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Modeling trajectories of long-term care needs at old age: A Japanese-Swedish comparison

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Abstract: A simulation model has been developed, which looks at the future state of functional limitations and provision of long-term care from the individual's point of view and compares the prospects of Japanese and Swedish old persons. The model calculates the distribution on level of functional limitations combined with level of long-term care (LTC) for a 78-year-old man or woman after 3, 6, 9, 12 and 15 years given the initial state expressed in those terms.

Longitudinal data for the model has been taken from the Nihon University Japanese Longitudinal Study of Aging (NUJLSOA) study, two waves three years apart, and the Swedish National Study of Aging and Care (SNAC) study, baseline and three-year follow up. Transition probabilities are calculated by relating individual states between waves. Changes over time are then calculated in the model by matrix multiplication using the Markov assumption.

The results are in most respects similar for Japan and Sweden. A difference is that institutional care in Sweden is a much more definite stage reflecting differences in end-of-life care policy. Future state and mortality depends to a great degree on the initial state, both in terms of dependency and level of LTC. Thus, 78-year-old people who have no functional dependency and no LTC have a much higher probability of surviving the coming 10–15 years than people of the same age who already are dependent and in need of LTC services. Not a few of the initially independent 78-year-old persons will retain that state even after 15 years. However, the effect of the initial state seems to decrease over time.

Keywords: *dependency; long-term care; simulation; modeling; transitions*

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1 Introduction

The world's aging population challenges us to find ways to preserve our elderlies' health and independence and provide for the growing need for different forms of care—not least long-term care (LTC). Japan and Sweden, both welfare states at the forefront of the population aging process, face similar problems but yet are trying to solve them in different ways. Addressing the magnitude of the coming challenges demands long-term projections under differing assumptions of costs and manpower requirements. Many such projections have been made in both countries. They rely mainly on projections of population and—in the more advanced versions—of health and dependency based on longitudinal population surveys (European Commission, 2015; Maeda, 2015; de La Maisonneuve and Martins, 2013, Sakai, Sato, and Nakazawa, 2015; Swedish Agency for Health and Care Services Analysis, 2015; Ueda, Horiuchi, and Tsutsui, 2011; Ueda, 2012). Generally, they indicate rapid cost increases in coming years if they are to provide care at the present level. However, the projected cost trends are much steeper in Japan than in Sweden.

This long-term cost analysis is very important from a governmental perspective. However, the longitudinal survey data also allows a look at the future from an individual perspective. By looking at longitudinal survey data from a certain age, we can explore life chances after that age over time in terms of mortality, ill health and dependency trends, and use of LTC. By correlating these life chances to initial health conditions and access to LTC, we can identify the positive health and needs factors and thus acquire a scientific basis for health promotion and ill-health prevention. For both Japan and Sweden there exist reliable, nationally representative population surveys providing data that can be used for this type of analysis. In both cases, the analysis involves demography, ill health and needs trends, and the provision of services. The idea is to compare synthesized old-age trajectories in Japan and Sweden using similar simulation models. This also allows us to explore the effect of alternative scenarios in terms of dependency development and LTC provision.

The exploration of individual life chances in this way is not common, but there are some studies with similar aims. The popular death-calculator approach estimates remaining life years based upon answers to an array of questions on life circumstances that have been identified in studies as influencing mortality and lifespan[1] More serious are a host of studies looking at mortality or life expectancy for different subgroups—often with a clinical aim. Keeler *et al*. studied the impact of functional status on life expectancy in older persons. Among other things, they found that the life expectancy of an ADL-disabled 75-year-old is similar to that of an 85-year-old independent person (Keeler *et al*., 2010). This relationship of mortality to ADL limitations has also been studied by Stineman *et al*., who divided participants into five stages of performing activities of daily living (ADL) (0, I, II, III, and IV) and found that the risk of dying was five times greater at stage IV than at stage 0. Some authors have developed indices intended to predict mortality with a clinical perspective, often—but not always—limited to frail persons (Carey *et al*., 2008; Klein *et al*., 2005; Zhang *et al*., 2012). Chan, Zimmer, and Saito (2011) and Chan *et al*. (2016) studied gender, educational, and ethnic differences in active life expectancy in Singapore and concluded that, unlike Western nations, there was no gender difference.

Some studies have looked into individual prospects in LTC; for example, Kemper *et al*. used microsimulation to estimate the amount of time a 65-year-old could expect to need LTC (three years on average) and what kind of private expenditure that would involve (Kemper, Komisar, and Alecxih, 2005). Ernsth Bravell *et al*. investigated how health, ADL, and use of LTC affected survival among very old people. They concluded that, in Sweden, the use of formal LTC increased with age and that, once the oldest people started to receive LTC, they seldom returned to living without it. In a Cox regression, health and ADL-dependency significantly predicted survival but not age as such (ErnsthBravell, Berg, and Malmberg, 2008).

Other studies have calculated transition rates for level of dependency over shorter or longer periods of time. A pioneering study was made by Manton: using the U.S. National Long Term Care Surveys of 1982 and 1984, he observed that a significant number of persons showed improvements even at a high level of impairment. (Manton, 1988). Transition rates and rates of institutionalization were also calculated by Branch and Ku using Massachusetts Health Care Panel Study data. According to that study, the best predictors of ADL status were initial ADL status, hospitalization, and institutionalization (Branch and Ku 1989).

Béland and Zunzunegui later calculated two-year transition probabilities for functional status (functional limitations, activities of daily living (ADL), and instrumental activities of daily living (IADL)) by age group and gender. Like Manton, they found that some improved functionally—especially the younger old people—but among the older old people, deterioration was more common (Béland and

1. www.death-clock.org

Zunzunegui, 1999). A similar result was found by Holstein *et al*., who reported strong mortality selection, but also that a notable minority improved in functional ability over time (Holstein *et al*., 2007). Change in functional status over two years was also calculated by Crimmins and Saito, who found that improvement and decline in status were subject to different covariates (Crimmins and Saito, 1993). Calculations of life expectancy by ADL status have further been made by Zeng, Gu and Land (2004) using an extended multi-state life table method. They found that the disabled life expectancy was significantly underestimated if information concerning the changes in disability status before death were excluded.

All these studies (with the exception of Branch and Ku (1989), and ErnsthBravell *et al*. (2008)) deal with either functional dependency and mortality or level of LTC. The purpose of this study was to calculate probability distributions for dependency and level of long-term care need combined, starting from varied initial conditions of these terms at 78 years of age. The results are then compared between Japan and Sweden. The studied time period in both cases is 15 years, from 78 to 93 years of age, and results are shown by 3-year time-steps.

2 Material and methods

Longitudinal data on health and LTC level for Japan and Sweden were obtained from the Nihon University Japanese Longitudinal Study of Aging (NUJLSOA) and the Swedish National Study on Aging and Care of the population in the Stockholm area of Kungsholmen (SNAC-K).

For NUJLSOA, data were gathered on several measures of ill health—including each individual's ability to perform activities of daily living (ADL), such as taking a bath or shower, dressing, eating, standing up from a bed or chair, going to the bathroom, and using the toilet (Katz *et al*., 1963). Corresponding data regarding instrumental activities of daily living (IADL) were also recorded. These activities include preparing meals, purchasing household items or medication, doing light household work, and taking a bus or train. For each of these activities, it was noted whether the individual reported the activity as difficult or not. If any difficulty was reported, individuals were asked if they found the activity somewhat difficult, very difficult, or so difficult they were unable to do it at all. In the present study, individuals are classified as being dependent for an activity if they answered "very difficult" or "unable." Persons were classified as IADL-dependent if they were dependent in at least one IADL but no ADL, and ADL-dependent if dependent in at least one ADL .

LTC was classified as no LTC, home-related LTC, or institutional care. Home-related LTC included home nursing, home rehabilitation, home bathing services, day services, overnight services, and other services such as welfare equipment rental or purchase or home improvement services. Facility services, such as welfare facility, insurance facility, or medical treatment nursing facility, were classified as institutions.

From the NUJLSOA data, a dataset was prepared using the wave 3 (2003) and wave 4 surveys (2006), and from these people aged 78, 81, 84, 87, 90 and 93 years at the wave 3 survey. However, to increase statistical power, these age groups were augmented with ages 1 year below and 1 year above—i.e. 77, 78, and 79; 80, 81 and 82; 83, 84, and 85; 86, 87 and 88; 89, 90 and 91; and 92, 93, and 94. Persons in institutions were not included in the first 1999-wave of the study, but persons who transferred to institutions in consecutive waves were followed. Therefore we could identify those who were institutionalized at wave 3 and 4. The dataset that was used includes 1,666 persons in wave 3 and 1,246 persons in wave 4. For each gender and age group in both waves, there were three levels of dependency and three levels of LTC, *i.e.* 3 x 3 = 9 states in all.

The Swedish National Study on Aging and Care (SNAC) was initiated by the Swedish government and involves four areas in Sweden, one of which is the Kungsholmen area of Stockholm. Each area is studied in two parts: a population part aimed at monitoring health and disability, and a care-system part that records acute and long-term care for all inhabitants aged 65 years and older. The Swedish dataset was prepared using individual, longitudinal SNAC data for the population part of the Kungsholmen study (SNAC-K) from the baseline study (2001–2004) and the three-year follow-up (2004–2007) (Lagergren, 2004). The basic design of the population part is to survey a sample of persons in the age groups 60, 66, 72, 78, 81, 84, 87, 90, 93, and 96 years. The younger people (aged 60–72 years) are re-examined after six years, the older (78 years and above) after three years. The data collection is very broad and involves medical examinations, questionnaires, and interviews concerning living circumstances, style, disability, provision of informal and formal care, and physical and mental performance tests. From these data, IADL dependency and ADL dependency were defined in the same way as in the Japanese study. The IADL variables of preparing meals, purchasing household items or medication, doing laundry (not in Japan), doing light household work, and taking a bus or train were used, as were the ADL variables of taking a bath or shower, dressing, eating, standing up from a bed or chair, going to the bathroom, and using the toilet.

In the SNAC study, home-related LTC provisions are registered in terms of number of home-help services provided per week. Four levels were used in the original analysis (no home help, <2 hours/week, 2–12 hours/week, and >12 hours/week). For institutional care there were two levels: sheltered housing and nursing home. However, for reasons of comparability with the Japanese results, where no division into levels of home-related LTC was possible, the three levels of home help will be summarized in the presentation of results. Likewise, the two levels of institutional care will be summarized. Using the SNAC data, a dataset was prepared containing 1,233 observations of men and women from the age groups 78, 81, 84, 87, and 90 years at baseline (2001–2004) and the same persons three years later at first follow-up (2004–2007). The data thus contained five age groups for each gender, and for each age-group fifteen states at baseline (three levels of dependency x five levels of LTC = 15 states). In the follow-up, death is added as a state.

Transition probabilities were calculated by a series of logistic regression analyses in both cases. The calculations referred to transitions in three-year time steps. The first calculation step involved three-year probability of death using age group, gender, initial dependency (three levels), and initial level of LTC (three levels in the case of Japan and five levels in the Swedish case) as independent variables. In the next step, three-year transition probabilities between states of dependency for the survivors were calculated using multinomial logistic regression analysis and age group, gender, initial dependency, and initial level of LTC as independent variables. In the last step, transition probabilities between levels of LTC were calculated, again using multinomial logistic regression analysis and age group, gender, initial as well as updated dependency, and initial level of LTC as independent variables. Tables showing the results of the regression analyses are found in the Appendix.

In this way, transition probabilities between the states, including death, were calculated for men and women from 78 to 81 years. Then, using the same regression results, transition probabilities were calculated from 81 to 84, from 84 to 87, from 87 to 90, and finally from 90 to 93 years. By successive multiplication of the resulting stepwise transition, probability matrices corresponding accumulated matrices for transition of states from 78 years to 81, 84, 87, 90, and 93 years were calculated. The calculations were made separately for men and women and were based on the Markov assumption of independency between time steps (see Section 4: Discussion). For Sweden, the results were calibrated to agree with national distributions of death, dependency, and LTC provision in 2003. For Japan, the calibration was made to agree with the dependency and LTC distributions in wave 4 as no national distributions were available. Calibration was done by age group and gender for both dependency and LTC-level distributions. In both cases, the technique was to adjust the intercept coefficients in the regression analysis in order to achieve a certain distribution of the target variable. This means that all relations between variables remain the same in terms of odds ratios—only the levels are adjusted.

The cumulative transition-probability matrices were used to calculate the resulting distribution of states by successive age given the initial state.

3 Results

In Tables 1 and 2, we show the probability of death and the distribution by degree of dependency of the surviving men, depending on their initial states at 78 years of age, after 3, 6, 9, 12, and 15 years. The corresponding results for women (not shown here) follow a similar pattern, though the probability of death given the initial state is lower and the probability of dependency among the surviving women is higher.

Table 1. Predicted probability of dependency transitions, Japan, men (percentages)

	Dead	**Distribution among survivors**			
		No limitations	**IADL dependency**	**ADL dependency**	**Total (survivors)**
Initial distribution at 78 years of age		87.1	5.9	7.0	100.0
Initial state	After 3 years				
No limitations	14.8	80.9	13.6	5.4	100.0
IADL dependency	29.5	27.1	34.0	39.0	100.0
ADL dependency	54.6	7.8	13.0	79.2	100.0
Total	18.4	75.3	14.6	10.0	100.0
Initial state	After 6 years				
No limitations	28.2	60.8	27.4	11.8	100.0
IADL dependency	51.6	32.4	31.8	35.8	100.0
ADL dependency	75.2	15.2	24.0	60.8	100.0
Total	32.8	58.5	27.5	14.1	100.0
Initial state	After 9 years				
No limitations	47.9	43.0	31.1	25.8	100.0
IADL dependency	70.6	29.8	29.5	40.7	100.0
ADL dependency	87.5	18.7	24.9	56.4	100.0
Total	52.0	42.1	31.0	26.9	100.0
Initial state	After 12 years				
No limitations	68.1	28.9	41.0	30.1	100.0
IADL dependency	84.0	23.5	38.7	37.8	100.0
ADL dependency	94.1	17.9	35.0	47.1	100.0
Total	70.9	28.6	40.9	30.6	100.0
Initial state	After 15 years				
No limitations	83.7	23.9	36.7	39.4	100.0
IADL dependency	92.4	21.4	35.5	43.1	100.0
ADL dependency	97.4	18.5	33.6	47.9	100.0
Total	85.2	23.7	36.7	39.6	100.0

Table 2. Predicted probability of dependency transitions, Sweden, men (percentages)

	Dead	Distribution among survivors			
		No limitations	**IADL dependency**	**ADL dependency**	**Total (survivors)**
Initial distribution at 78 years of age		84.0	9.3	6.7	100.0
Initial state	After 3 years				
No dependency	9.2	84.0	10.7	5.3	100.0
IADL dependency	24.6	22.8	40.7	36.5	100.0
ADL dependency	66.7	0.0	11.8	88.2	100.0
Total	14.5	76.8	13.2	10.0	100.0
Initial state	After 6 years				
No dependency	25.2	71.5	16.9	11.6	100.0
IADL dependency	58.2	33.3	28.1	38.6	100.0
ADL dependency	91.8	2.6	13.9	83.5	100.0
Total	32.8	68.7	17.5	13.7	100.0
Initial state	After 9 years				
No dependency	45.4	59.4	22.1	18.5	100.0
IADL dependency	78.9	40.6	24.8	34.6	100.0
ADL dependency	98.1	8.3	15.8	75.9	100.0
Total	52.1	58.5	22.2	19.3	100.0
Initial state	After 12 years				
No dependency	66.3	46.9	26.0	27.1	100.0
IADL dependency	89.6	40.2	25.8	34.0	100.0
ADL dependency	99.6	17.9	18.9	63.3	100.0
Total	70.7	46.6	26.0	27.3	100.0
Initial state	After 15 years				
No dependency	83.3	34.3	28.3	37.4	100.0
IADL dependency	95.4	32.4	27.8	39.7	100.0
ADL dependency	99.9	23.7	23.6	52.7	100.0
Total	85.6	34.2	28.3	37.5	100.0

Note that the initial state in terms of dependency at age 78 has a profound influence on probability of death—especially in the short run. Also, as should be expected, the expected degree of dependency among the survivors is strongly dependent on the initial state. In both Japan and Sweden, there is a probability of recovery. After 15 years, very few who were initially dependent survive.

In Tables 3 and 4, LTC-level transitions (including death) are shown over time for women from the initial level of age 78 in the Japanese and Swedish cases. The corresponding results for men (not shown here) follow a similar pattern, though a smaller proportion of men than women end up in institutional care.

Table 3. Predicted probability of LTC level transitions, Japan, women (percentages)

	Dead	Distribution among survivors			
		No LTC	Home-related LTC	Institution	Total (survivors)
at 78 years of age		90.5	8.2	1.3	100.0
Initial state	After 3 years				
No LTC	8.6	79.9	15.4	4.7	100.0
Home-related LTC	24.7	25.2	59.0	15.8	100.0
Institution	36.4	17.7	24.8	57.5	100.0
Total	10.3	75.6	18.5	5.9	100.0
Initial state	After 6 years				
No LTC	19.0	62.3	31.2	6.6	100.0
Home-related LTC	44.8	30.4	54.1	15.5	100.0
Institution	59.4	23.8	43.5	32.8	100.0
Total	21.6	60.2	32.6	7.2	100.0
Initial state	After 9 years				
No LTC	37.3	45.5	40.9	13.7	100.0
Home-related LTC	64.8	28.3	50.7	21.0	100.0
Institution	76.7	23.3	47.9	28.8	100.0
Total	40.1	44.5	41.4	14.1	100.0
Initial state	After 12 years				
No LTC	59.4	38.1	39.6	22.3	100.0
Home-related LTC	80.3	28.2	43.1	28.7	100.0
Institution	87.9	24.6	42.5	32.9	100.0
Total	61.5	37.6	39.7	22.6	100.0
Initial state	After 15 years				
No LTC	78.1	30.7	39.9	29.4	100.0
Home-related LTC	90.5	25.3	40.9	33.8	100.0
Institution	94.4	23.0	40.8	36.3	100.0
Total	79.3	30.4	39.9	29.6	100.0

As with functional dependency, the initial LTC level state at age 78 makes a great difference when it comes to the probability of death and the future LTC level. However, it seems that institutional care is much less definitive in the Japanese case than the Swedish. In the latter case, almost no one makes the transition from institutional care to a lower level of care, whereas this is fairly common in the Japanese case (see Section 4: Discussion).

In Tables 5 and 6, we show the probability of death and the distribution of LTC levels for survivors after 3, 6, 9, 12, and 15 years for persons who initially had no LTC services.

The probability of death increases over time, of course, and is greater among men than women. A higher proportion of female than male survivors also end up in institutional care. However, this is more common in Sweden than in Japan.

Table 4. Predicted probability of LTC level transitions, Sweden, women (percentages)

	Dead	Distribution among survivors			
		No LTC	Home-related LTC	Institution	Total (survivors)
at 78 years of age		86.9	8.5	4.6	100.0
Initial state	After 3 years				
No LTC	5.2	85.8	11.3	2.9	100.0
Home-related LTC	27.0	6.1	69.3	24.5	100.0
Institution	62.2	0.0	0.0	100.0	100.0
Total	9.7	69.3	15.1	6.3	100.0
Initial state	After 6 years				
No LTC	15.9	72.9	18.9	8.2	100.0
Home-related LTC	56.2	9.5	52.1	38.5	100.0
Institution	87.9	0.0	0.0	100.0	100.0
Total	22.6	69.3	20.4	10.3	100.0
Initial state	After 9 years				
No LTC	32.1	58.3	25.9	15.8	100.0
Home-related LTC	77.9	11.4	41.2	47.5	100.0
Institution	96.7	0.0	0.0	100.0	100.0
Total	39.0	56.7	26.3	17.0	100.0
Initial state	After 12 years				
No LTC	52.4	40.4	32.8	26.8	100.0
Home-related LTC	90.6	11.9	34.0	54.1	100.0
Institution	99.3	0.0	0.0	100.0	100.0
Total	57.8	39.8	32.8	27.4	100.0
Initial state	After 15 years				
No LTC	72.0	17.2	40.1	42.7	100.0
Home-related LTC	96.4	7.5	31.0	61.5	100.0
Institution	99.8	0.0	0.0	100.0	100.0
Total	75.3	17.1	39.9	43.0	100.0

4 Discussion

Using the presented simulation model, it is possible to calculate probabilities of future individual states in terms of death, functional dependency, and level of LTC. One could also use other assumptions than we have regarding mortality and health in the population and provision of LTC services.

The main result of the calculations thus far is that the future state depends to a great degree on the initial state, both in terms of dependency and level of LTC. Thus, 78-year-old people who have no functional dependency and no LTC have a much higher probability of surviving the coming 10–15 years than people of the same age who already are dependent and in need of LTC services. Not a few of the initially independent 78-year-old persons will retain that state even after 15 years. However, the effect of the initial state seems to decrease over time. Improvement in short term is not uncommon, verifying the results of many studies cited above (Manton, 1988; Béland and Zunzunegui, 1999; Holstein *et al*., 2007), One finds a clear difference between men and women. Women have lower mortality, but develop dependency and need

Table 5. Predicted probability of death and distribution of LTC Level for survivors at initial ages 78 and 84 by gender, Japan (percentages)

	Dead	Distribution of LTC level for survivors with no initial LTC			
		No LTC	Home-related LTC	Institution	Total (survivors)
Men 78 years old					
After 3 years	15.8	89.4	8.2	2.4	100.0
After 6 years	29.7	80.3	16.7	3.0	100.0
After 9 years	49.3	69.7	23.6	6.8	100.0
After 12 years	69.1	65.6	23.5	10.9	100.0
After 15 years	84.2	59.4	25.6	15.0	100.0
Men 84 years old					
After 3 years	22.7	77.0	18.1	4.9	100.0
After 6 years	50.5	68.3	21.9	9.8	100.0
After 9 years	74.1	60.4	25.1	14.5	100.0
Women 78 years old					
After 3 years	8.6	79.9	15.4	4.7	100.0
After 6 years	19.0	62.3	31.2	6.6	100.0
After 9 years	37.3	45.5	40.9	13.7	100.0
After 12 years	59.4	38.1	39.6	22.3	100.0
After 15 years	90.5	30.7	39.9	29.4	100.0
Women 84 years old					
After 3 years	14.1	60.3	30.6	9.2	100.0
After 6 years	39.1	44.7	36.5	18.8	100.0
After 9 years	65.1	33.6	39.1	27.3	100.0

for LTC more rapidly than men. This is a well-known phenomenon (Chan, Zimmer and Saito, 2011; Chan *et al*., 2016). Men and women age along different patterns. Comparing Japan and Sweden, we find some differences and yet many similarities. Mortality in relation to dependency seems to be about the same. Also, the proportion that ends up in ADL dependency is quite similar.

When it comes to LTC, there is a marked difference between Japan and Sweden. Many more persons in the Japanese case, than in the Swedish, leave institutional care. In Sweden, the transfer from institutional care to no LTC or home-related LTC is almost negligible. The reason seems to be different health and LTC policy but also different ways of registration in the databases. In the Japanese dataset, hospital care is registered as “No LTC” which could explain why so many move from institutional care to “No LTC.” In Sweden, even if the people die at the hospital (and only around 10% do), they are still registered as receiving LTC— either at home or in an institution — as hospital care is not regarded as a type of housing.

All simulation models have their limitations. Describing the state of an individual in just four variables—age, gender, functional limitation and LTC level—is of course an extreme simplification. Many other variables will influence the transition of a 78-year-old person from independence to a state of dependency and need for LTC—including lifestyle and life condition factors such as living alone or with family, smoking, alcohol use, diet, and exercise. Both the Japanese and the Swedish datasets contain multiple variables that cover these influencing factors. It should also be noted that the three-year

Table 6. Predicted probability of death and distribution of LTC level for survivors at initial ages 78 and 84 by gender, Sweden (percentages)

	Death	Distribution of LTC level for survivors with no initial			
		No LTC	Home-related LTC	Institution	Total (survivors)
Men 78 years old					
After 3 years	10.0	86.4	10.1	3.6	100.0
After 6 years	27.6	76.8	15.6	7.5	100.0
After 9 years	47.9	65.9	21.4	12.7	100.0
After 12 years	68.0	52.1	28.5	19.4	100.0
After 15 years	84.2	33.1	37.5	29.4	100.0
Men 84 years old					
After 3 years	17.3	73.7	17.6	8.7	100.0
After 6 years	45.7	54.4	27.7	17.8	100.0
After 9 years	72.5	33.6	37.5	28.8	100.0
Women 78 years old					
After 3 years	5.2	85.8	11.3%	2.9	100.0
After 6 years	15.9	72.9	18.9	8.2	100.0
After 9 years	32.1	58.3	25.9	15.8	100.0
After 12 years	52.4	40.4	32.8	26.8	100.0
After 15 years	72.0	17.2	40.1	42.7	100.0
Women 84 years old					
After 3 years	8.9	69.9	20.6	9.5	100.0
After 6 years	30.7	44.6	32.1	23.3	100.0
After 9 years	57.3	18.2	40.8	41.0	100.0

mortality and dependency transitions are calculated using the initial state as covariates. It is of course possible that dependency changed during the intervening period, making the connection between dependency and mortality stronger, but to this no regard is taken by the calculation method used.

The Markov assumption is another simplification that can influence results. It involves assuming that the results of two time-steps can be achieved by multiplying two one-step transition matrices. This is possible under the Markov assumption because the transitions are assumed to be independent. There is no memory in the stochastic process. In reality, it may well be that the probability of transitioning from independence to dependence relies on whether the independent person has previously been dependent. It is possible that some of the transitions from dependence to independence violate the Markov assumption, but there may be other explanations as well. Sometimes old people recover. Also, assessments are not perfect, and sometimes a dependent person can be classified as not dependent in a later survey without any actual change taking place.

Calibrations were made in both Japanese and Swedish cases, but in different ways and for somewhat different reasons. The justification for this is that you cannot expect the transition matrices from one age-group to the next to reproduce the initial distribution by age group. It takes a series of transitions for convergence to be achieved and the result will normally not be the initial distribution. In the Swedish case, calibration has been made to agree with national distributions of death, dependency, and LTC provision. In the Japanese case, these data were not available; instead, the NUJLSOA fourth wave distribution by gender was used as target. The calibration means that you get overall agreement with the chosen target distribution, but you still assume that all other relations between variables remain the same as in the original dataset. Of course it is easy to use any target distribution in both cases. The target distribution is just one model assumption that can be varied.

The strength of the individual-oriented approach applied in this study is the different perspective it provides on aging, risk of death, and the progress of functional dependency and need for LTC. This perspective is more relevant from an individual point of view.

5 Conclusions

An important result of the study is that the initial state makes a great difference to the future. This initial state is in many ways the result of how life has been lived up to the age of 78. If this information is available at a younger age, the chances of influencing coming developments are greater, and the incentive to change lifestyle and habits is more powerful. It is well known that the health and dependency of the older persons is a major determinant of future LTC costs. Health promotion and disease prevention are major public tools for achieving a positive result. However, most of that must be achieved by the middle-aged and by the old persons themselves.

Another result of these calculations is that an old person gets a realistic view of what to expect. Many old people try to deny what is waiting for them and refuse to act—by changing a living situation, for example, or seeking assistance. Health promotion sometimes gives the impression that simply living a healthy life, running, and eating a healthy diet will grant near immortality with no functional dependency until death. Unfortunately, this is far from reality, and realizing this could make it easier to accept the unacceptable: that we all age and die, and that there is no escape.

This model is a first attempt to come to grips with these issues from an individual perspective. The model can be further developed by introducing more levels of disability and LTC provision and using more complete datasets. However, introducing more variables would appear to require the use of microsimulation. This could be well worth the effort. The basic approach would be the same.

Authors' Contribution

Mårten Lagergren developed the simulation model and performed the calculations. Also, as national coordinator of the SNAC study, he supervised the data collection in that study, which provided the Swedish data. Yasuhiko Saito initiated and managed the NUJLSOA study, which provided the Japanese data for the study. He also took a very active part in discussing and presenting the modelling results. Noriko Kurube has participated together with Lagergren in a long series of different Japanese-Swedish LTC comparisons, and in this study—besides taking part in discussing and presenting the results—she provided expertise in Japanese old age and care.

Conflict of Interest

The authors declare that there is no conflict of interest.

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ETHICS

Ethics approval for the SNAC-K study has been obtained by Centrala Etikprövningsnämnden (Central Ethical Review Board) 2007-09-20 (Dnr Ö 26-2007). Ethics approval for the longitudinal survey entitled "Nihon University Japanese Longitudinal Study of Aging" has been obtained by the Ethics Review Committee of the School of Medicine, Nihon University, Tokyo, Japan.

Consent was obtained from all participating persons in the studies.

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Appendix: Supplementary Information

Table A1. Regression coefficients used in the life trajectory model, Japan

	Parameter	Estimate	Stand. error	*P*-value
	intercept	-1.7681	0.1531	<0.0001
Sex	konb	-0.6534	0.1395	<0.0001
Age group 81 years	old81	-0.2364	0.1929	0.2204
Age group 84 years	old84	0.2407	0.1988	0.2260
Age group 87 years	old87	0.4617	0.2153	0.0320
Age group 90 years	old90	0.7645	0.2667	0.0042
IADL dependency	funk0_1	0.6024	0.1965	0.0022
ADL dependency	funk0_2	1.5476	0.2001	<0.0001
Home-related LTC	insats0_1	0.6171	0.1860	0.0009
Institution	insats0_2	1.0961	0.2990	0.0002

Step 1: Dependency

	Parameter	Estimate	Stand. error	*P*-value	Estimate	Stand. error	*P*-value
		function 1			function 2		
	Intercept	3.3490	0.2792	<0.0001	0.7596	0.3169	0.0165
Sex	konb	-0.2332	0.2258	0.3017	0.1395	0.2412	0.5629
Age group 81 years	old81	-0.2277	0.3006	0.4486	0.4891	0.3347	0.1440
Age group 84 years	old84	-1.0981	0.3054	0.0003	-0.0440	0.3398	0.8969
Age group 87 years	old87	-1.2288	0.3601	0.0006	0.3679	0.3700	0.3201
Age group 90 years	old90	-1.4532	0.4990	0.0036	0.0171	0.4574	0.9702
IADL dependency	funk0_1	-2.6063	0.2796	<0.0001	-0.7396	0.2591	0.0043
ADL dependency	funk0_2	-4.4172	0.4642	<0.0001	-2.2926	0.3546	<0.0001
Home-related LTC	insats0_1	-1.5763	0.2920	<0.0001	-0.9680	0.2703	0.0003
Institution	insats0_2	-2.7196	0.7458	0.0003	-1.5390	0.6114	0.0118

Step 2: LTC Level

	Parameter	**Estimate**	**Stand. error**	***P*-value**	**Estimate**	**Stand. error**	***P*-value**
		function 1			function 2		
	Intercept	4.3150	0.4031	<0.0001	1.4669	0.4274	0.0006
Sex	konb	-0.2987	0.3287	0.3635	-0.1486	0.3349	0.6572
Age group 81 years	old81	0.2542	0.4353	0.5593	0.5213	0.4487	0.2454
Age group 84 years	old84	-0.2137	0.4375	0.6252	0.1450	0.4481	0.7463
Age group 87 years	old87	-0.4632	0.4655	0.3197	-0.3510	0.4741	0.4592
Age group 90 years	old90	-0.6686	0.5534	0.2270	-0.4237	0.5435	0.4357
IADL dep., before	Funk3_1	-0.2284	0.4145	0.5816	-0.3227	0.4125	0.4340
ADL dep., before	Funk3_2	-0,3705	0.4738	0.4342	-0.2902	0.4481	0.5173
IADL dep., after	Funk4_1	-0.4600	0.5085	0.3656	1.3363	0.5233	0.0107
ADL dep., after	Funk4_2	-2.8081	0.3915	<0.0001	-0.3399	0.4030	0.3990
Home-related LTC	insats0_1	-1.4175	0.3867	0.0002	0.5437	0.3612	0.1322
Institution	insats0_2	-2.7502	0.6054	<0.0001	-1.6378	0.5393	0.0024

Table A2. Regression coefficients used in the life trajectory model, Sweden

	Parameter	**Estimate**	**Stand. error**	***P*-value**
	intercept	-3.0877	0,2826	<0.0001
Sex	konb	-0.6731	0.2242	0.0027
Age group 81 years	old81	0.0187	0.3765	0.9603
Age group 84 years	old84	0.3607	0.3693	0.3287
Age group 87 years	old87	1.0841	0.3345	0.0012
Age group 90 years	old90	1.2559	0.3059	<0.0001
IADL dependency	funk0_1	0.8071	0.2737	0.0032
ADL-dependency	funk0_2	1.4220	0.4022	0.0004
Home related LTC, <2 hrs/week	insats0_1	0.9483	0.3111	0.0023
Home-related LTC, 2–12 hrs/week	insats0_2	1.1772	0.3630	0.0012
Home-related LTC, >12 hrs/week	insats0_3	1.6884	0.4544	0.0002
Institution	insats0_4	2.1376	0.3994	<0.0001

Step 1: Dependency

	Parameter	**Estimate**	**Stand. error**	***P*-value**	**Estimate**	**Stand. error**	***P*-value**
		function 1			function 2		
	Intercept	3.2946	0.3318	<0.0001	1.1147	0.3435	0.0012
Sex	konb	0.0356	0.2940	0.9037	-0.0431	0.2840	0.8794
Age group 81 years	old81	-0.5756	0.3617	0.1113	0.0561	0.3617	0.8768
Age group 84 years	old84	-0.5959	0.4060	0.1422	0.3887	0.3900	0.3189
Age group 87 years	old87	-1.3775	0.4106	0.0008	0.1861	0.3744	0.6192
Age group 90 years	old90	-2.4160	0.4069	<0.0001	-0.4465	0.3350	0.1826
IADL dependency	funk0_1	-2.9489	0.2957	<0.0001	-0.5727	0.2698	0.0388
ADL dependency	funk0_2	-13.1114			-1.7121	0.5246	0.0011
Home-related LTC, <2 hrs/week	insats0_1	-1.2774	0.5710	0.0253	0.1949	0.3285	0.5531
Home-related LTC, 2–12 hrs/week	insats0_2	-11.5588			-0.8054	0.4306	0.0614
Home-related LTC, >12 hrs/week	insats0_3	-9.0346			-0.9921	0.5993	0.0979
Institution	insats0_4	-9.9774			-11.9022		

Step 2: LTC level, functions 1 and 2

	Parameter	Estimate	Stand. error	*P*-value	Estimate	Stand. error	*P*-value
		function 1			function 2		
	Intercept	14.4295	0.6528	<0.0001	11.0611	0.6381	<0.0001
Sex	konb	-0.5524	0.4909	0.2605	-0.2955	0.5010	0.5553
Age group 81 years	old81	0.2004	0.6208	0.7468	0.1655	0.6313	0.7932
Age group 84 years	old84	0.0870	0.7056	0.9019	0.3852	0.7023	0.5834
Age group 87 years	old87	-0.1751	0.6550	0.7803	-0.2502	0.6670	0.7075
Age group 90 years	old90	-0.0439	0.5837	0.9401	0.3425	0.5796	0.5546
IADL dep., before	Funk0_1	-0.4794	0.4759	0.3137	-0.0736	0.4865	0.8798
ADL dep., before	Funk0_2	-1.8789	0.9792	0.0550	-1.7580	1.0045	0.0801
IADL dep., after	Funk3_1	-10.3876	0.2936	<0.0001	-7.8673		
ADL dep., after	Funk3_2	-14.2343	0.4512	<0.0001	-11.7687	0.3817	<0.0001
Home-related LTC, <2 hrs/week	insats0_1	-3.0348	0.7741	<0.001	0.2161	0.5355	0.6866
Home-related LTC, 2–12 hrs/week	insats0_2	-2.8908	1.1615	0.0128	-2.6774	1.1584	0.0208
Home-related LTC, >12 hrs/week	insats0_3	-9.0461			-9.1202		
Institution	insats0_4	-9.4218			-9.2415		

Step 2: LTC level, functions 3 and 4

	Parameter	Estimate	Stand. error	*P*-value	Estimate	Stand. error	*P*-value
		function 3			function 4		
	Intercept	7.9654	0.6867	<0.0001	-5.7576	1.0526	<0.0001
Sex	konb	0.4804	0.5557	0.3873	0.1705	0.6927	0.8055
Age group 81 years	old81	0.0702	0.6692	0.9165	0.4065	0.9355	0.6639
Age group 84 years	old84	0.6541	0.7177	0.3621	0.8189	0.9629	0.3951
Age group 87 years	old87	0.3343	0.6689	0.6172	0.8981	0.8972	0.3168
Age group 90 years	old90	0.1399	0.6060	0.8175	1.0132	0.8134	0.2129
IADL dep., before	Funk0_1	0.1943	0.5113	0.7040	0.7121	0.7626	0.3504
ADL dep., before	Funk0_2	-0.5748	0.7465	0.4413	0.6454	0.9634	0.5029
IADL dep., after	Funk3_1	-7.0805			5.2530		
ADL dep., after	Funk3_2	-9.0837			2.8397	0.4825	<0.0001
Home-related LTC, <2 hrs/week	insats0_1	-0.8380	0.6093	0.1690	0.0085	0.6579	0.9897
Home-related LTC, 2–12 hrs/week	insats0_2	0.6425	0.5631	0.2539	0.0777	0.7291	0.9151
Home-related LTC, >12 hrs/week	insats0_3	-8.1202			2.6184		
Institution	insats0_4	-11.2927			-9.7316		