Table 4 Results of multiple linear regression analysis of LTC expenditure including gender-service type interactions (Model B)

Variable	Unstandardized coefficients		Standardized coefficients	
	B	SE	Beta	*P*-value
(Constant)	59161.015	949.460		<0.0001
Dementia	27218.951	656.148	0.099	<0.0001
Care needs level (reference: care needs level 1)				
2	27904.786	729.299	0.113	<0.0001
3	72534.167	807.310	0.267	<0.0001
4	103395.938	892.336	0.347	<0.0001
5	135628.660	955.506	0.430	<0.0001
Age (years, reference: 65–74 years)				
75–84 years	6214.695	840.640	0.027	<0.0001
≧85 years	10990.395	833.212	0.050	<0.0001
Service Type (reference: home care services)				
Community-based/other care services	46730.972	3303.569	0.070	<0.0001
Facility care services	142259.625	1317.133	0.557	<0.0001
Female-home care services (reference: non-female-home care services)	9767.839	640.710	0.044	<0.0001
Female-community-based/other care services (reference: non-female-community-based/others care services)	26500.656	3652.406	0.036	<0.0001
Female-facility care services (reference: non-female-facility care services)	−5663.907	1304.733	−0.021	<0.0001

referent category, female home care service use was associated with an increase of 9768 Japanese yen/month (approximately US$81)). The same tendency was observed in community-based/other care service use, where women who used these services had higher LTC expenditures than those who did not (using non-female-community-based/other care services as the referent category, female-community-based/other care services were associated with an increase of 26 501 Japanese yen/month [approximately US$221)). In contrast, women who used facility care services showed lower LTC expenditures than individuals who did not (using non-female-facility care services as the referent category, female-facility care services were associated with a decrease of 5664 Japanese yen/month (approximately US$47)).

Discussion

This study examined the factors associated with LTC expenditures, and revealed that the female gender, older age, higher care needs level, and facility care service use were associated with higher LTC expenditures. These results are consistent with those reported by Olivares-Tirado *et al.*[30]

Our results also showed that regardless of gender, age, care needs level, and service type, individuals with dementia had higher LTC expenditures than non-dementia patients. These findings are similar to those from earlier studies that reported higher healthcare resource utilization and costs for individuals with Alzheimer's disease and dementia when compared with individuals without these conditions.[31–34] Individuals diagnosed with dementia are more likely to also be diagnosed with other comorbidities,[35] and to report greater difficulties in instrumental activities of daily living.[36] As a result, individuals with dementia may tend to use more LTC services and therefore incur higher LTC expenditure than non-dementia individuals. Most types of dementia are progressive without any full recovery. Therefore, finding ways to reduce the risk of developing dementia is an important public health goal. LTC service providers should also be prepared for the increase in demand for services that would invariably result from the impending increase in dementia sufferers.

This study also indicated that the use of different service types (homecare services, community-based/other care services, and facility care services) was associated with LTC expenditure. Facility care services had the highest LTC expenditure, followed by community-based/other care services and home care services.

A previous study has reported that institutionalization delay, institutionalization length, and nursing home admission rate are determinants of healthcare costs and resource utilization for facility care services.[37] In addition, facility care services

generally cost more than the other types of LTC services. A study has shown that community-based care has lower LTC expenditure than facility care, and is therefore more cost-saving from the payer's perspective.[16] The Japanese government has reported the average care needs level of facility care users to be higher than 3, irrespective of the type of facility care service used.[38] As there are greater reimbursement limitations with higher care needs levels, the high average care needs levels of those receiving facility care services may explain their elevated expenditures.

Our results indicated that women had significantly higher LTC expenditures than men, which corroborated the results reported by Schwarzkopf *et al.*[10] A possible explanation for this observation is that the main caregivers of informal care to dementia patients are predominantly female, and are composed mostly of daughters and spouses of the patients.[39] Kim *et al.*[40] also reported that while the overall medical costs of women was three times that of men, the medical costs of men increases more rapidly than women within an aging population. As women generally live longer than men, the latter would be less likely to play the role of caregiver for their spouses or parents. Men with dementia are also more likely to benefit from informal care (from their daughters or spouses) than women with dementia, and would therefore have lower expenditures for formal LTC services than women.

Furthermore, since LTC is a labor-intensive industry that requires a large number of skilled caregivers, the impending shortage of caregivers in Japan is expected to develop into a serious problem in the near future. In this way, a major challenge for dementia care is maintaining the balance between supply and demand in the LTC system under controlled increases in expenditure.

For the interactions between gender and types of service use, our study showed that women who used home care services or community-based/other care services had higher expenditures than non-home care service users or non-community-based/other care service users. However, women who used facility care services had lower LTC expenditures than non-facility care service users.

In addition, women who used facility care services had lower expenditures than men, which may be influenced by a difference in financial status. According to the Japanese government's *Women and Men in Japan* report, the relative poverty rates of women are higher than men, regardless of marital status; also, the proportion of elderly people over 65 year of age who lived alone in 2010 was 21% for women and 11.68% for men.[41] Furthermore, another government survey reported that relative poverty rates tend to increase with increasing age, but with a higher rate for women; this gap was found to expand even further with increasing age.[42] Thus, women in Japan may face more difficult financial situations than their male counterparts. Facility care services require the highest proportion of out-of-pocket payments, and are limited to individuals whose conditions are sufficiently severe to warrant these services. As many elderly women may be financially dependent on others (mainly husbands or children), this may affect women's choices in the type of facility care services to use.

Facility care services in Japan are offered in three main types of facilities: welfare facilities (*Kaigo Roujin Fukushi Shisetsu*), healthcare facilities (*Kaigo Roujin Hoken Shisetsu*), and recuperative medical care facilities (*Kaigo Ryouyougata Iryou Shisetsu*). Welfare facilities provide living assistance to the elderly. Healthcare facilities provide not only living assistance, but also include some medical services. Recuperative medical care facilities support the elderly who need both LTC and medical care. Of these three, women tend to use welfare facilities, which require the lowest out-of-pocket payments. According to a survey conducted by the MHLW,[43] women's use of welfare facilities was 52.5%, whereas men was only 46.3%

Among those with care needs levels 1–4 who used facility care services, the proportion of women in our sample was higher than the proportion of men. However, this relationship was reversed in individuals with care needs level 5.Since the higher out-of-pocket payments for facility care services may be a deterrent, women may only decide to use facility care services when there are no other available options.

Furthermore, gender differences in caregiver roles may be one of the reasons for the lower facility care service expenditures in women. Women account for as much as 70% of the main caregivers in Japan.[41,44] Therefore, many men who require living assistance at home are able to receive informal care provided by their spouse, daughters, or daughters-in-law. However, the life expectancy of women is on average 6 years longer than men in Japan.[45] Consequently, when many elderly women reach the age where they require assistance at home, there is a higher possibility that their spouses have already passed away. As men are also likely to be the main breadwinner in a family, they would be less inclined to stop working in order to assume a full-time caregiver role. A previous

study has indicated that financial considerations are a major barrier for women in the use of LTC services.[46] This gender difference in access to care is therefore an important issue that needs to be resolved.

In this study, we focused on individuals who had received only one of the three LTC service types. We examined our data and found that more than 95% of our subjects had used only one type of service during the observation period, especially for facility care services (which would preclude the use of the other types). As a result, approximately 5% of our candidate subjects were excluded from analysis as they used more than one type of service in a month.

However, other studies have analyzed the simultaneous use of different types of LTC services. Eloniemi-Sulkava *et al.* investigated a multi-component intervention program for elderly couples with dementia, and found that the intervention would reduce community services and expenditure for 2 years; but there were no differences between facility care users with or without dementia after 2 years.[47] Banerjee and Wittenberg estimated the costs and benefits of commissioning memory services for early dementia diagnoses and interventions for patients with dementia, and concluded that these services should be delivered by multi-disciplinary and inter-agency teams in order to provide the best services.[48] In an investigation of the future demand for LTC services and the associated costs, Comas-Herrera *et al.* reported that unless more effective treatments for cognitive impairment are developed and made widely available, it would be necessary to implement substantial increases in formal services.[49] Therefore, these findings indicate the need for service providers, service users and their families, as well as governments to work together to deliver appropriate and adequate services to LTC users with dementia; and also to formulate efficient and effective service plans, medication management, and facility-provided preventive care.

Our findings showed that higher care needs levels were significantly and positively associated with LTC expenditure, which supports the findings of a previous study.[16] In general, the care needs levels reflect disease severity in service users. However, if an LTC user's condition worsens to the point that they require acute medical care, LTC expenditure may be reduced, but total healthcare expenditure would still increase. Future studies are needed to examine all healthcare expenditures, including those from private healthcare and informal care services, to clarify the differential trends of LTC and medical care expenditure in such patients.

Age was significantly associated with LTC expenditure in our analysis. Greater frailty accompanies aging, and the frailty syndrome has been shown to be significantly associated with reduced survival.[50,51] Therefore, the frailty syndrome is likely to be a powerful risk factor for the decrease of physical function in elderly individuals. The age-induced frailty of users may lead to requirements for higher care needs levels, thereby resulting in higher LTC expenditures.

As medical technologies improve, average life expectancies are also likely to increase. However, increasing age is also associated with higher probabilities of chronic diseases such as dementia. Chronic diseases reduce the long-term quality of a patient's life, as well as impose a heavy financial and mental burden on patients and their families. In order to cope with the problems of an aging society, there are several policy issues that need to be considered. The first is to identify ways to reduce the risk of developing dementia, as prevention is generally more favorable than long-term treatments. However, when individuals suffer from irreversible conditions that require permanent LTC services, it becomes necessary to provide high quality and affordable care. In this way, there is a need for the development of patient-centered dementia care.

Japan is an aging society, and the proportion of elderly persons within its population is increasing rapidly. The MHLW's Health and Welfare Bureau for the Elderly announced that among the elderly people in Japan, the proportion of individuals with dementia was approximately 15% (exceeding 4.6 million), and is expected to rise to 7.3 million by 2025.[52] As healthcare funding for the elderly is not likely to be increased over a short period of time, the prevention of dementia is a crucial issue. The provision of cost-effective healthcare services for the elderly, especially those with dementia, is therefore a major consideration in countries with aging populations.

Our results indicate that dementia was strongly associated with LTC expenditure. Although previous studies have reported that gender has a pivotal role in LTC expenditure, we demonstrated in Model B that the service types interacting with the female gender are also determinants of LTC expenditure.

Our findings indicate the need for the critical evaluation of dementia patients and women in the LTC system. Future studies should examine if there are specific differences in facility service use between the genders that result in higher LTC expenditures for women, and if the LTC

expenditures of home care services and community-based/other care services would be more equal between the genders if the expenditures for informal care could be quantified. Future policy interventions should take facility care service users, higher care needs levels, older age, dementia, and gender into consideration when developing appropriate service plans to ensure the sustainability of the LTC system.

Limitations

The main limitations to our study design are similar to those faced by all studies based on insurance claims data. Dementia was identified using the names of the healthcare services provided. However, data limitations did not allow us to unequivocally confirm the accuracy of the dementia diagnosis. In addition, this is a cross-sectional study, and the associations between dementia and LTC expenditure may be partly affected by unobserved confounders. If this relationship was explained solely by worsening health conditions among dementia patients, we would expect to see higher spending not only for LTC expenditure, but also for medical care. Therefore, the increases in expenditure may not be solely attributable to dementia.

Another limitation of this study is that informal care, where spouses or children act as caregivers, is not reflected in LTCI or national healthcare insurance expenditures. The expenditures associated with informal care are difficult to calculate, which makes it difficult for the accurate quantification of all LTC cost components. The LTC service system in Germany provides cash allowances for informal care, and a study has reported that approximately 80% of total LTC costs in community-based dementia care could be attributed to informal care.[39] In contrast, the expenditures for informal care in Japan could not be calculated. Accurately quantifying overall LTC expenditure is therefore an issue that needs to be resolved.

Despite these limitations, we are, to the best of our knowledge, the first study to estimate the influence of dementia on LTC expenditure using a large sample size in Japan. Furthermore, although the relationship between dementia and LTC expenditure has been previously investigated,[12] our study uses a national database that covers most types of services provided.

Conclusions

The findings of this study showed that facility care service use, dementia, older age, higher care needs levels, the female gender, and women who use home care services or community-based/other care services were associated with higher LTC expenditure. We also found that individuals with dementia were strongly associated with increased LTC expenditure. While the possibility of reducing expenditures in these individuals remains unknown, the findings of this study may support the development of advanced LTC policy strategies.

Acknowledgements

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Disclaimer statements

Contributor H.-R. Lin, T. Otsubo, N. Sasaki, and Y. Imanaka conceived and designed the study. Y. Imanaka made the initial design, set up funding and resources, and acquired the data. H.R. Lin analyzed and interpreted the data and drafted the manuscript. H.-R. Lin, T. Otsubo, N. Sasaki, and Y. Imanaka contributed substantially to its revision. All authors have read and approved the submitted manuscript. The manuscript has not been submitted elsewhere nor published elsewhere in whole. The manuscript has been carefully reviewed by an experienced editor whose first language is English and who specialized in editing papers written by scientists whose native language is not English. YI takes responsibility for the paper as a whole.

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Conflict of interest The authors report no conflicts of interest.

Ethical approval This study was approved by the Ethics Committee of Kyoto University Graduate School of Medicine (Approval Number E1023).

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10th Annual Conference Japan Health Economics Association

Template for Structured Abstracts

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Affiliation	京都大学大学院　医学研究科　医療経済学分野
Presentation Title	Prediction of Long-Term Care Expenditure Increase among Elderly with Dementia Using Decision Tree Modeling
Background	As the Long-Term Care Insurance implemented in Japan since 2000, there is a rapid increase in the demand for long-term care services in older individuals with dementia. Previous studies have demonstrated that dementia is an independent predictor of medical and long-term care utilization and expenditure. However, little is known about the influence of the types of long-term care services on long-term care expenditure increase among insured elderly dementia patients.
Purpose	The purpose of this study is to determine risk factors including dementia that are associated with long-term care expenditure increase equal 50% or above in one year among elderly patients in Japan.
Methods	We developed and pruned a supervised learning approach using Random Forest (RF) and nonparametric Classification and Regression Tree (CART), an algorithm of machine learning, to create risk factors for long-term care expenditure increase more than 50% between June 2011 and June 2010. The data were obtained from database of the long-term care (LTC) insured who had applied LTC service in keeping the same care needs level 1 to 5, aged 65 years and above in June 2010 and June 2011 in Kyoto prefecture. In order to avoid model over fitting, we did sampling by case-to-control ratio 1:1. Finally, our samples consisted of 8,024 adults enrolled and set 70% as training dataset, and 30% as validation dataset.
Results	The supervised learning approach, which including CART for LTCI expenditure increase equal to 50% or above included days of hospitalization equal to 30 or above in one year, baseline care needs level, Alzheimer's disease, service type, new dementia diagnosis, sex, diabetes mellitus, age, heart disease, and hypertension. The area under the curve (AUC) of CART is 0.7997.
Discussions	Days of hospitalization equal to 30 or above in one year is the most important risk factor to predict long-term care expenditure increase. As discharge from long-term hospitalization may require more long-term care service than before, the policy interventions should be taken to keep the appropriate discharge path as well as rehabilitation plan to postpone decline of insured's activities of daily living.

Prediction of Long-Term Care Expenditure Increase among Elderly Using Decision Tree Modeling

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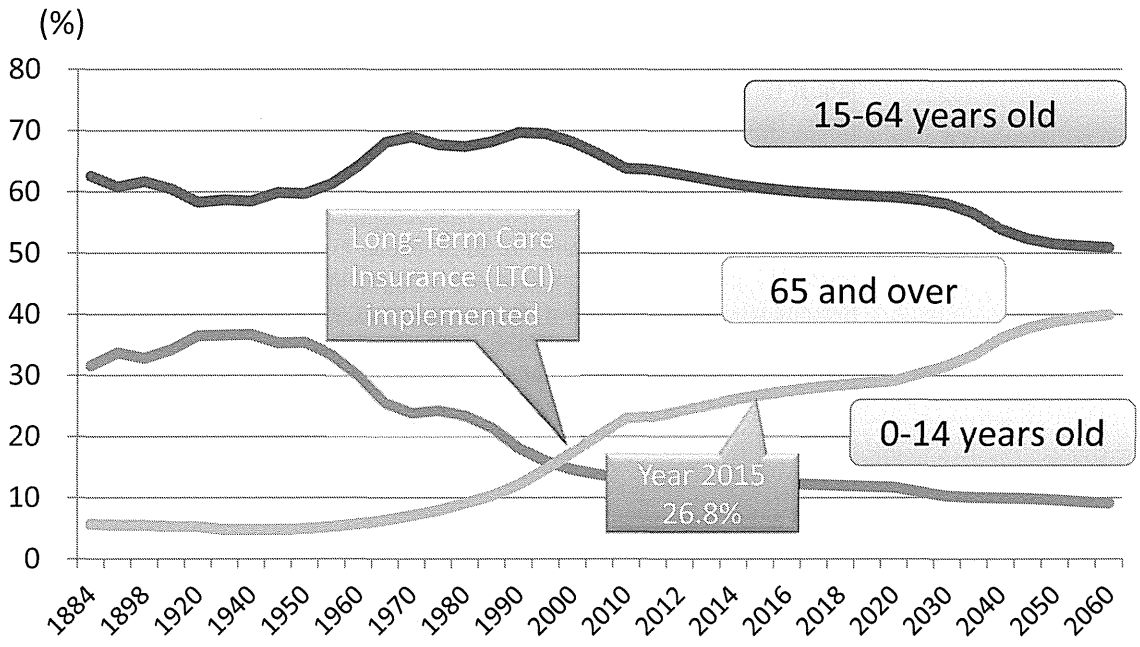
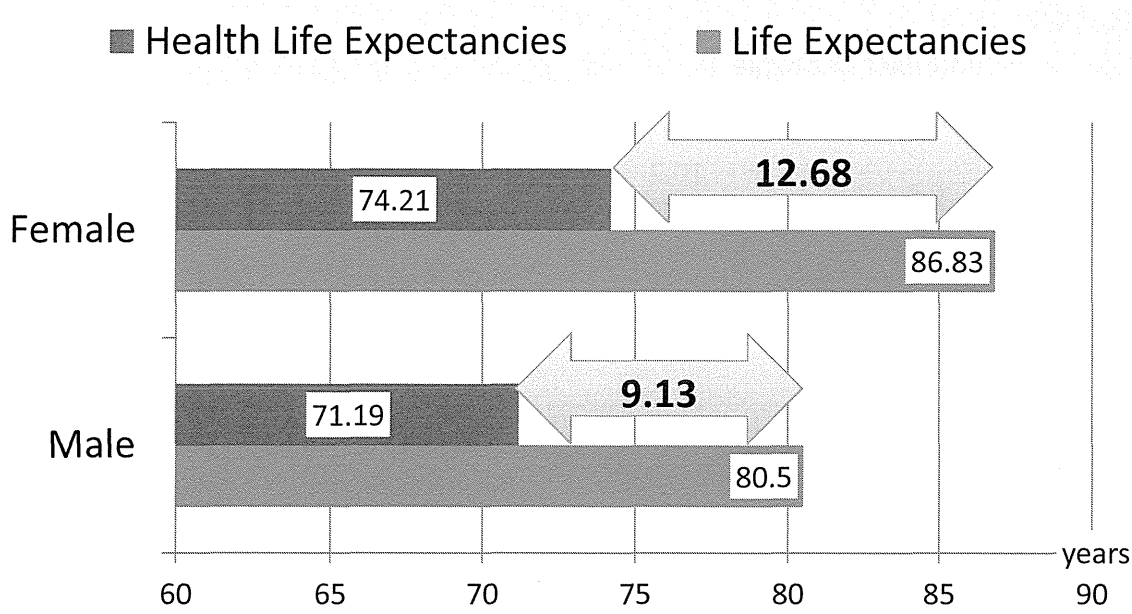
5th Sep 2015

Age Structure of Population



National Institute of Population and Society Research. (2012) Population Statistics of Japan 2012.
Statistics Bureau, Ministry of Internal Affairs and Communications (2015) Statistical Handbook of Japan 2014.

Life expectancies of Japan.



Health and Social Statistics Division of Statistics and Information Department(2015). Abridged Life Tables for Japan 2014.
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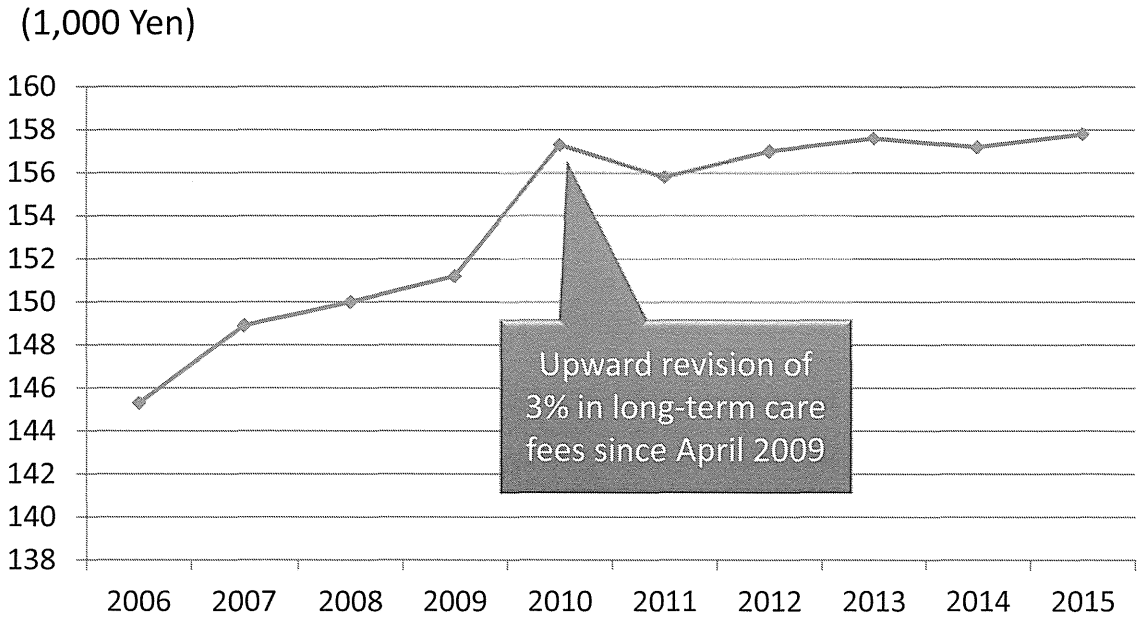
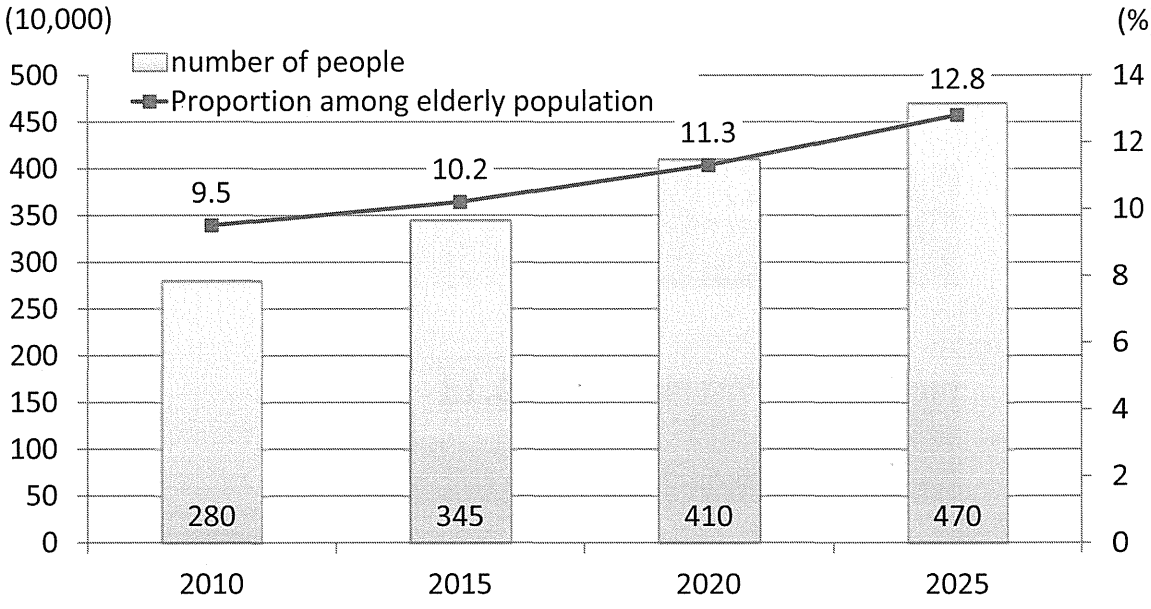
The increases of LTCI expenditure (Benefits per recipient)



Statistics Bureau, Ministry of Internal Affairs and Communications,
Survey of Long-term Care Benefit Expenditures 2006-2015

Estimated Number of The Elderly with Dementia based on the LTCI statistics



Ministry of Health Labour and Welfare, Health and Welfare Bureau for Elderly. 2013

The influence in expenditure by dementia

- The total healthcare resource utilization of subjects with dementia diagnosis were 1.67 times greater than that without dementia diagnosis. (Chung et, al.(2014))
- The expenditure of people with dementia are estimated to be around 3 times than for normal elderly in Medicare and Medicaid. (Goldfeld et, al.(201))

Factors related to medical/LTC expenditure/utilization

- Male gender, diabetes, tuberculosis, malaria, poor sanitation, respiratory ailments, gastrointestinal diseases, dementia, depression, and disability were associated with higher out-of-pocket expenditures. (Brinda et, al.(2012))
- Dementia is associated with significant expenditures. (Bharmal et, al.(2012); Pimouguet et al.(2010))
- Higher care needs level and institutional care were found to be associated with the highest LTCI expenditures. (Olivares-Tirado et, al.(2011))
- Age is a contributing factor to the rising expenditures on LTC. (Hashimoto et, al.(2010))

Aim

- To determine **factors** including dementia that are associated with long-term care expenditure increase among elderly patients in Japan.

Materials

- Database (Kyoto Prefecture)
  - Long-term care insurance database
  - National health care insurance database
  - Medical Care System for the Latter-stage Elderly People database
- Subject
  - ① Aged 65 years and above
  - ② Utilized LTCi service in June 2010
  - ③ Having expenditure record in June 2011
  - ④ Baseline Care-Needs Level 1 to 5
  - ⑤ Beneficiaries of National Healthcare Insurance or Late-stage Medical Care System for the Elderly
- Sample size
  - 8,024 (case-to-control 1:1)
  - 70% Training set(5,616); 30% validation set(2,408)

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Methods

- Descriptive analysis
- Random Forest (Feature Selection)
  - 500 trees and 3 factors were tried at each split
- Classification and regression tree (CART)
  - Complexity parameter: 0.001
  - Minimum number of partition size: 20
- Factors (13 of all)
  - Sex, Age Group, Medical Area, Baseline Care Needs Level, New Dementia Diagnosis, DM, Delirium, Heart Disease, Hypertension, Alzheimer's disease, Cognitive Impairment, Service Type, Days of Hospitalization equal to 30 or above in one year
- Outcome:
  - LTCI expenditure increase equal to 50% or above in one year: Yes/No

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Result

Summary Statistics of Variables (1/3)

Variables	Range	N	(%)
Sex	Male	1,550	(28%)
	Female	4,066	(72%)
Age Group	<65	96	(2%)
	65-74	596	(11%)
	75-84	2,334	(42%)
	85-94	2,345	(42%)
	>95	341	(6%)
Medical Area	Tango	335	(6%)
	Cyutan	582	(10%)
	Nantan	245	(4%)
	Kyoto・Otokuni	3,485	(62%)
	Yamashirokita	782	(14%)
	Yamashirominami	187	(3%)
Baseline Care Needs Level	1	1,284	(23%)
	2	1,763	(31%)
	3	1,201	(21%)
	4	773	(14%)
	5	595	(11%)

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Result

Summary Statistics of Variables (2/3)

Variables	Range	N	(%)
New Dementia Diagnosis	Yes	786	(14%)
	No	4,830	(86%)
Heart Disease	Yes	770	(14%)
	No	4,846	(86%)
DM	Yes	477	(8%)
	No	5,139	(92%)
Hypertension	Yes	3,706	(66%)
	No	1,910	(34%)
Delirium	Yes	130	(2%)
	No	5,486	(98%)
Alzheimer's disease	Yes	1,265	(23%)
	No	4,351	(77%)
Cognitive Impairment	Yes	12	(0%)
	No	5,604	(100%)

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Result

Summary Statistics of Variables (3/3)

Variables	Range	N (%)
Service Type	Facility Care Service	1,306 (23%)
	Home Care Service	4,238 (75%)
	Community-Based Care Service	72 (1%)
Days of Hospitalization equal to 30 or above in one year	Yes	988 (18%)
	No	4,628 (82%)
LTCI Expenditure Increased equal to 50% or above in one year	Yes	2,781 (50%)
	No	2,835 (50%)
Total		5,616 (100%)

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Result

Feature selected factors (N=5,616)

Variables	Mean Decrease Accuracy	Mean Decrease Gini
Days of Hospitalization equal to 30 or above in one year	163.6	360.49
Care Needs Level	36.72	70.67
Alzheimer's disease	31.64	22.15
Service Type	24.8	41.33
New Diagnosis of Dementia	19.27	16.7
Sex	12.6	15.45
DM	11.5	12.66
Heart Disease	7.55	14
Age Group	7.16	31.96
Hypertension	6.96	17.96

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Rules of LTCI expenditure increase equal to 50% or above in one year from CART (1/4)

No	Rules	Prob	Occurrence
47	IF Days of hospitalization equal to 30 or above in one year="Y" then LTCI expenditure increase equal to 50% or above in one year	0.99	988
46	IF Days of hospitalization equal to 30 or above in one year ="N" AND CNL="1, 2" AND Alzheimer's disease="Y" AND Service Type="Facility, Home" then LTCI expenditure increase equal to 50% or above in one year	0.62	612
45	IF Days of hospitalization equal to 30 or above in one year ="N" AND Alzheimer's disease="Y" AND Service Type="Facility, Home" AND CNL="3" AND Sex="Male" then LTCI expenditure increase equal to 50% or above in one year	0.61	56
44	IF Days of hospitalization equal to 30 or above in one year ="N" AND Alzheimer's disease="Y" AND Service Type="Facility, Home" AND CNL="3" AND Sex="Female" AND Age="65-74" then LTCI expenditure increase equal to 50% or above in one year	0.69	13
43	IF Days of hospitalization equal to 30 or above in one year ="N" AND CNL= "1, 2" AND Alzheimer's disease="Y" AND Service Type= "Facility ,Home" then LTCI expenditure increase equal to 50% or above in one year	0.71	7
42	IF Days of hospitalization equal to 30 or above in one year ="N" AND CNL= "3" AND Alzheimer's disease="Y" AND Service Type= "Facility ,Home" AND Sex = "Female" AND Age= "75-84, 85-94, >95" AND Delirium= "N" then LTCI expenditure increase equal to 50% or above in one year	0.43	170
37	IF Days of hospitalization equal to 30 or above in one year ="N" AND CNL= "1, 2, 3" AND Alzheimer's disease="Y" AND Service Type= "Community" then LTCI expenditure increase equal to 50% or above in one year	0.05	21
35	IF Days of hospitalization equal to 30 or above in one year ="N" AND Alzheimer's disease="N" AND CNL=" 1, 2" AND Age="75-84,85-94" AND Service Type="Home" AND New Dementia="Y" then LTCI expenditure increase equal to 50% or above in one year	0.64	76

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Rules of LTCI expenditure increase equal to 50% or above in one year from CART (2/4)

No	Rules	Prob	Occurrence
34	IF Days of hospitalization equal to 30 or above in one year ="N" AND Alzheimer's disease="N" AND CNL=" 1, 2" AND Age="75-84,85-94" AND Service Type="Facility" AND New Dementia="Y" then LTCI expenditure increase equal to 50% or above in one year	0.29	7
32	IF Days of hospitalization equal to 30 or above in one year ="N" AND Alzheimer's disease="N" AND CNL="1, 2" AND Age= "75-84,85-94" AND Service Type ="Facility, Home" AND New Dementia="N" AND Sex="Male" AND Heart Disease="Y" then LTCI expenditure increase equal to 50% or above in one year	0.62	56
31	IF Days of hospitalization equal to 30 or above in one year ="N" AND Alzheimer's disease="N" AND CNL="1, 2" AND Age="75-84, 85-94" AND Service Type="Facility, Home" AND New Dementia="N" AND Sex="Male" AND Heart Disease="N" AND Medical Area="CyuTan, Kyoto.Otokuni, NanTan, Tango" AND Hypertension="Y" then LTCI expenditure increase equal to 50% or above in one year	0.56	201
30	IF Days of hospitalization equal to 30 or above in one year ="N" AND Alzheimer's disease="N" AND CNL="1, 2" AND Age="75-84, 85-94" AND Service Type="Facility, Home" AND New Dementia="N" AND Sex="Male" AND Heart Disease="N" AND Medical Area="CyuTan, Kyoto.Otokuni, NanTan, Tango" AND Hypertension="N" then LTCI expenditure increase equal to 50% or above in one year	0.42	90
28	IF Days of hospitalization equal to 30 or above in one year ="N" AND Alzheimer's disease="N" AND CNL="1, 2" AND Age="75-84, 85-94" AND Service Type="Facility, Home" AND New Dementia="N" AND Sex="Male" AND Heart Disease="N" AND Medical Area="YamashitaKita, YamashitaMinami" then LTCI expenditure increase equal to 50% or above in one year	0.41	66
25	IF Days of hospitalization equal to 30 or above in one year ="N" AND Alzheimer's disease="N" AND Service Type="Facility, Home" AND New Dementia="N" AND Sex="Female" AND CNL="1" AND Age ="85-94" AND Medical Area="CyuTan, Kyoto.Otokuni, NanTan" then LTCI expenditure increase equal to 50% or above in one year	0.53	219

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Rules of LTCI expenditure increase equal to 50% or above in one year from CART (3/4)

No	Rules	Prob	Occurrence
24	IF Days of hospitalization equal to 30 or above in one year ="N" AND Alzheimer's disease="N" AND Service Type="Facility, Home" AND New Dementia="N" AND Sex="Female" AND CNL="1" AND Age ="85-94" AND Medical Area="YamashitaKita, YamashitaMinami, Tango" then LTCI expenditure increase equal to 50% or above in one year	0.39	57
22	IF Days of hospitalization equal to 30 or above in one year ="N" AND Alzheimer's disease="N" AND Service Type="Facility, Home" AND New Dementia="N" AND Sex="Female" AND CNL="1" AND Age ="75-84" then LTCI expenditure increase equal to 50% or above in one year	0.43	234
20	IF Days of hospitalization equal to 30 or above in one year ="N" AND Alzheimer's disease="N" AND Age="75-84,85-94" AND New Dementia="N" AND Sex="Female" AND CNL="2" AND Medical Area="CyuTan, Tango" AND Heart Disease="N" AND Service Type="Home" then LTCI expenditure increase equal to 50% or above in one year	0.56	84
19	IF Days of hospitalization equal to 30 or above in one year ="N" AND Alzheimer's disease="N" AND Age="75-84,85-94" AND New Dementia="N" AND Sex="Female" AND CNL="2" AND Medical Area="CyuTan, Tango" AND Heart Disease="N" AND Service Type="Facility" then LTCI expenditure increase equal to 50% or above in one year	0.14	7
17	IF Days of hospitalization equal to 30 or above in one year ="N" AND Alzheimer's disease="N" AND Age="75-84,85-94" AND New Dementia="N" AND Sex="Female" AND CNL="2" AND Medical Area="CyuTan, Tango" AND Heart Disease="Y" then LTCI expenditure increase equal to 50% or above in one year	0.14	7
15	IF Days of hospitalization equal to 30 or above in one year ="N" AND Alzheimer's disease="N" AND Age="75-84,85-94" AND New Dementia="N" AND Sex="Female" AND CNL="2" AND Medical Area="Kyoto.Otokuni, NanTan, YamashiroKita, YamashiroMinami" then LTCI expenditure increase equal to 50% or above in one year	0.40	547

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Rules of LTCI expenditure increase equal to 50% or above in one year from CART (4/4)

No	Rules	Prob	Occurrence
10	IF Days of hospitalization equal to 30 or above in one year ="N" AND Alzheimer's disease="N" AND CNL=" 1, 2" AND Age="75-84,85-94" AND Service Type="Community" then LTCI expenditure increase equal to 50% or above in one year	0.08	13
8	IF Days of hospitalization equal to 30 or above in one year ="N" AND Alzheimer's disease="N" AND CNL=" 1, 2" AND Age="65-74, >94" then LTCI expenditure increase equal to 50% or above in one year	0.33	294
6	IF Days of hospitalization equal to 30 or above in one year ="N" AND Alzheimer's disease="N" AND CNL="3" then LTCI expenditure increase equal to 50% or above in one year	0.31	724
3	IF Days of hospitalization equal to 30 or above in one year ="N" AND CNL="4,5" then LTCI expenditure increase equal to 50% or above in one year	0.19	1,067

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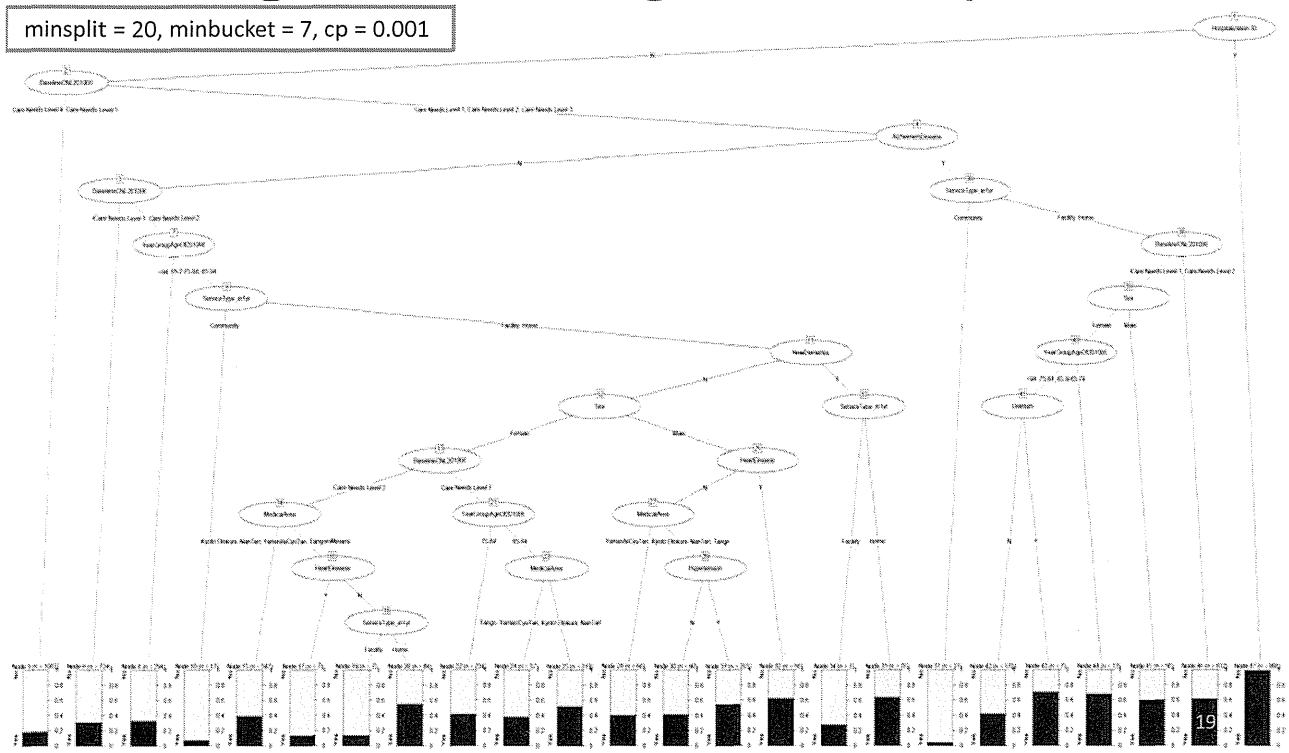
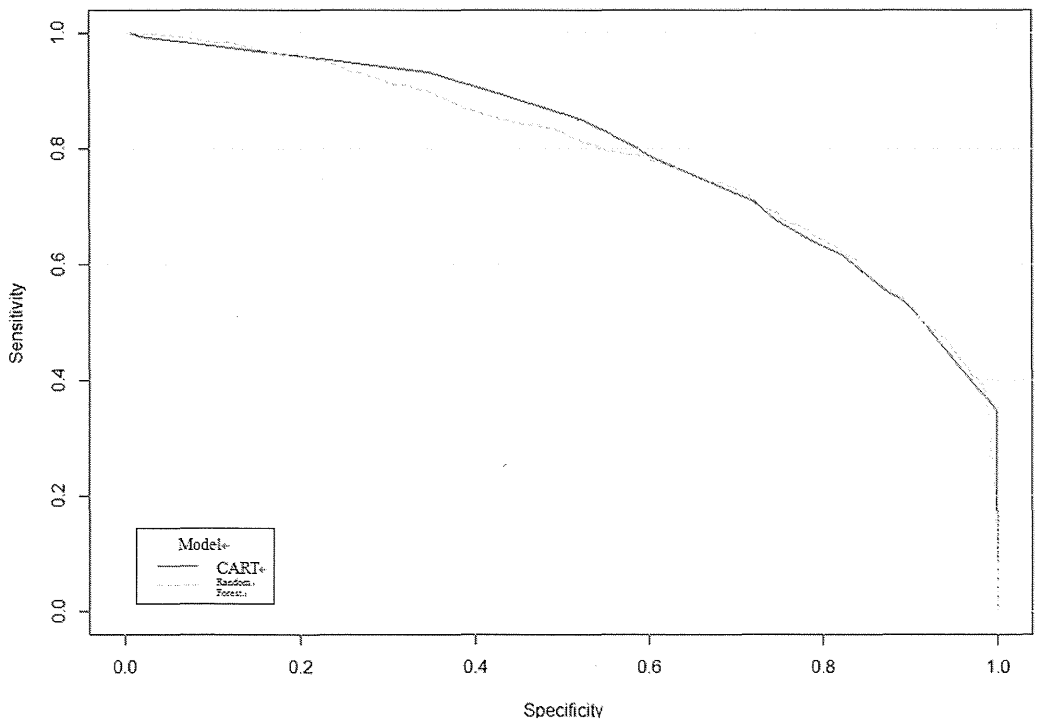
Decision Tree (CART) model fitted using the CART algorithm to predict

minsplit = 20, minbucket = 7, cp = 0.001



The Sensitivity/Specificity plot of CART and Random Forest models



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Performance Evaluation Index Formulae

		Classified as	
		LTCI expenditure increase equal to 50% or above in one year	LTCI expenditure increase less than 50% in one year
Actual	LTCI expenditure increase equal to 50% or above in one year	TP	FN
	LTCI expenditure increase less than 50% in one year	FP	TN
Sensitivity		$\frac{TP}{TP+FN}$	
Specificity		$\frac{TN}{TN+FP}$	

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The evaluation results

Evaluation	CART	Random Forest
Prediction Accuracy	0.7168	0.7122
Sensitivity	0.6359	0.6383
Specificity	0.8125	0.7985
AUC	0.7997	0.7908

(validation set, n=2,408)

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Rules Table (1/2)

Rule	Hospitalization> 30 days	CNL	Alzheimer's disease	Service Type	New Dementia	Sex	Age	Deliriu m	Heart disease	Hypertensi on	Medical Area	Prob	N(%)
47	O											0.99	988(18)
46	X	1/2	O	F/H								0.62	612(11)
45	X	3	O	F/H		M						0.61	56(1)
44	X	3	O	F/H		F	65-74					0.69	13(0)
43	X	3	O	F/H		F	75-84/ 85-94/ >95	O				0.71	7(0)
42	X	3	O	F/H		F	75-84/ 85-94/ >95	X				0.43	170(3)
37	X	1/2/3	O	C								0.05	21(0)
35	X	1/2	X	H	O		75-84/ 85-94					0.64	76(1)
34	X	1/2	X	F	O		75-84/ 85-94					0.29	7(0)
32	X	1/2	X	F/H	X	M			O			0.62	56(1)
31	X	1/2	X	F/H	X	M			X	O	Tango/ CyuTan/ NanTan/ Kyoto.Otokuni	0.56	201(4)
30	X	1/2	X	F/H	X	M			X	X	Tango/ CyuTan/ NanTan/ Kyoto.Otokuni	0.42	90(2)
28	X	1/2	X	F/H	X	M			X		YamashiroKita/ YamashiroMinami	0.41	66(1)

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Rules Table (2/2)

Rule	Hospitalization> 30 days	CNL	Alzheimer's disease	Service Type	New Dementia	Sex	Age	Delirium	Heart disease	Hypertension	Medical Area	Prob	N(%)
25	X	1	X	F/H	X	F	85-94				CyuTan/ NanTan/ Kyoto.Otokuni	0.53	219(4)
24	X	1	X	F/H	X	F	85-94				Tango/ YamashiroKita/ YamashiroMinami	0.39	57(1)
22	X	1	X	F/H	X	F	75-84					0.43	234(4)
20	X	2	X	H	X	F	75-84/ 85-94		X		Cyutan/Tango	0.56	84(1)
19	X	2	X	H	X	F	75-84/ 85-94		O		Cyutan/Tango	0.14	7(0)
17	X	2	X	F/H	X	F	75-84/ 85-94		O		Cyutan/Tango	0.14	7(0)
15	X	2	X	F/H	X	F	75-84/ 85-94		O		Kyoto.Otokuni/ NanTan/ YamashiroKita/ YamashiroMinami	0.40	547(10)
10	X	1/2	X	C			75-84/ 85-94					0.08	13(0)
8	X	1/2	X	C			65-74/ >95					0.33	294(5)
6	X	3	X									0.31	724(13)
3	X	4/5										0.19	1,067(19)

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About the result(1/2)

- Big Tree
  - Too many factors
  - The small bucket(7) and spilt size(20).
    - More detail rules but may cause over fitting
    - Small cases of terminal node
  - Both relevant and irrelevant features that might achieving many terminal nodes(24 rules)

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About the result (2/2)

Factors	Mean Decrease Accuracy	Difference
Days of Hospitalization equal to 30 or above in one year	163.6	
Care Needs Level	36.72	126.88
Alzheimer's disease	31.64	5.08
Service Type	24.8	6.84
New Diagnosis of Dementia	19.27	5.53
Sex	12.6	6.67
DM	11.5	1.1
Heart Disease	7.55	3.95
Age Group	7.16	0.39
Hypertension	6.96	0.2

Use the same dataset to build another tree simpler.

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