

## **Are the Kihon Checklist and the Kaigo-Yobo Checklist compatible with the Frailty Index?**

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## ABSTRACT

**Objectives:** To explore comparability of Kihon Checklist (KCL) and Kaigo-Yobo Checklist (KYCL) to Frailty Index (FI) in predicting risks of long-term care insurance (LTCI) certification and/or mortality over three years.

**Design:** Prospective cohort study.

**Setting and Participants:** 1023 Japanese community-dwelling older adults from the Kusatsu Longitudinal Study of Aging and Health.

**Measures:** Frailty status was quantified at baseline using KCL, KYCL, and 32-deficit and 68-deficit FI. Relationships of the measures were examined using Spearman's rank correlation coefficients. Cox regression models examined the risk of new certification of LTCI or mortality according to KCL, KYCL, and FI. Predictive abilities of KCL and KYCL were compared with FI using area under the receiver operating characteristic curve (AUC), C statistics, net reclassification improvement (NRI), and integrated discrimination improvement (IDI).

**Results:** Mean age was 74.7 years and 57.6% were women. KCL and KYCL were significantly correlated to 32-FI ( $r=0.60$  and  $0.36$ , respectively) and to 68-FI ( $r=0.88$  and  $0.61$ , respectively). During the follow-up period, 92 participants (9%) were newly certified for LTCI or died. Fully adjusted Cox models showed higher KCL, KYCL, 32-FI, and 68-FI were all significantly associated with elevated risks (HR=1.03, 95%CI=1.01-1.04,  $p<0.001$ ; HR=1.04, 95%CI=1.02-1.05,  $p<0.001$ ; HR=1.03, 95%CI=1.01-1.05,  $p=0.001$ ; HR=1.04, 95%CI=1.02-1.06,  $p<0.001$ , respectively, per 1/100 increase of max score). AUC and C-statistics of KCL and KYCL were statistically not different from those of 32-FI and 68-FI. Predictive abilities of KCL were superior to 32-FI in NRI and IDI but inferior to 68-FI in category-free NRI, and those of KYCL were superior to 32-FI in IDI but inferior to 68-FI in NRI.

## Conclusions:

Although KCL and KYCL include smaller numbers of items than standard FI, both tools were shown to be highly correlated with FI, significant predictors of LTCI certification and/or mortality, and compatible to FI in the risk prediction.

## INTRODUCTION

There is a growing number of researches regarding frailty mounting in the literature. Although the concept of frailty has been widely accepted as a state of increased vulnerability to negative health outcomes, consensus regarding its standard definition has not been reached.<sup>1</sup> Among the various frailty criteria proposed, the Kihon Checklist (KCL) and the Kaigo-Yobo Checklist (KYCL) have increasingly been used as frailty assessment tools.<sup>2-7</sup> KCL and KYCL are both simple YES/NO questionnaires of 25 and 15 items, respectively, comprehensively covering multiple domains of important geriatric syndromes. These indices, initially developed in Japan, have now been translated into English and other languages and used in non-Japanese populations.<sup>8-13</sup> Previous studies attempted to validate KCL and KYCL as frailty assessment tools and showed that both were highly correlated to frailty status<sup>3,4</sup> defined by the Fried's phenotype,<sup>14</sup> currently most frequently used frailty criteria.<sup>15</sup>

The Fried's phenotype operationalizes frailty as a biological syndrome, characterized by five specific physical symptoms: shrinking, exhaustion, weakness, slowness, and low physical activity.<sup>14</sup> There is another commonly used frailty operationalization, the Frailty Index (FI).<sup>16</sup> This approach, in contrast, considers disabilities, comorbidities, symptoms, and signs as deficits, and can quantify frailty status on a FI.<sup>16</sup> In that KCL and KYCL include a wide range of activities of daily living (ADL), Instrumental ADL (IADL), physical function, nutritional status, oral function, housebound status, cognitive function, and depressive symptoms that can be used as a deficit to construct the FI, both indices may be more comparable to the conceptualization of the FI.<sup>3,17,18</sup> However, most of the previous studies using KCL or KYCL stratified the continuous total scores by cut-points and defined categorized frailty status, such as robust, prefrail, and frail, or non-frail and frail, based on the frailty phenotype.<sup>18</sup> To our knowledge, there have been no studies in the literature comparing KCL and KYCL with the FI in risk prediction or discrimination. Thus we aimed to explore the potentials of KCL and KYCL as a FI and examined their comparability in relation to a standard FI in predicting risks of long-term care insurance (LTCI) certification and/or mortality in a Japanese elderly population.

## METHODS

### Study setting and population

The Kusatsu Longitudinal Study of Aging and Health is a cohort study of community-dwelling adults aged  $\geq 65$  in Kusatsu town, Japan.<sup>19-21</sup> Briefly, the study was launched in 2001, and has been following up on the participants by annual health check-ups and biennial health monitoring surveys.

Among 1254 individuals who participated in the health check-up in July 2014, 1048 (83.6%) completed both KCL and KYCL questionnaires. Three participants who did not have enough deficit data to construct a FI, four who were already certified for the LTCI by 2014, and 18 who moved out or were lost for follow-up were excluded, leaving 1023 participants (81.6%) as the final analytic sample. This study was approved by the ethics committee at \*\*\* and all participants provided written informed consent.

### Frailty assessment

#### *Kihon Checklist*

This 25-item YES/NO questionnaire covers a wide range of domains: ADL (n=3), IADL (n=3), social activities (n=4), cognitive function (n=3), depressive symptoms (n=5), fall-related issues (n=2), nutritional status (n=2), and oral function (n=3).<sup>22</sup> One point is given to

each item and the total score ranges from 0-25, with a higher score indicative of greater frailty.

### ***Kaigo-Yobo Checklist***

KYCL is another YES/NO questionnaire of 15 items: ADL (n=1), social activities (n=5), fall-related issues (n=3), nutritional status (n=4), vision (n=1), and hospitalization (n=1).<sup>19</sup> The total score ranges from 0-15, with a higher score indicative of greater frailty.

### ***Frailty Index***

Two sets of FI (32 and 68 deficits) were generated according to the standard procedure.<sup>23</sup> The first FI consisted of 32 deficits (32-FI) that were not included in KCL or KYCL. The second FI was based on these 32 deficits as well as 25 deficits from KCL and 15 deficits from KYCL. Four deficits from KYCL were excluded as identical or similar to items included in KCL, leaving 68 items (68-FI). (**Supplementary Table**)

### **Follow-up and outcomes**

The participants were followed up through December 2017, for the composite outcome of newly certified LTCI or mortality. LTCI is a mandatory system of national social insurance that provides various types of formal care and support to eligible older adults aged  $\geq 65$  with disabilities.<sup>24,25</sup> The certification processes include functional disability assessment and a reference letter from attending doctors.<sup>26</sup> For a participant who was certified for LTCI and died during the follow-up period, LTCI certification was used as an event. A LTCI application date was used for the LTCI certification outcome. These outcomes were monitored using the local resident registries and LTCI system databases.

### **Covariates**

Baseline covariates used for adjustment were age, gender, smoking, alcohol use, and education, which were considered to have effects on the relationship between frailty and loss of independency.

### **Statistical Analysis**

Relationships among KCL, KYCL, 32-FI, and 68-FI were examined using Spearman's rank correlation coefficients since distribution of the four indices was similarly skewed to the right.

Cox regression models examined the risk of new certification of LTCI or mortality according to KCL, KYCL, 32-FI, and 68-FI. For comparison, hazard ratios and 95% confidence intervals (CI) for these frailty measures were calculated per 1/100 of the maximum scores (0.25 for KCL, 0.15 for KYCL, and 0.01 for FI).

Predictive abilities of KCL and KYCL were separately compared with 32-FI using three measures: (1) changes in the area under the receiver operating characteristic (ROC) curve (AUC) and C statistics, (2) categorical and category-free net reclassification improvement (NRI), and (3) integrated discrimination improvement (IDI).<sup>27</sup> The ROC curves were depicted for KCL, KYCL, 32-FI, and 68-FI, for each of which AUC was calculated. C statistics adjusted for age and gender and ones adjusted for age, gender, education, smoking, and alcohol use were calculated. NRI quantifies how better KCL or KYCL correctly reclassified individuals with and without the events, which were LTCI certification or mortality in this case. Cut-points for the predicted probability quartiles of 32-FI were used for the categorical NRI. IDI is the difference of two models' discrimination slopes, which are

calculated as a difference of mean predicted probabilities between those with and without events.

All statistical analyses were conducted using StataSE 14 (StataCorp LP, College Station, TX) and SAS software (Version 9.4, SAS institute, Cary, NC). Statistical significance was based on 2-tailed p value of <0.05.

## RESULTS

Mean age was 74.7 years and 57.6% were women. Mean scores of KCL and KYCL were 3.7 and 1.5, respectively. Means of 32-FI and 68-FI were 0.15 and 0.14, respectively.

Both KCL and KYCL were significantly correlated to 32-FI, with correlation coefficients of 0.60 and 0.36 (both  $p < 0.0001$ ). Correlation between KCL and KYCL was also significant (Spearman's  $\rho = 0.52$ ,  $p < 0.0001$ ). 68-FI, which combined all components of the three others, was significantly associated with KCL, KYCL, and 32-FI (Spearman's  $\rho = 0.88$ ,  $0.61$ , and  $0.87$ , all  $p < 0.0001$ ).

During the follow-up period, 92 participants (9%) were newly certified for LTCI ( $n = 52$ ) or died ( $n = 40$ ). Higher KCL, KYCL, 32-FI, and 68-FI were all significantly associated with elevated risks of LTCI certification or mortality (fully adjusted models: HR=1.03, HR=1.04, HR=1.03, 95% CI=1.01-1.05, HR=1.04, respectively, all  $p < 0.001$ ). (**Table 1**)

**Figures A and B** show ROC curves of KCL, KYCL, 32-FI, and 68-FI predicting composite outcomes of incident LTCI certification or mortality. AUC of KCL, KYCL, 32-FI, and 68-FI were 0.675, 0.644, 0.637, and 0.678, respectively, suggesting "poor" predictive power. The cut-points with highest Youden's index for KCL and KYCL were 8 and 4.

AUC, age- and gender-adjusted and fully adjusted C statistics of KCL, KYCL, 32-FI, and 68-FI are summarized and compared in **Table 2**. AUC, age- and gender-adjusted and fully adjusted C statistics did not show any significant difference in predictive ability of KCL and KYCL against 32-FI and 68-FI. While KCL reclassified participants with and without the events significantly better than 32-FI in category-free (by 26.2%) and categorical (by 15.7%) NRI, and IDI, KCL was inferior to 68-FI significantly in category-free NRI by 1.4% and non-significantly in categorical NRI by 9.8% and IDI.

While predictive ability of KYCL was shown to be non-significantly higher than 32-FI in category-free and categorical NRI and significantly higher than in IDI, that of 68-FI was superior significantly in category-free (by 30.3%) and categorical (by 12.2%) and non-significantly in IDI.

## DISCUSSION

We compared risk-predictive abilities of KCL and KYCL as a continuous score in relation to FI, using an array of measures including Cox regression models, ROC curve, AUC, C statistics, NRI, and IDI in 1023 Japanese community-dwelling older people and demonstrated that KCL and KYCL were significant predictors of LTCI certification and/or mortality and their predictive abilities were compatible with FI.

It is noteworthy that KCL consisting of only 25 items was shown to have better overall predictive abilities than 32-FI, mostly significantly. In addition, the predictive ability of KCL was comparable to that of 68-FI, which means adding 43 deficits to KCL did not much

improve the risk prediction. The 25 items of KCL may be a balanced collection of major core deficits from various domains, while 32 deficits used by 32-FI were leftover ones not used by KCL and KYCL and thus may be weaker predictors of adverse outcomes. KYCL includes as few as 15 items, less than half of deficits required for standard FI.<sup>23</sup> Therefore, it was rather expected the predictive ability of KYCL was significantly lower than that of 68-FI in most measures. However, predictive ability measures of KYCL were mostly better than 32-FI although the differences were small and mostly did not reach statistical significance.

On top of their risk-predictive abilities compatible to FI, KCL and KYCL have unique features. While FI can flexibly be constructed based on an arbitrary set of deficits, which may hinder precise comparisons between FI with different deficits across cohorts or, even in the same cohort.<sup>23</sup> As items are fixed in KCL and KYCL, frailty status can be compared without constraints of different cohorts or time points. KCL and KYCL don't require special equipment, therefore are quicker to conduct than FI.<sup>17</sup> Furthermore, they consist of all self-reported items and can be administered by non-healthcare professionals or by mail, email, or phone.

Although FI can effectively quantify overall frailty status, it may be much harder to identify which component is the leading cause of frailty. The items used in KCL and KYCL are grouped into several domains of geriatric syndromes. Therefore, it may be easier to identify the primary cause of frailty and to prepare for specific future events,<sup>28-30</sup> as well as implement tailored and focused interventions.<sup>5</sup>

Strengths of this study include use of various statistical measures conducted to compare predictive abilities of KCL and KYCL with that of FI in a prospective cohort study, a wide range of covariates used for adjustment when appropriate, and comparison with two types of FI, one of which (32-FI) consisted of only deficits not included KCL or KYCL and the other (68-FI) combined all deficits of KCL, KYCL, and 32-FI.

Our findings should be interpreted with caution. First, the sample size is relatively small and the population used is limited to Japanese community-dwelling older people as in the previous studies.<sup>3-7</sup> Therefore, our findings may not be generalizable to other populations and more studies are needed cross-culturally. Second, we used the composite outcome of LTCI certification and/or mortality as a surrogate marker of loss of independence. Although LTCI is an established national system in Japan, it may be difficult to compare our findings with that of studies done in other countries with different long-term care systems.

## **CONCLUSION**

Although KCL and KYCL include smaller numbers of items than a standard FI, both tools were shown to be highly correlated with FI, significant predictors of loss of independence, and compatible to FI in the risk prediction. In addition to their usefulness and feasibility, total scores of KCL and KYCL can be potentially used as a FI to assess and quantify frailty status. Compatibility of KCL and KYCL should be further confirmed by future research, focusing on other outcomes and using different ethnic populations.

## **ACKNOWLEDGEMENT**

We are grateful to the participants and municipal officers in Kusatsu town. This study was supported by grants from \*\*\*, JST/RISTEX, Grants-In-Aid for Scientific Research (B) JP20390190, (B) JP21390212, (B) JP24390173, and (B) JP26310111 from the Ministry of Education, Culture, Sports, Science and Technology, Japan.

## **Conflict of Interest**

The authors have no conflicts in the cover letter as well as in the manuscript, as noted above.

## **Author Contributions**

Study concept and design: GK and YT. Acquisition of data: YT, AK and SS. Analysis and interpretation of data: GK, YT, AK and SS. Drafting the article: GK. Revising the article critically for important intellectual content: GK, YT, AK and SS. Final approval of the version to be published: GK, YT, AK and SS.

## **Sponsor's Role**

None

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**Table 1.** Univariate and multivariate Cox regression models predicting 4-year incident mortality or long-term care insurance certification according to Kihon Checklist, Kaigo-Yobo Checklist, 32-deficit Frailty Index, and 68-deficit Frailty Index (N=1023).\*

Variable	Unadjusted model		Fully adjusted model†	
	Hazard ratio (95% CI)	p value	Hazard ratio (95% CI)	p value
Kihon Checklist score	1.04 (1.03-1.05)	<0.001	1.03 (1.01-1.04)	<0.001
Kaigo-Yobo Checklist score	1.05 (1.04-1.06)	<0.001	1.04 (1.02-1.05)	<0.001
32-deficit Frailty Index	1.04 (1.03-1.05)	<0.001	1.03 (1.01-1.05)	0.001
68-deficit Frailty Index	1.05 (1.04-1.07)	<0.001	1.04 (1.02-1.06)	<0.001

\* 32-deficit Frailty Index does not include deficits included in Kihon Checklist or Kaigo-Yobo Checklist. 68-deficit Frailty Index includes the 32 deficits and all 36 deficits included in Kihon Checklist and Kaigo-Yobo Checklist. Hazard ratios for 32-deficit and 68-deficit Frailty Indexes were per 0.01 increase. Hazard ratios for Kihon Checklist and Kaigo-Yobo Checklist scores were per 0.25 and 0.15 increase, respectively, to be comparable with Frailty Index (corresponding to 0.01 increase in Frailty Index). † Adjusted for age, gender, education (year), smoking, and alcohol.

**Table 2.** Risk prediction abilities of Kihon Checklist and Kaigo-Yobo Checklist compared with 32-deficit and 68-deficit Frailty Indices\*

	Kihon Checklist	32-deficit Frailty Index*	68-deficit Frailty Index*
Area under the curve (95%CI)	0.675 (0.614-0.737)	0.637 (p=0.16)	0.678 (p=0.82)
C statistic, age- and gender adjusted (95%CI)	0.796 (0.747-0.844)	0.792 (p=0.61)	0.799 (p=0.49)
C statistic, fully adjusted <sup>†</sup> (95%CI)	0.821 (0.772-0.869)	0.809 (p=0.17)	0.821 (p=0.95)
Category-free NRI <sup>‡</sup>	-	0.262 (p=0.02)	-0.014 (p=0.02)
Categorical NRI <sup>‡</sup>	-	0.157 (p=0.04)	-0.098 (p=0.37)
IDI <sup>‡</sup>	-	0.017 (p=0.05)	-0.004 (p=0.94)
	Kaigo-Yobo Checklist	vs. 32-deficit Frailty Index*	vs. 68-deficit Frailty Index*
Area under the curve (95%CI)	0.644 (0.579-0.709)	0.637 (p=0.85)	0.678 (p=0.17)
C statistic, age- and gender adjusted (95%CI)	0.798 (0.747-0.848)	0.792 (p=0.59)	0.799 (p=0.81)
C statistic, fully adjusted <sup>†</sup> (95%CI)	0.822 (0.771-0.872)	0.809 (p=0.27)	0.821 (p=0.94)
Category-free NRI <sup>‡</sup>	-	0.091 (p=0.40)	-0.303 (p=0.01)
Categorical NRI <sup>‡</sup>	-	0.011 (p=0.90)	-0.122 (p=0.09)
IDI <sup>‡</sup>	-	0.026 (p=0.02)	-0.005 (p=0.57)

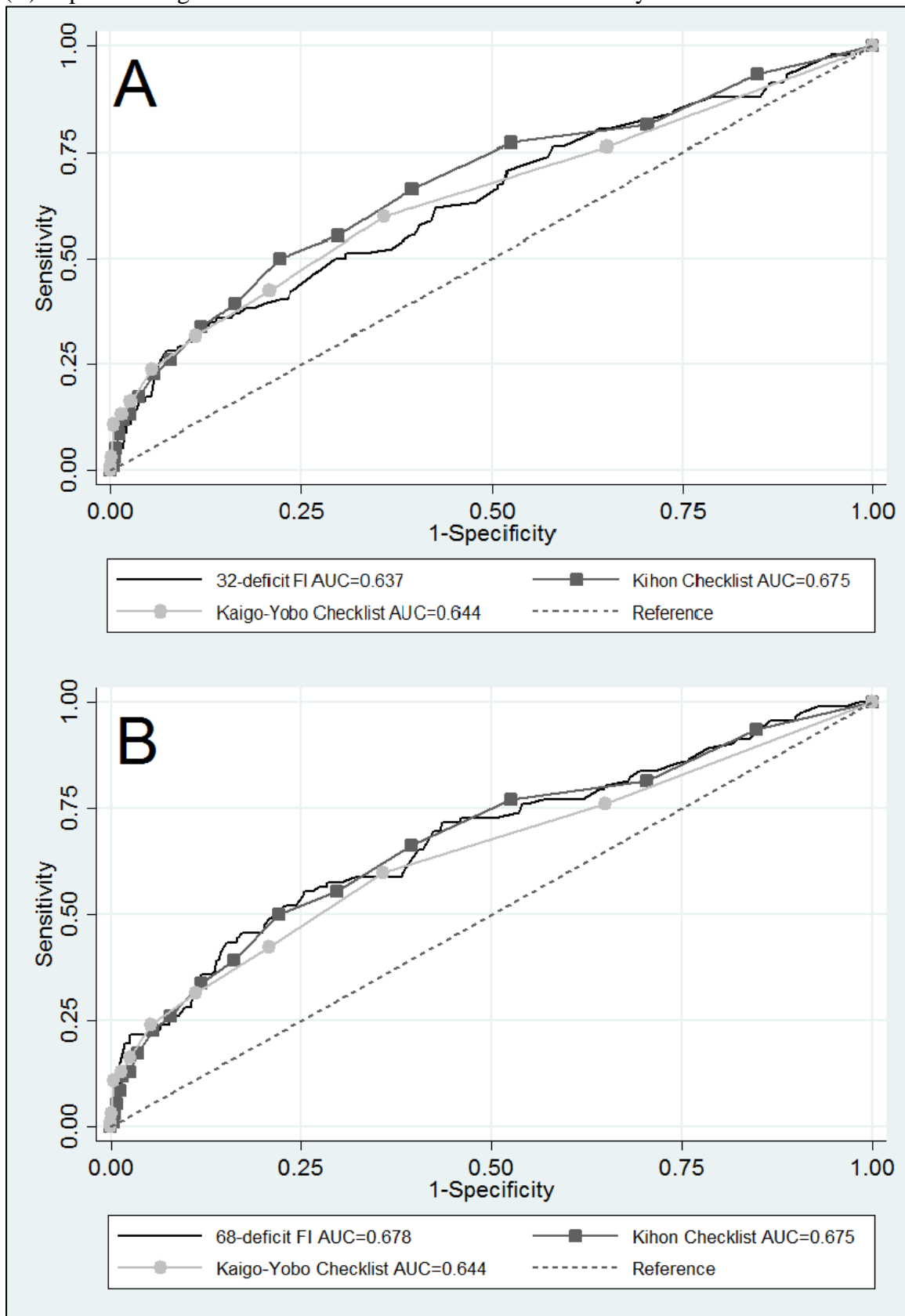
CI: confidence interval, IDI: Integrated discrimination improvement, NRI: Net reclassification improvement

\* p value for difference from Kihon Checklist or comparison with Kihon Checklist.

<sup>†</sup> Adjusted for age, gender, education, smoking, and alcohol.

<sup>‡</sup> Positive value suggests Kihon Checklist or Kaigo-Yobo Checklist has better predictive ability.

**Figures A and B.** Receiver operating characteristic curves of Kihon Checklist and Kaigo-Yobo Checklist in comparison with 32-deficit Frailty Index (A) and 68-deficit Frailty Index (B) to predict long-term care insurance certification or mortality.



**Supplementary Table.** List of deficits for constructing frailty index

	variable	coding
	<b>Kihon Checklist (n=25)</b>	
1	Do you go out by bus or train by yourself?	Yes=0, No=1
2	Do you go shopping to buy daily necessities by yourself?	Yes=0, No=1
3	Do you manage your own deposits and savings at the bank?	Yes=0, No=1
4	Do you sometimes visit your friends?	Yes=0, No=1
5	Do you give advice to your family or friends?	Yes=0, No=1
6	Are you able to climb up stairs without using handrails or wall for support?	Yes=0, No=1
7	Can you stand up from a chair without support?	Yes=0, No=1
8	Can you keep walking for 15 minutes?	Yes=0, No=1
9	Have you experienced a fall in the past year?	Yes=1, No=0
10	Do you have a fear of falling while walking?	Yes=1, No=0
11	Have you lost 2-3 kg in the past 6 months?	Yes=1, No=0
12	Height and weight to calculate BMI	BMI <18.5=1, BMI ≥18.5=0
13	Do you have more difficulty chewing solid food than 6 months ago?	Yes=1, No=0
14	Do you have choking or coughing while drinking tea or soup?	Yes=1, No=0
15	Do you have dry mouth or difficulty swallowing food because of dry mouth?	Yes=1, No=0
16	Do you go out at least once a week?	Yes=0, No=1
17	Do you go out less often than last year?	Yes=1, No=0
18	Do people point out your forgetfulness, such as “you always ask the same question”	Yes=1, No=0
19	Can you look up phone numbers and make a call?	Yes=0, No=1
20	Do you sometimes find yourself not knowing what month or date it is?	Yes=1, No=0
21	In the past 2 weeks, you have felt a lack of fulfilment in your life.	Yes=1, No=0
22	In the past 2 weeks, you have less enjoyed things you used to than before.	Yes=1, No=0
23	In the past 2 weeks, you have felt more difficulty or trouble in doing what you could do easily before.	Yes=1, No=0
24	In the past 2 weeks, you do not feel you are a useful person.	Yes=0, No=1
25	In the past 2 weeks, you have felt tired without a reason.	Yes=1, No=0
	<b>Kaigo-Yobo Checklist (n=15)</b>	
1	Do you usually stay at home all day long?	Yes=1, No=0
2	How often do you usually go out?	More than once per 2-3 days=0, Less than once a week=1
3	Do you have any hobby?	Yes=0, No=1
4	Do you have neighbors who you can talk closely with?	Yes=0, No=1
5	Besides your neighbors, do you have close friends, families, or relatives who you visit?	Yes=0, No=1

6	Have you experienced a fall in the past year?	Yes=1, No=0
7	Can you walk for 1 km?	Yes=0, No=1
8	Can you see things clearly? (with glasses if necessary)	Without difficulty=0, With difficulty or can not=1
9	Do you often slip or stumble at home?	Yes=1, No=0
10	Do you refrain from going out because of fear of falling?	Yes=1, No=0
11	Have you been hospitalized in the past year?	Yes=1, No=0
12	Do you have appetite these days?	Yes=0, No=1
13	Do you have any difficulty chewing? (even with a denture)	Yes=1, No=0
14	Have you lost 3 kg or more in the past 6 months?	Yes=1, No=0
15	Do you think you have lost muscle or fat in the past 6 months?	Yes=1, No=0
	<b>32-deficit Frailty Index (n=32)</b>	
1	Self-rated general health	Very good=0, Good=1/3, Fair=2/3, Poor=1
2	How is your hearing?	No difficulty=0, With loud voice=1/3, Only with loud voice in an ear=2/3, Almost can't=1
3	Can you walk?	Can walk=0, Can with support=0.5, Can't=1
4	Can you eat by yourself?	No difficulty=0, With some preparation=0.5, Can't=1
5	Can you bathe by yourself?	No difficulty=0, With support=0.5, Can't=1
6	Can you dress yourself?	No difficulty=0, With support=0.5, Can't=1
7	Can you use toilet by yourself?	No difficulty=0, With support=0.5, Can't=1
8	Do you sometimes fail to make it to toilet?	No=0, sometimes=0.5, always or on urinary catheter=1
9	Can you fill out forms for pension etc.?	Yes=0, No=1
10	Can you visit someone in the hospital?	Yes=0, No=1
11	Can you prepare meals by yourself?	Yes=0, No=1
12	Can you make payment for bills?	Yes=0, No=1
13	Hypertension	Present=1, Absent=0
14	Hyperlipidemia	Present=1, Absent=0
15	Diabetes	Present=1, Absent=0
16	Heart disease	Present=1, Absent=0
17	Stroke	Present=1, Absent=0
18	Are you basically satisfied with your life?	Yes=0, No=1
19	Have you dropped many of your activities and interests?	Yes=1, No=0
20	Do you feel that your life is empty?	Yes=1, No=0
21	Do you often get bored?	Yes=1, No=0
22	Are you in good spirits most of the time?	Yes=0, No=1
23	Are you afraid that something bad is going to happen to you?	Yes=1, No=0
24	Do you feel happy most of the time?	Yes=0, No=1
25	Do you often feel helpless?	Yes=1, No=0
26	Do you prefer to stay at home, rather than going out and doing new things?	Yes=1, No=0
27	Do you feel you have more problems with memory than most?	Yes=1, No=0

28	Do you think it is wonderful to be alive now?	Yes=0, No=1
29	Do you feel pretty worthless the way you are now?	Yes=1, No=0
30	Do you feel full of energy?	Yes=0, No=1
31	Do you feel that your situation is hopeless?	Yes=1, No=0
32	Do you think that most people are better off than you are?	Yes=1, No=0

BMI: Body mass index

68-deficit Frailty Index was constructed based on Kihon Checklist, Kaigo-Yobo Checklist and 32-deficit Frailty Index, with 4 duplicate items in Kaigo-Yobo Checklist excluded.