy responses and survey attrition (i.e., non-response and mortality). These analyses included all proxy respondents (omitted from the main analysis) and assumed that those lost to survey attrition never left the survey. Since we did not have residential information for any of these individuals, we worked from an assumption that they did not move from the municipality of residence reported in their last completed survey. For those lost to non-response and mortality, we also assumed stability in other time-varying characteristics, including disability. Because many proxy respondents were missing some survey items, we used multiple imputation to generate 20 full datasets prior to estimating the models in *Analyses 2*.

These supplemental analyses were motivated by evidence that attrition was significantly more common among those who were unemployed, male, unmarried and those with disabilities. In addition, those living in oldest age structures were significantly less likely to drop out of the survey. There were no other significant relationships between municipality age structure and proxy response, nonresponse, or mortality.

The compositional relationships identified in *Analysis 1* did not change when we used this artificially constructed sample. Because those with missing data were more likely to be unemployed, unmarried and have a disability, the negative relationships between reporting a disability and both employment and marriage were stronger in these analyses. As such, the relative odds of reporting any disability in older and oldest areas (areas with a higher prevalence of marriage and employment) were slightly greater (approximately 5–10%) for this sample. All other results were consistent with the main analyses. We also estimated a second set of supplemental models in which we assumed that all those lost to survey attrition (non-respondents and those that died) had at least one functional limitation and at least one ADL/IADL difficulty. Since those living in oldest areas were less likely to leave the survey, the association between living in oldest areas and reporting an ADL/IADL was eliminated under this assumption. All other results were consistent with the main analyses.

Our operationalization of age structure assumes that individuals did not move subsequent to their first survey. Across these four waves of data, 114 out of 3,580 individuals moved (3.2%) out of their municipality over these nine years. Of these, only 60 individuals moved out of their municipality and did not return later (1.68% of the sample). We estimated an additional set of models allowing the age structure category for these individuals to vary as they moved from one municipality to another, but this did not change our results.

Discussion and Conclusions

Our analyses demonstrate that differences in population composition play an important role in shaping observed relationships between age structure at the local level and health at the individual level. Elderly living in relatively older areas differ from those living in other areas in ways that are theoretically relevant for elderly health outcomes. We found that the higher likelihood of work and marriage contributes to lower disability prevalence in relatively older areas in Japan. Elderly living in these areas may have or have had jobs that are less likely to provide an adequate pension or allow an earlier retirement (e.g., farming, running a small

family business). In addition, work status at older ages in these areas may be tied to social norms and community functioning. Similar to work status, the higher prevalence of married individuals in relatively older areas may reflect greater marriage rates, fewer divorces, or be a result of respondents' earlier moves to younger areas (to live with family) following widowhood. While heterogeneous levels of marriage and employment contribute to lower disability prevalence in relatively older areas, the opposite is true of SES differences. Those living in relatively older areas were less likely to have high levels of income and education; and more likely to have low income levels. These SES differences between places contributed to a relatively higher likelihood of reporting ADL/IADL difficulties in older areas. Lastly, our analysis indicates that both gender and age varied little by age structure categories.

In our least restrictive model (Model 4), living in relatively older areas was associated with higher odds of reporting any disability. Supplementary analyses indicated that these results primarily reflect associations between age structure and three specific disability measures—"walking", "lifting" and "shopping". For functional limitations, the association between age structure and disability was mostly attributable to walking (200–300 meters), and to a lesser extent lifting (approximately 25 pounds). In particular, the odds of reporting trouble walking (a distance which approximates a city block) for those living in older and oldest areas was approximately double that of those living in "average" areas. Similarly, the odds of reporting problems "shopping for personal items" (an ADL/IADL difficulty) for those living in older/oldest areas was more than double the odds for those living in "average" areas. One plausible explanation for these results is that areas with relatively older age structures are less likely to attract economic investment (e.g., shopping centers) or to have the ability to fund "age-friendly" infrastructure improvements. As such, pedestrian-friendly "new urbanism"—which has been linked to both walking and shopping activities among the elderly (Patterson & Chapman, 2004)—may be difficult to implement in older areas. Relatively older areas may also require an automobile for daily activity and previous research indicates that places with large amounts of motorized travel are associated with increased elderly disability (Clarke, Ailshire, & Lantz, 2009).

Previous studies examining local-area age structure and health at older ages found that more elderly residents at the neighborhood level was associated with better health outcomes—fewer depressive symptoms, lower mortality rates during a natural disaster, and lower odds of reporting low self-rated health (Browning et al., 2006; Kubzansky et al., 2005; Subramanian et al., 2006). After accounting for compositional differences between municipalities, we found the opposite pattern for these two disability measures. The above studies differed from ours in that they did not focus on disability and only examined neighborhood age structure within one American city. Japan, besides its cultural differences, differs significantly from the U.S. context due to its extreme population aging and larger regional variation in aging. In addition, this study includes numerous rural, suburban and isolated areas—and this may be particularly important for difficulties related to shopping and walking.

While we find that municipal age structure is an important correlate of elderly health, there are a number of other place-based characteristics (e.g., level of urbanization, average SES,

population change) that are likely related to age structure, each other, and elderly health in complex ways. It may be that none of these indicators directly influence elderly health, but are correlates and signals of processes and attributes that do. At the same time, there are reasons to believe that some characteristics of places (e.g., transportation needs, social cohesion) are associated with age structure. Subsequent extensions to this paper should seek to identify factors that are both related to an area's age structure and influence elderly health.

This study used one of many possible ways of operationalizing age structure. The four-category classification we have used may not be appropriate in other countries, and the substantive meaning of the categories may change as Japan's population continues to age. In addition, it is difficult to ascertain the extent to which compositional differences may be a result of selective migration over the life course or aging in place; although this concern is somewhat alleviated by low rates of Japanese elderly mobility. We focused on disability, but there are a number of other elderly health outcomes that may be related to age structure at a municipality level, including more subjective indicators of well-being.

Our findings show that some characteristics of older individuals differ systematically between relatively older and younger areas in Japan. It also suggests that elderly living in relatively older places may have some disadvantage when it comes to the onset of disability, despite being more likely to work and be married. As such, this paper provides an impetus to isolate and better understand how community characteristics that affect elderly health at the local level may be associated with trends in population aging. In 2007, the World Health Organization identified eight criteria for determining whether or not a city may be "age-friendly"—including transportation, housing, employment, and social participation. These mechanisms typically operate at the municipality level and may also be related to, or shaped by, differences in local-area age structure. Similar to the widening gap between rich and poor, growing "age structure disparity" is projected within developed countries over the coming decades. Identifying ways in which the characteristics of residents and places change in tandem with these societal shifts will be an increasingly important research focus.

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Table 1

Response Type by Survey Wave, National Survey of Japanese Elderly.

	Followed Up	New Sample	Proxy	Non- Response	Responses	Deaths
Wave 1 (1987)	-	2,200	-	-	2,200	(163)
Wave 2 (1990)	2,037	404	(190)	(214)	2,037	(212)
Wave 3 (1993)	2,229	-	(179)	(186)	1,864	(232)
Wave 4 (1996)	1,997	976	(304)	(222)	2,447	-
Total		3,580	(673)	(622)	8,548	(607)

Table 2

Descriptive Statistics. By Total Sample, Survey Sample, and Survey Wave. National Survey of Japanese Elderly (n=8,548).

Wave	TOTAL		Sample 1				Sample 2				Sample 3			
			1	2	3	4	1	2	3	4	1	2	3	4
Proportion Elderly with Functional Limitations; Mean (SD)	0.28 (0.45)		0.30 (0.46)	0.29 (0.45)	0.34 (0.47)	0.40 (0.49)	0.08 (0.28)	0.12 (0.32)	0.16 (0.37)	0.12 (0.32)	0.12 (0.32)	0.16 (0.37)	0.12 (0.32)	0.12 (0.32)
Proportion Elderly with ADL/IADL Limitations; Mean (SD)	0.11 (0.32)		0.13 (0.32)	0.11 (0.31)	0.15 (0.36)	0.19 (0.39)	0.01 (0.12)	0.05 (0.22)	0.06 (0.23)	0.02 (0.14)	0.02 (0.14)	0.06 (0.23)	0.02 (0.14)	0.02 (0.14)
Education ^{fc} (%):														
Did Not Attend High School	47		60	58	59	57	7	7	7	7	5	7	7	5
Some or Completed High School	40		31	33	32	34	77	77	77	78	56	78	78	56
>High School	13		9	9	9	9	16	16	16	15	39	16	15	39
Income (%):														
<¥1,200,000	25		32	29	29	24	12	11	11	11	8	12	11	8
¥1,200,000 – <¥3,000,000	34		33	36	35	35	36	35	34	35	26	36	35	26
¥3,000,000 – <¥5,000,000	17		13	13	17	15	20	27	28	28	28	27	28	28
¥5,000,000	9		6	8	6	7	21	18	15	15	19	18	15	19
Did not answer	15		16	14	13	19	11	9	12	12	19	11	9	12
Currently Working (%)	31		26	27	26	20	52	50	43	55	55	52	50	43
Married & Living With Spouse (%)	65		63	61	57	53	86	84	80	85	85	84	80	85
Mean Age	70.1		69.2	71.2	73.8	76.0	61.1	64.1	67.1	62.8	62.8	64.1	67.1	62.8
Female ^{fc} (%)	56		55	56	58	60	52	54	53	52	52	54	53	52
Co-residence with Children (%):														
Live with No Children	43		40	41	44	44	45	47	50	47	47	45	47	50
Live with Unmarried Child	21		21	18	18	18	30	25	21	33	33	30	25	21
Live with Married Child	36		39	41	38	38	25	27	29	20	20	27	29	20
N	8,548		2,200	1,671	1,532	1,247	366	332	302	898	898	366	332	302

^{fc}Time constant covariate

Table 3

Descriptive Statistics and Bivariate Analysis by Age Structure Categories, National Survey of Japanese Elderly, Waves 1–4 (n=8,548)

(% 65+): Age Structure of Residential Municipality	10% “Young”	>10% & 15% “Average”	>15% & 20% “Older”	20% “Oldest”
Proportion Elderly with Functional Limitations, Mean (SD)	0.27 (0.44)	0.27 (0.44)	0.29 (0.45)	0.30 (0.46)
Proportion Elderly with ADL/IADL Limitations, Mean (SD)	0.11 (0.32)	0.10 (0.31)	0.13* (0.33)	0.12 (0.33)
Education ^{tc} (%):				
Did Not Attend High School	45	45	53*	47
Some or Completed High School	39	41	38*	44
>High School	16	14	9*	9*
Income (%):				
<¥1,200,000	20*	24	27*	29*
¥1,200,000 – <¥3,000,000	37	34	31*	35
¥3,000,000 – <¥5,000,000	18	17	16	18
¥5,000,000	11	11	8*	5*
Did not answer	14	14	18*	13
Currently Working (%)	27*	29	35*	38*
Married & Living With Spouse (%)	62	64	67*	69*
Age (mean)	69.8*	70.4	70.1	69.6*
Female ^{tc} (%)	58	55	56	57
Co-residence with Children (%):				
Live with No Children	42	43	39*	56*
Live with Unmarried Child	28*	21	18*	14*
Live with Married Child	30*	35	43*	31*
N	1,760	3,917	2,248	623

^{tc} time constant covariate;

* statistically different than the reference category (>10% & 15%).

Table 4

Odds Ratios for Reporting Any Functional Limitation or Any ADL/IADL Difficulty, Conditional upon Random Effects

	Functional Limitations				ADL/IADL			
	Model 1	Model 2	Model 3	Model 4	Model 1	Model 2	Model 3	Model 4
Age Structure of Residential Municipality (% elderly) ^{tc}								
“Young” (10 %)	0.93	0.95	0.86	0.95	1.09	1.15	1.00	1.30
“Average” (>10% & 15%)	1.00	1.00	1.00	1.00	1.00	1.00	1.10	1.00
“Older” (>15 & 20%)	1.20	1.00	1.35 [*]	1.27 [*]	1.40 [*]	1.17	1.62 ^{**}	1.65 ^{**}
“Oldest” (>20%)	1.09	0.98	1.37 [#]	1.26	1.41	1.33	1.78 [*]	2.07 [*]
Education ^{tc}								
Did Not Attend High School	1.00			1.00		1.00		1.00
Some High School	0.47 ^{***}			0.96		0.40 ^{***}		0.93
>High School	0.28 ^{***}			0.78		0.32 ^{***}		0.73
Income								
<¥1,200,000	1.99 ^{***}			1.34 ^{**}		2.72 ^{***}		1.95 ^{***}
¥1,200,000 – <¥3,000,000	1.00			1.00		1.00		1.00
¥3,000,000 – <¥5,000,000	0.47 ^{***}			0.63 ^{***}		0.65 [*]		0.94
¥5,000,000	0.31 ^{***}			0.54 ^{***}		0.35 ^{***}		0.70
Did not answer	1.82 ^{***}			1.49 ^{***}		2.67 ^{***}		2.27 ^{***}
Currently Working (ref.=not working)								
		0.19 ^{***}	0.38 ^{***}				0.10 ^{***}	0.19 ^{***}
Currently Married (ref.=not married)								
		0.25 ^{***}	0.81 [#]				0.27 ^{***}	0.86
Living Arrangement (ref.=live w/no children):								
Living with a Unmarried Child				0.94				0.81
Living with a Married Child				0.79 [*]				0.93

	Functional Limitations				ADL/IADL			
	Model 1	Model 2	Model 3	Model 4	Model 1	Model 2	Model 3	Model 4
Age (one year increase)				1.16***				1.26***
Female ^c				2.98***				0.97
Time (three year increase)				0.94#				0.99
Log Likelihood	-4408	-4215	-4103	-3795	-2670	-2547	-2477	-2173
AIC	8,825	8,451	8,219	7,627	5,350	5,115	4,969	4,382
Indiv.-Level Random Effect (Ln Variance)	1.46	1.24	1.15	1.06	1.68	1.52	1.53	1.75
Municipality-Level Rnd. Effect	0	0	0	0	0	0	0	0
N	8,213	8,213	8,213	8,213	8,348	8,348	8,348	8,348
<i>tc</i> time constant covariate;								
***	p	0.001;						
**	p	0.01;						
*	p	0.05;						
#	p	0.10						