Development of a predictive model using the Kihon Checklist for older adults at risk of needing long-term care based on cohort data of 19 months

Kanae Sato,1 Shinya Ishii,2 Michiko Moriyama,1 Junyi Zhang3 and Kana Kazawa2

1Division of Nursing Science, Graduate School of Biomedical and Health Sciences, Hiroshima University, Hiroshima, Japan
2Department of Medicine for Integrated Approach to Social Inclusion, Graduate School of Biomedical and Health Sciences, Hiroshima University, Hiroshima, Japan
3Mobilities and Urban Policy Lab, Graduate School of Advanced Science and Engineering, Graduate School for International Development and Cooperation, Hiroshima University, Hiroshima, Japan

Correspondence
Kana Kazawa RN PHN CNS PhD, Department of Medicine for Integrated Approach to Social Inclusion, Graduate School of Biomedical and Health Sciences, Hiroshima University, Kasumi 1-2-3 Minami-ku, Hiroshima 734-8553 Japan.
Email: kkazawa@hiroshima-u.ac.jp

Aim: This study developed a risk scoring tool and examined its applicability using data from the Kihon Checklist cohort dataset for 19 months to predict the transition from no certification for long-term care to long-term care level 3 or above.

Methods: Data were collected from 26,357 functionally independent, community-dwelling older adults in a Japanese city who answered the Checklist in 2014 and were followed for 19 months. Individuals certified for long-term care during the follow-up period were classified into three levels depending on their certification status: low, moderate, and high long-term care levels. Relationships between the Kihon Checklist domains and high long-term care levels were examined using the logistic regression model. A score chart predicting incidents of high long-term care levels was created to facilitate its applicability.

Results: As of 2016, 971 participants were certified for long-term care (3.7%), of which 168 (0.6%), 357 (1.4%), and 446 (1.7%) were certified as high, moderate, and low long-term care levels, respectively. Variables associated with the certification of high long-term care level included difficulties in activities of daily living, a decline in locomotor and cognitive function in the Kihon Checklist domains, and age. The score chart was created based on these variables and demonstrated excellent discriminatory ability, with an area under curve of 0.817 (95% confidence interval: 0.785–0.849).

Conclusions: The Kihon Checklist can predict the future development of a high degree of dependency. The score chart we developed can be easily implemented to identify older adults at high risk with reasonable accuracy.

Keywords: frailty, good health and well-being, Kihon Checklist, predictive modeling, risk of long-term care.

Introduction

Japan has the highest proportion of older adults (aged 65 years and older) in the world. In 2018, the percentage of older adults was 28.1%, and this value is projected to increase to 38.4% by 2065.1 In a super-aged society, prolonging healthy life expectancy to avoid the need for long-term care (LTC) is essential for maintaining the social security system.2 In 2000, the Japanese government introduced the Long-term Care Insurance (LTCI) system to support older adults who need LTC. LTCI data can be used to identify frail individuals at high risk of needing LTC3-5 in the near future and to provide preventive care and interventions. Approximately 7–10% of community-dwelling older adults in Japan are frail.6,7 Therefore, early identification and intervention for frail older adults are critical for maintaining and improving their quality of life.

Various evaluation tools have been developed to identify frailty in older populations. The Cardiovascular Health Study criteria8 and the Frailty Index,9 which evaluate physical frailty, have been used internationally. In Japan, the Kihon Checklist (KCL), a

© 2022 The Authors. Geriatrics & Gerontology International published by John Wiley & Sons Australia, Ltd on behalf of Japan Geriatrics Society.
This is an open access article under the terms of the Creative Commons Attribution License, which permits use, distribution and reproduction in any medium, provided the original work is properly cited.
Local governments
In 2018, 21.8% of newly certi-
The care burden of family caregivers dra-
However, how to use the KCL results
Because the population is aging so rap-
Moreover, the Japanese
depend on the local government’s discretion.
Previous studies using the KCL examined the relationship between the KCL domains and the assessment of frailty using the Comprehensive Geriatric Assessment, and verified the risk of LTC certification by setting the presence or absence of LTC certification as a dependent variable and the domains of the KCL as independent variables. However, there is no study on the combination of KCL domains. While many studies have focused on the presence or absence of LTC certification, the differences in LTC care levels have not received much attention.
Tsuji et al. developed a 12-item risk assessment scale to predict incident functional disability, including all LTC levels among older adults. This scale identifies all levels of LTC certification with good sensitivity and specificity. However, we believe that targeting LTC level 3 or above, described as “almost all care is required due to a significant decrease in activities of daily living and instrumental activities of daily living (IADL),” is extremely important. This population requires extensive professional care and a considerable increase in per capita expenditure compared with the population with LTC level 2 and below. Moreover, the Japanese government sets LTC level 3 and above as a criterion for admission to LTC facilities. The care burden of family caregivers dramatically increases when LTC reaches level 3 or above, which leads to a deterioration in the caregiver’s quality of life and health. In 2018, 21.8% of newly certified older adults with LTC were of level 3 or above. Because the population is aging so rapidly that there are insufficient numbers of care professionals, it is important to efficiently identify people at risk of shifting to LTC level 3 and to connect them to preventive services at an early stage.
Historically, the use of the KCL in local governments has been to identify older adults in each domain and implement specific preventive programs. However, because multiple factors are involved in the deterioration of their condition, it is necessary to make a comprehensive evaluation by combining KCL domains. Furthermore, previous studies have suggested that there may be differences between risk factors predicting severe (LTC level 3 and above) and mild LTC levels because individual trajectories of deterioration are different in LTC levels among older adults. For populations with different trajectories, interventions tailored to their specific characteristics could be effective. It is most important to develop methods to evaluate older adults comprehensively using a combination of KCL domains associated with severe LTC levels.
Thus, to identify older adults at risk of LTC level 3 or above, we created a predictive model that interprets the results of the KCL by combining each domain and examining the possibility of applying it in clinical settings. A predictive model based on the KCL may enable authorities to effectively apply scientifically sound selection criteria to assist high-risk older adults in need of preventive care.
Therefore, this study aimed to develop a risk scoring model using 19 months of KCL cohort data to predict the transition of older adults from no certification for LTC to LTC level 3 or above and then to examine the model’s ability to estimate the probability of such status. Before developing this tool, we identified the KCL domains that were more likely to shift with each level of LTC status.

Methods
Study design
A retrospective cohort study was conducted.
Participants and procedure
Participants included older residents residing in Kure City, Hiroshima Prefecture, Japan, aged 65+ years at the time of KCL implementation. As of March 2014, the older adult population in Kure city numbered 72,177, accounting for 33.6% of the city’s total population.
In June 2014, the KCL was administered to 43,630 older adults in Kure. By August 2014, 28,958 (66.4%) of them had answered the KCL. Subsequently, those who had already been certified for LTC, had completed the KCL, were deceased, had out-migrated, or had missing data were excluded (n = 1833). After matching the KCL data of those who responded to all 25 items in August 2014 with the LTC certificate data in March 2016 and excluding deaths and out-migration, 26,357 valid responses were analyzed.

Ethical considerations
As the long-term care insurer, Kure City provided us with the data, and the analysis was conducted on an opt-out basis. Opt-out information was posted from the Hiroshima University website to the public domain. For insured persons, in conformance with the City Personal Protection Regulations, this study was performed as a joint research project with Hiroshima University and formed part of the city’s healthcare policies. The ethics committee of Hiroshima University approved this study on December 14, 2016 (No. 578) and October 25, 2021 (No. E-2644).

Measures
KCL domains
KCL is a self-administered questionnaire consisting of seven domains (difficulties in IADL, decreased locomotor function, undernutrition, decreased oral function, being homebound, decreased cognitive function, and depressive mood), with 25 questions with yes or no answers. In each domain, there are cut-off points that are useful for predicting LTC certification.

LTC: Level classification
The original seven LTC levels (support needs: levels 1 and 2, and care needs: levels 1 to 5) were reclassified into three levels: (1) low LTC level (LTC-Low [support needs level 1 or 2; care is not needed but is necessary for maintaining/improving mental and physical functions in the future]); (2) moderate LTC level (LTC-Moderate [care needs level 1 or 2; care is needed but independent living is possible]); and (3) high LTC level (LTC-High [care needs level 3 or above; care is needed and independent living is difficult]).

Statistical analysis
Relationship between KCL results (2014) and LTC certification (2016)
First, the number of participants eligible for each KCL domain was calculated with respect to the 26,357 participants who
completed the KCL in 2014 and were followed up for 19 months until March 2016. We specified the LTC levels of the participants in March 2016 using the LTC data provided by Kure City. We conducted a chi-square test to calculate the number and percentage of hits in one or more domains and to determine the association with each LTC certification.

**Developing a risk scoring tool to predict transition to LTC level 3 and above**

First, in a preliminary analysis to assess the additive contribution of the KCL to improve the prediction of transition to LTC-High, logistic regression models with and without the KCL to estimate the probability of LTC-High were built and compared. All models were adjusted for age and sex, and the KCL was entered as a total score or the scores calculated in each domain. The additive contribution of the KCL was evaluated using continuous net reclassification improvement (NRI) and integrated discrimination improvement (IDI). NRI quantifies the correct movement in categories, whereas IDI assesses the improvement for integrated sensitivity and specificity. ²⁴

Second, a multivariate logistic regression model including age, sex, and all KCL domains was constructed. It is common practice among local governments to apply specific cut-off points to each domain of KCL to determine eligibility for intervention services programs. As previous studies have reported that it is possible to predict new LTC certification using cut-off points, ¹¹,¹² we decided to adopt cut-off points and dichotomized all KCL domains.

Backward elimination was implemented, and a shrinkage method was applied to correct the regression coefficients for over-optimism. Lastly, to enhance its clinical applicability, the final model was presented as a score chart, which was created based on rounded values of the shrunken regression coefficients.

We used the receiver operating characteristic (ROC) curve and calculated the area under the curve (AUC) to evaluate the discriminative classification with each LTC certification.

**Results**

The average age of the participants (N = 26 357) was 76.8 (SD ± 6.5; age range: 66–104) years. Dividing age groups into five age categories from 65 and above, people aged 70–74 made up the largest age group (N = 7447; 28.3%). In all age groups, there were more women than men (53.0–69.8%).

**Participants’ KCL result in 2014 and LTC level in 2016**

The numbers and proportions of the study population with different hits for KCL domains in 2014 and those who were certified or not certified for LTC in 2016 are shown in Table 1. Among the 971 participants certified for LTC in 2016 (3.7%), 168 were categorized as LTC-High (0.6%), 357 as LTC-Moderate (1.4%), and 446 as LTC-Low (1.7%). Participants who hit for even one KCL domain (hitting even one applicable domain) were more likely to transition to LTC certification.

Only 152 (1.4%) participants who did not hit any KCL domain in 2014 became LTC-certified. However, 819 (5.4%) of those who had hits for any domain in 2014 became LTC-certified, showing a more significant proportion among this group (P < 0.001). Regarding all three LTC levels, the number of participants with at least one impairment was significantly higher than the number with no impairment (P < 0.001).

**Table 1** Participants’ KCL result in 2014 and long-term care level in 2016

| KCL domain                      | KCL results in 2014 n (%) | Certified LTC benefits in 2016 | Not certified in 2016 n (%) |
|--------------------------------|---------------------------|-------------------------------|----------------------------|
|                                | Total | LTC-High level | LTC-Moderate level | LTC-Low level | Total |
| Total number                   | 26 357 | (100.0) | 971 (3.7) | 168 (0.6) | 357 (1.4) | 446 (1.7) | 25 386 (96.3) |
| Number of respondents with no impairment | 11 255 | (100.0) | 152 (1.4) | 35 (0.3) | 59 (0.5) | 58 (0.5) | 11 103 (98.6) |
| Number of respondents with at least 1 impairment | 15 102 | (100.0) | 819 (5.4) | 133 (0.9) | 298 (2.0) | 388 (2.6) | 14 283 (94.6) |
| Difficulties in IADL (range: 1–5, cut-off ≥3) | 2587 | (100.0) | 339 (13.1) | 79 (3.1) | 138 (5.3) | 122 (4.7) | 2248 (86.9) |
| Decline in locomotor function (range: 1–5, cut-off ≥3) | 4875 | (100.0) | 508 (10.4) | 85 (1.7) | 169 (3.5) | 254 (5.2) | 4367 (89.6) |
| Undernutrition (range: 1–2, cut-off ≥2) | 401 | (100.0) | 34 (8.5) | 5 (1.2) | 17 (4.2) | 12 (3.0) | 367 (91.5) |
| Decline in oral function (range: 1–3, cut-off ≥2) | 4332 | (100.0) | 285 (6.6) | 59 (1.4) | 90 (2.1) | 136 (3.1) | 4047 (93.4) |
| Being homebound (range: 1–2, applicable at not going out more than once a week) | 2243 | (100.0) | 255 (11.4) | 52 (2.3) | 98 (4.4) | 105 (4.7) | 1988 (88.6) |
| Decline in cognitive function (range: 1–3, cut-off ≥2) | 8679 | (100.0) | 520 (6.0) | 101 (1.2) | 214 (2.5) | 205 (2.4) | 8159 (94.0) |
| Depressive mood (range: 1–5, cut-off ≥2) | 7905 | (100.0) | 546 (6.9) | 85 (1.1) | 195 (2.5) | 266 (3.4) | 7359 (93.1) |
| Total KCL frailty (range: 1–25, cut-off ≥7) | 7270 | (100.0) | 653 (9.0) | 118 (1.6) | 236 (3.2) | 299 (4.1) | 6617 (94.0) |

*Chi-square test, P < 0.001.* Long-term care levels were re-grouped into three: LTC-Low (support needs level 1 or 2 under Long-term Care Insurance), LTC-Moderate (care needs level 1 or 2), and LTC-High (care needs level 3 or above).

*Note:* Percentage of people in each domain who had a hit in at least one impairment.

IADL, instrumental activities of daily living; KCL, Kihon Checklist, LTC, long-term care.
shows the predictive performance of models with and have been associated with LTC certiﬁcation and increased admission to institutions. The novel score chart predicting the risk of LTC certiﬁcation in previous studies. Our ﬁndings also showed that the IADL domain has the highest OR, and can predict future certiﬁcation. Decreased IADL has been associated with the onset of mild cognitive impairment (MCI)27 and increased admission to institutions.28 Therefore, we understand that IADL is the key to the early detection of the risk of decreased cognitive functioning. Furthermore, we found that the risk of requiring LTC increased with age, which is strongly related to LTC certification, as pointed out in a previous study.29

The KCL has been used primarily to select a wide range of frail older adults for community-based preventive programs by the municipal government. The key to implementing the results of this study in municipal governments is the ability to determine the risk of the target population and prioritize interventions. Considering the trade-off between this clinical feasibility and the predictive accuracy of models, we believe that the score chart is easy to use for municipal governments.29 The novel score chart predicting the risk of LTC level 3 or above in the future has higher speciﬁcity than other models and may contribute to efﬁcient targeting and cost-effective interventions for large populations. In addition, risk scoring

### Table 2 Comparison of models using age and sex with models adding KCL in all domains

|                          | AUC (95% CI) | Sensitivity | Speciﬁcity | P-value of test for differences in AUC | Continuous NRI (95% CI) | IDI (95% CI) |
|--------------------------|--------------|-------------|-------------|----------------------------------------|-------------------------|--------------|
| Age- and sex-adjusted model (Model 1) | 0.800 (0.766-0.834) | 75.0% | 70.1% |                         |                         |              |
| Model 1 + KCL total score (Model 2) | 0.837 (0.806-0.868) | 72.0% |                  | 0.640 (0.493-0.786) | 0.012 (0.007-0.017) | 0.025 (0.017-0.034) |
| Model 1 + KCL domain score (continuous variable) (Model 3) | 0.846 (0.816-0.877) | 73.8% | 80.7% | 0.150 (0.506-0.799) | 0.064 (-0.085-0.214) | 0.014 (0.008-0.019) |

* P < 0.05, ** P < 0.01, *** P < 0.001. Sensitivity and speciﬁcity were calculated using Youden’s index method. Bonferroni-adjusted P-values are shown in the table (the observed P-value was multiplied by the number of comparisons made to adjust for pairwise comparisons).

AUC, area under the curve; IDI, integrated discrimination improvement; KCL, Kihon Checklist; NRI, net reclassiﬁcation improvement; 95% CI, 95% conﬁdence interval.

Based on LTC levels in 2016, IADL (LTC-High: 3.1%; LTC-Moderate: 5.3%) and being homebound (LTC-High: 2.3%; LTC-Moderate: 4.4%) were the most common KCL domains for which LTC-High and LTC-Moderate participants showed hit responses. However, a decline in locomotor function (5.2%), IADL (4.7%), and being homebound (4.7%) were the most common KCL domains for which participants allocated to the LTC-Low category showed hit responses.

**Additive contribution of the KCL for the prediction of LTC-High**

Table 2 shows the predictive performance of models with and without the KCL. The addition of the KCL, either as a total score (model 2) or as the score in each domain (model 3), to the model including age and sex (model 1) signiﬁcantly improved predictive performance. In addition, the model with KCL domain scores (model 3) performed signiﬁcantly better than that with the KCL total score (model 2) in terms of IDI (P < 0.001). IDI showed that model 3 improved average sensitivity and average ‘one minus speciﬁcity’ compared with other models.24

**Prediction accuracy of score chart using the selected KCL domains**

With LTC-High as the dependent variable, the results of logistic regression analysis using the backward stepwise selection method showed that age (OR = 1.14; 95% conﬁdence interval (CI): 1.12–1.17), IADL (OR = 3.63; 95% CI: 2.56–5.16), decreased locomotor function (OR = 1.49; 95% CI: 1.06–2.10), and decreased cognitive function (OR = 1.62; 95% CI: 1.16–2.26) were the predictive variables (Table 3). The calculated AUC was 0.839 (95% CI: 0.808–0.869). Sensitivity was 79.8% and speciﬁcity was 73.4% when the sum of sensitivity and speciﬁcity was maximized.

These four variables were used to create a score chart (Table 4). Age was converted from a continuous to a categorical variable and divided into three groups to make the score chart easy to implement. The score for each variable was calculated based on their odds ratios (Figure 1). Using Youden’s index method, the optimal cut-off values were indicated as 4 points. This score chart can be used to identify at-risk populations in clinical settings, minimizing the risk of missing them. At a cut-off point of 4, the sensitivity was 76.8% and speciﬁcity was 69.4%. The AUC of the score chart was 0.817, which is lower than that of the model with four selected variables, but is still considered excellent.26

**Discussion**

This study showed that vulnerable older adults who hit any of the KCL domains were at risk of LTC certiﬁcation. The multivariate logistic regression analysis revealed that IADL, decreased cognitive and locomotor function, and age were independently associated with certiﬁcation for LTC-High. Of these, decreased locomotor and cognitive function14,15 have been associated with LTC certiﬁcation in previous studies. Our ﬁndings also showed that the IADL domain has the highest OR, and can predict future certiﬁcation for LTC. Decreased IADL has been associated with the onset of mild cognitive impairment (MCI)27 and increased admission to institutions.28 Therefore, we understand that IADL is the key to the early detection of the risk of decreased cognitive functioning. Furthermore, we found that the risk of requiring LTC increased with age, which is strongly related to LTC certiﬁcation, as pointed out in a previous study.29
Based on multi-domain assessments supports decision-making related to prioritizing and combining preventive interventions for individuals. For example, for people younger than 75 years, if the person hits the three domains of KCL, namely IADL, decreased locomotor function, and decreased cognitive function, then the total would be 5 points, which exceeds the cut-off of 4; hence, such individuals can be judged to be at risk of LTC level 3 or above. Similarly, for people aged 75–89 years, having a hit in one of the three domains of the KCL can be considered high risk. Utilizing this model makes it possible to correctly identify and intervene among older adults in need of preventive measures for LTC. Our study contributes to advanced research on future efforts related to LTC prevention, public health, and medical policy-making.

There are several limitations to this study. First, the analysis was based on data from only 57% of insured persons of Kure city’s older adults, owing to missing or untraceable data. Research from a different perspective is needed to determine why older adults did not respond to the KCL. A better understanding of the reasons for older adults requiring LTC, such as illness or family situation, may enable high-risk individuals to be targeted and for early intervention to be provided. Second, this study used data from older adults living in one area. As risk characteristics are expected to vary between regions, it is necessary to replicate the study using data from different regions.

We propose to identify older adults at high risk of requiring increased levels of LTC and intervention in the future. Therefore, it is worth conducting intervention studies to prevent LTC among high-risk populations in selected communities identified by our modeling results.

**Acknowledgements**

We would like to thank Kure City, especially the Division of Health Promotion, Division of National Health Insurance, and Division of LTCl, for providing financial support and data. We also thank Data Horizon Co., Ltd for technical support for data cleaning.
Disclosure statement

The authors declare no conflicts of interest.

Data availability statement

This study was conducted as the insurer’s project (Kure City) in accordance with the personal information protection ordinance. Therefore, the dataset analyzed in this study are not publicly available.

References

1 Japanese Cabinet office. The Situation Elderly 2019. [cited 17 Feb 2021]. Available from: https://www8.cao.go.jp/kourei/whitepaper/w-2019/ gaiyou/pdf/1s1s.pdf. (in Japanese).
2 Ministry of Health, Labour and Welfare, Japan. Experts’ Group on Healthy Life Expectancy. 2019. [cited 17 Feb 2021]. Available from: https://www.mhlw.go.jp/content/10904750/0000495323.pdf. (in Japanese).
3 The Japan Geriatrics Society. Statement from the Japanese Society of Geriatrics on Frailty. 2014. [cited 17 Feb 2021]. Available from: https://jpn-geriat-soc.or.jp/info/topics/pdf/20140513_01_01.pdf. (in Japanese).
4 Kojima G. Prevalence of frailty in nursing homes: a systematic review and meta-analysis. J Am Med Dir Assoc 2015; 16: 940–945.
5 Vermeiren S, Vella-Azzopardi R, Beckwée D et al. Frailty and the prediction of negative health outcomes: a meta-analysis. J Am Med Dir Assoc 2016; 17: e1–e1163.e17.
6 Kojima G, Iliffe S, Tamiguchi Y, Shimada H, Rakugi H, Walters K. Prevalence of frailty in Japan: a systematic review and meta-analysis. J Epidemiol 2017; 27: 347–353.
7 Murayama H, Kobayashi E, Okamoto S et al. National prevalence of frailty in the older Japanese population: findings from a nationally representative survey. Arch Gerontol Geriatr 2020; 91: 104220. https://doi.org/10.1016/j.archger.2020.104220.
8 Fried LP, Tangen CM, Walston J et al. Frailty in older adults: evidence for a phenotype. J Gerontol A Biol Med Sci Med Sci 2001; 56: M146–M156.
9 Mitnitski AB, Mogilner AJ, Rockwood K. Accumulation of deficit as a proxy measure of aging. ScientificWorldJournal 2001; 1: 323–336.
10 Ministry of Health, Labour and Welfare, Japan. Partial Revision of “Guidelines for Comprehensive Business for Preventing Care and Daily Life.” 2018. [cited 17 Feb 2021]. Available from: https://www.mhlw.go.jp/file/06-Seisakujo2/12300000-Roukenkyoku/0000205728.pdf. (in Japanese).
11 Satake S, Shimokata H, Sendu K, Kondo I, Toba K. Validity of total kihon checklist score for predicting the incidence of 3-year dependency and mortality in a community-dwelling older population. J Am Med Dir Assoc 2017; 18: 552.e1–552.e6.
12 Tomata Y, Hozawa A, Ohmori-Matsuda K et al. Validation of the Kihon checklist for predicting the risk of 1-year incident long-term care insurance certification: the Ohsaki cohort 2006 study. Nihon Kosha Eisei Zasshi 2011; 58: 3–13 (in Japanese).
13 Fukutomi E, Okumiya K, Wada T et al. Importance of cognitive assessment as part of the “Kihon checklist” developed by the Japanese ministry of health, labor and welfare for prediction of frailty at a 2-year follow up. Geriatr Gerontol Int 2013; 13: 654–662.
14 Kamegaya T, Yamaguchi H, Hayashi K. Evaluation by the basic checklist and the risk of 3 years incident long-term care insurance certification. J Gen Fam Med 2017; 18: 230–236. https://doi.org/10.1007/jgfz.52.
15 Fukutomi E, Okumiya K, Wada T et al. Relationships between each category of 25-item frailty risk assessment (Kihon checklist) and newly certified older adults under long-term care insurance: a 24-month follow-up study in a rural community in Japan. Geriatr Gerontol Int 2015; 15: 864–871.
16 Tsugi E, Kondo K, Kondo N et al. Development of a risk assessment scale predicting incident functional disability among older people. Japan Gerontological evaluation study. Geriatr Gerontol Int 2018; 18: 1433–1458.
17 Ministry of Health, Labour and Welfare, Japan. 2015. Reference (3) Mechanism for Certification of Long-Term Care Required in the Long-Term Care Insurance System. [cited 18 Feb 2021]. Available from: https://www.mhlw.go.jp/topics/kaiou/kentou/15kourei/sankou3.html. (in Japanese).
18 Jin X, Mori T, Sato M, Watanabe T, Noguchi H, Tamiya N. Individual and regional determinants of long-term care expenditure in Japan: evidence from national long-term care claims. Eur J Public Health 2020; 30: 873–878.
19 Ministry of Health, Labour and Welfare, Japan. About Priority of Special Elderly Nursing Home. 2014. [cited 17 Feb 2021]. Available from: https://www.mhlw.go.jp/file/05-Shingikai-12301000-Roukenkyoku-Soumyaku/0000064525.pdf. (in Japanese).
20 Sugiyama T, Tamiya N, Watanabe T et al. Association of care recipients’ care-need level with family caregiver participation in health check-ups in Japan. Geriatr Gerontol Int 2018; 18; 26–32.
21 Ministry of Health, Labour and Welfare, Japan. Overview of municipalities. Applicants requiring long-term care and number of certified persons. 2020. [cited 7 April 2022]. Available from: https://www.mhlw.go.jp/content/12300000/0007059588.pdf. (in Japanese).
22 Fujiwara Y, Amano H, Kumaiga S et al. Physical and psychological predictors for the onset of certification of long-term care insurance among older adults living independently in a community a 40-month follow-up study. Nihon Kosha Eisei Zasshi 2006; 53: 77–91 (in Japanese).
23 Chuo University. Research and Research Project on Big Data Analysis to Clarify the Actual Situation of Dementia. 2020. [cited 7 April 2022]. Available from: https://www.chuo-u.ac.jp/research/news/2020/05/49387/.
24 Michael JP, D’A RB Sr, D’A RB Jr et al. Evaluating the added predictive ability of a new marker: from area under the ROC curve to reclassification and beyond. Stat Med 2008; 30: 157–172.
25 R: A language and environment for statistical computing. [cited 30 Febr 2021]. Available from: https://www.R-project.org/. Vienna, Austria: R Foundation for Statistical Computing.
26 Hosmer DW Jr, Lemeshow S. Applied logistic regression, 2nd edn. Canada: Wiley-Interscience, 2000; 156–164.
27 Jekel K, Damian M, Wattmo C et al. Mild cognitive impairment and deficits in instrumental activities of daily living: a systematic review. Alzheimers Res Ther 2015; 7: 1–20.
28 Na L, Hennessy S, Xie D et al. Premorbid activity limitation stages are associated with posthospitalization discharge disposition. Am J Med Qual Rehabil 2018; 97: 440–449.
29 Steyerberg EW, Vergouw E. Towards better clinical prediction models: seven steps for development and an ABCD for validation. Eur Heart J 2014; 35: 1925–1931.

Supporting Information

Additional supporting information may be found in the online version of this article at the publisher’s website:

Table S1. Multivariate logistic regression analysis with LTC level 1 and above as the dependent variable

Table S2. Ordinal logistic regression analysis with LTC levels 1 to 2 and LTC level 3 and above as dependent variables

How to cite this article: Sato K, Ishii S, Moriyama M, Zhang J, Kazawa K. Development of a predictive model using the Kihon Checklist for older adults at risk of needing long-term care based on cohort data of 19 months. Geriatr. Gerontol. Int. 2022;22:797–802. https://doi.org/10.1111/ggi.14456