Supplementary Information

Authors

Hirotaka Nakashima, Takahiro Imaizumi, Hitoshi Komiya, Akemi Morohashi, Kazuhisa Watanabe, Chisato Fujisawa, Yosuke Yamada, Yoshimasa Nagao, Hiroyuki Umegaki

[*]Corresponding author

Hirotaka Nakashima

Department of Geriatrics, Nagoya University Hospital, Nagoya, Japan

Email: nakashima.hirotaka.d5@f.mail.nagoya-u.ac.jp

Supplementary Table 1. Original version of STRATIFY and the modified versions used in the present study.

Supplementary Table 2. Laboratory data used to construct the Frailty Index-laboratory (FI-lab).

Supplementary Table 3. Items included in the standard non-laboratory Frailty Index (FI-clinical).

Supplementary Table 4. Fall risk assessment tool used at the authors' hospital.

Supplementary Table 5. Common primary reasons for admission.

Supplementary Table 6. Baseline characteristics of the study population and outcomes according to FI-lab score (n=5984).

Supplementary Table 7. Results of subgroup analyses.

Supplementary Table 8. Results of sensitivity analyses.

Supplementary Figure 1. Frequency distributions for the STRATIFY (A), standard non-laboratory Frailty Index (FI-clinical) (B), and Frailty Index-laboratory (FI-lab) (C) (n=5984).

Supplementary Table 1

Original version of STRATIFY and the modified versions used in the present study.

	Item	Original STRATIFY[*]	Modified STRATIFY
1	History of falls	Did the patient present to hospital with a fall or has he or she fallen on the ward since admission? (Yes = 1, No = 0)	History of falls within 1 year.[‡] (Yes = 1, No = 0)
2	Mental status	Agitated?[†] (Yes = 1, No = 0)	Is the patient confused, disoriented, or agitated?[†,§] (Yes = 1, No = 0)
3	Vision	Visually impairment to the extent that everyday function is affected?[†] (Yes = 1, No = 0)	(Same as the original)
4	Toileting	In need of especially frequent toileting?[†] (Yes = 1, No = 0)	(Same as the original)
5	Transfer and mobility	Transfer and mobility score of 3 or 4?[†] (Yes = 1, No = 0)	(Same as the original)

Notes: STRATIFY = St. Thomas's Risk Assessment Tool in Falling Elderly Inpatients

[*]Based on Oliver et al. BMJ 1997; 315: 1049.

[†]Judged by nurses. No attempt was made to standardize the formation of these judgments.

[‡]Based on history-taking.

[§]Referring to Papaioannou et al. BMC Medicine 2004; 2: 1.

Supplementary Table 2

Laboratory data used to construct the Frailty Index-laboratory (FI-lab).

Variable[*]	Unit	Total population 0 (Normal)	1 (Abnormal)	Male 0 (Normal)	1 (Abnormal)	Female 0 (Normal)	1 (Abnormal)
WBC	×10³/µL	3.3-8.6	<3.3 or >8.6				
Neutrophil	×10³/µL	1.0-7.5	<1.0 or >7.5				
Lymphocyte	×10³/µL	1.0-4.0	<1.0 or >4.0				
Hemoglobin	g/dL			13.7-16.8	<13.7 or >16.8	11.6-14.8	<11.6 or >14.8
Hematocrit	%			40.7-50.1	<40.7 or >50.1	35.1-44.4	<35.1 or >44.4
MCV	fL	83.6-98.2	83.6< or >98.2				
RDW	%	11-14	<11 or >14				
Platelet count	×10³/µL	158-348	<158 or >348				
Total protein	g/dL	6.6-8.1	<6.6 or >8.1				
Albumin	g/dL	4.1-5.1	<4.1 or >5.1				
Glucose	mg/dL	73-109	<73 or >109				
Urea	mg/dL	8-20	<8 or >20				
Creatinine	mg/dL			0.65-1.07	<0.65 or >1.07	0.46-0.79	<0.46 or >0.79
Uric acid	mg/dL			3.7-7.8	<3.7 or >7.8	2.6-5.5	<2.6 or >5.5
Sodium	mmol/L	138-145	<138 or >145				
Potassium	mmol/L	3.6-4.8	<3.6 or >4.8				
Chloride	mmol/L	101-108	<101 or >108				
Corrected calcium	mg/dL	8.8-10.1	<8.8 or >10.1				
AST	U/L	13-30	<13 or >30				
ALT	U/L			10-42	<10 or >42	7-23	<7 or >23
LDH	U/L	124-222	<124 or >222				
Total bilirubin	mg/dL	0.4-1.5	<0.4 or >1.5				
ALP (JSCC)	U/L	106-322	<106 or >322				
γGTP	U/L			13-64	<13 or >64	9-32	<9 or >32
Amylase	U/L	44-132	<44 or >132				
CK	U/L			59-248	<59 or >248	41-153	<41 or >153
Total cholesterol	mg/dL	142-248	<142 or >248				
Triglyceride	mg/dL			40-234	<40 or >234	30-117	<30 or >117
HDL-C	mg/dL			38-90	<38 or >90	48-103	<48 or >103
LDL-C	mg/dL	65-163	<65 or >163				
HbA1c	%	4.9-6.0	<4.9 or >6.0				
CRP	mg/dL	≤0.14	>0.14				
PT	%	80-120	<80 or >120				
APTT	%	80-120	<80 or >120				
Fibrinogen	mg/dL	200-400	<200 or >400				

Notes: ALT = alanine transaminase; ALP = alkaline phosphatase; APTT = activated partial thromboplastin time; AST = aspartate transaminase; CK = creatine kinase; CRP = C-reactive protein; γGTP = gamma-glutamyl transpeptidase; HbA1c = hemoglobin A1c; HDL-C = high-density lipoprotein cholesterol; JSCC = Japan Society of Clinical Chemistry; LDH = lactate dehydrogenase; LDL-C = low-density lipoprotein-cholesterol; MCV = mean cell volume; PT = prothrombin time; RDW = red cell distribution width; WBC = white blood cells

[*]Cut-off values were obtained from our Department of Laboratory Medicine.

Supplementary Table 3

Items included in the standard non-laboratory Frailty Index (FI-clinical).

Variable	Deficit value				
	0 points	0.33 points	0.5 points	0.66 points	1 point
1 History of falls	absent				present
2 Muscle weakness	absent				present
3 Difficulty with balance	absent				present
5 Shuffling or festinating gate	absent				present
4 Contracture	absent				present
6 Frequent urination	absent				present
7 Nocturia	absent				present
8 BMI	21.5-25.0 kg/m^2				<21.5 or >25.0 kg/m^2
9 Coronary artery disease	absent				present
10 Congestive heart failure	absent				present
11 Peripheral artery disease	absent				present
12 Dementia	absent				present
13 COPD	absent				present
14 Peptic ulcer disease	absent				present
15 Chronic kidney disease	absent				present
16 Cerebral vascular accident	absent				present
17 Diabetes mellitus	absent				present
18 Hypertension	absent				present
19 Use of sleep medication(s)	no				yes
20 Feeding	independent		needs help		totally dependent
21 Position change in bed	independent		needs help		totally dependent
22 Maintaining sitting position	independent				totally dependent
23 Sitting adjustment	independent				totally dependent
24 Transfer	independent	minor help		major help	totally dependent
25 Walking	independent	walks with help		wheelchair bound	Immobile
26 Use of walking aids	no				yes
27 Stairs	independent		needs help		total dependent
28 Grooming	independent				needs help with personal care
29 Bathing	independent				total dependent
30 Dressing	independent		needs help		total dependent
31 Toilet	independent		needs help		totally dependent
32 Bowel control	continent		occasional accident		incontinent
33 Use of diaper for defecation	no				yes
34 Bladder control	continent		occasional accident		incontinent
35 Use of diaper for urination	no				yes
36 Disorientation	absent				present
37 Impaired comprehension	absent				present
38 Impaired memory	absent				present
39 Swallowing difficulty	absent				present
40 Hearing problems	no problems				hear only loud voices

Supplementary Table 4

Fall risk assessment tool used at the authors' hospital.

Major category	Items
1. History of falls	
	1. History of falls
	2. History of syncope
	3. History of convulsions
	4. History of epilepsy
2. Disorder of the sensory system	
	1. Visual impairment
	2. Hearing impairment
3. Disorder of the musculoskeletal system	
	1. Muscle weakness
	2. Paralysis, numbness
	3. Dizziness
	4. Lightheadedness
	5. Joint abnormalities/contractures/deformations
	6. Gait disturbance
4. Disorder of cognition function	
	1. Disturbance of consciousness
	2. Restlessness
	3. Disorientation
	4. Memory disturbance
	5. Impaired judgment
	6. Not able to press a buzzer
5. Dysfunction of urination/defecation	
	1. Needs helper
	2. Fecal incontinence
	3. Frequent urination
	4. Go to bathroom often at night
	5. Needs diapers for defecation
	6. Urinary incontinence
	7. Needs diapers for urination
6. Mobility dysfunction/dependency	
	1. Inability to stand or walk
	2. Cane
	3. Walker
	4. Wheelchair
	5. Need assistance
	6. Use of intravenous infusion, placement of drains, oxygenation
7. Medication	
	1. Hypnotics (occasionally)
	2. Hypnotics (every day)
	3. Psychotropic drugs
	4. Anticancer agents
	5. Opioids
	6. Analgesics
	7. Antihypertensive agents

Supplementary Table 5

Common primary reasons for admission.

Rank	Major diagnostic category	n	%*
1	Cancer and complications	2650	44.3
2	Arrythmia	263	4.4
3	Heart failure	212	3.5
4	Arterial diseases	189	3.2
5	Neurological diseases other than stroke	175	2.9
6	Benign gastrointestinal tumor	156	2.6
7	Renal failure	130	2.2
8	Biliary diseases	130	2.9
9	Cardiac valvular diseases	110	1.8
10	Diabetes mellitus and complications	99	1.7
11	Acute coronary syndrome	82	1.4
12	Pneumonia	65	1.1
13	Gastrointestinal ileus	60	1.0
14	Gastrointestinal bleeding	57	1.0
15	Autoimmune disorders	45	0.8

*Percentage of cases to total admissions (n=5984).

Supplementary Table 6

Baseline characteristics of the study population and outcomes according to FI-lab score (n=5984).

	Total		Low (<0.25)		Moderate (0.25–0.4)		High (>0.4)		p[g]
Participants, n (%)	5984	(100.0)	2383	(39.8)	1859	(31.1)	1742	(29.1)	
Age, years	73.0	± 7.3	71.5	± 6.7	73.7	± 7.3	74.4	± 7.7	<.001[h]
Male sex	3798	(63.5)	1383	(58.0)	1253	(67.4)	1162	(66.7)	<.001[i]
Emergency hospitalization	1551	(25.9)	236	(9.9)	395	(21.2)	920	(52.8)	<.001[i]
Body mass index, kg/m^2	22.3	± 3.8	22.8	± 3.5	22.3	± 3.9	21.8	± 4.0	<.001[h]
Barthel Index[a], median (IQR)	100	(100–100)	100	(100–100)	100	(100–100)	100	(80–100)	<.001[h]
Barthel Index[a], mean ± SD[b]	94.1	± 15.5	98.0	± 8.2	95.4	± 13.3	87.4	± 21.7	
CCI[c]	2	(1–2)	2	(0–2)	2	(1–2)	2	(1–3)	<.001[h]
Polypharmacy score[d]	1	(0–2)	1	(0–2)	1	(0–2)	1	(1–2)	<.001[h]
STRATIFY score[e], median (IQR)	0	(0–1)	0	(0–0)	0	(0–1)	0	(0–1)	<.001[h]
STRATIFY score[e], mean ± SD[b]	0.42	± 0.72	0.30	± 0.56	0.39	± 0.70	0.62	± 0.89	
History of falls	807	(13.5)	201	(8.4)	255	(13.7)	351	(20.1)	<.001[i]
Mental state abnormality	353	(5.9)	76	(3.2)	94	(5.1)	183	(10.5)	<.001[i]
Vision impairment	442	(7.4)	188	(7.9)	117	(6.3)	137	(7.9)	.83[i]
Frequent urination	419	(7.0)	161	(6.8)	133	(7.2)	125	(7.2)	.59[i]
Transferring and/or mobility impairment	504	(8.4)	80	(3.4)	133	(7.2)	291	(16.7)	<.001[i]
FI-lab[f]	0.31	± 0.16	0.15	± 0.06	0.32	± 0.04	0.51	± 0.09	<.001[h]
Measured ratio	0.87	± 0.08	0.88	± 0.07	0.87	± 0.08	0.87	± 0.08	.027[h]
FI-clinical[f]	0.11	± 0.09	0.08	± 0.06	0.11	± 0.08	0.16	± 0.12	<.001[h]
Outcomes									
In-hospital falls	175	(2.9)	42	(1.8)	38	(2.0)	95	(5.5)	<.001[i]
In-hospital injurious falls	32	(0.5)	10	(0.4)	7	(0.4)	15	(0.9)	.07[i]
In-hospital mortality	95	(1.6)	3	(0.1)	8	(0.4)	84	(4.8)	<.001[i]
Length of hospital stay	9	(5–16)	8	(4–12)	8	(4–15)	12	(7–23)	<.001[h]
Discharge home	5382	(89.9)	2271	(95.5)	1718	(92.5)	1393	(80.3)	<.001[i]

Notes: Data are presented as the mean ± standard deviation, median (interquartile range), or number (percentage). CCI = Charlson Comorbidity Index; FI-clinical = standard non-laboratory Frailty Index; FI-lab = Frailty Index based on laboratory tests; IQR = interquartile range; SD = standard deviation; STRATIFY = St. Thomas's Risk Assessment Tool in Falling Elderly Inpatients.

[a]Barthel Index score ranges from 0 to 100, with a higher score indicating higher function.

[b]The mean and SD are shown for reference.

[c]The CCI score ranges from 0 to 37, with a higher score indicating more comorbidities.

[d]The polypharmacy score ranges from 0 to 6, with a higher score indicating more medications in use.

[e]The STRATIFY score ranges from 0 to 5, with a higher score indicating a higher fall risk.

[f]The FI-lab and FI-clinical scores range from 0 to 1, with a higher score indicating worse frailty.

[g]Test for trends among the three subgroups.

[h]Jonckheere-Terpstra test.

[i]Cochran-Armitage test.

Supplementary Table 7

Results of subgroup analyses.   .

Subgroup	n	In-hospital fall, n (%)		ROC-AUC		p^b
				STRATIFY	STRATIFY including FI-lab[s]	
Overall	5984	175	(2.9)	0.674	0.718	<0.001
Age						
< 75	3461	82	(2.4)	0.672	0.721	0.014
≥ 75	2523	93	(3.7)	0.647	0.698	0.002
Sex						
Male	3798	103	(2.7)	0.657	0.705	0.006
Female	2186	72	(3.3)	0.704	0.741	0.025

Notes: FI-lab = Frailty Index-laboratory; ROC-AUC = area under the receiver-operating characteristic curve; STRATIFY = St.

Thomas's Risk Assessment Tool in Falling Elderly Inpatients.

[a]A total of 6 items: 5 STRATIFY items and 1 item on whether FI-lab is higher than 0.4.

[b]Comparison between STRATIFY and STRATIFY including FI-lab.

Supplementary Table 8

Results of sensitivity analyses.

Model[a]	ROC-AUC	95% CI	p
With or without polypharmacy score[b]			
STRATIFY	0.674	(0.632–0.716)	ref
STRATIFY + polypharmacy score[b]	0.675	(0.633–0.716)	0.64
STRATIFY + FI-lab	0.715	(0.677–0.753)	0.018
STRATIFY + FI-lab + polypharmacy score[b]	0.715	(0.677–0.753)	0.017
STRATIFY + FI-clinical	0.707	(0.667–0.747)	0.003
STRATIFY + FI-clinical + polypharmacy score[b]	0.709	(0.668–0.749)	0.001
Changing cut-off point of FI-lab			
FI-lab (binary variable: cut-off 0.4)	0.659	(0.616–0.702)	ref
FI-lab (binary variable: cut-off 0.345)	0.670	(0.628–0.712)	0.34
STRATIFY including FI-lab[c] (binary variable: cut-off 0.4)	0.718	(0.681–0.755)	ref
STRATIFY including FI-lab[c] (binary variable: cut-off 0.345)	0.725	(0.690–0.759)	0.40
Changing fall prediction tool			
Fall risk assessment tool in the author's hospital	0.667	(0.626–0.709)	ref
STRATIFY	0.674	(0.632–0.716)	0.69
Fall risk assessment tool including FI-lab[d]	0.691	(0.652–0.731)	<0.001

Notes: CI, confidence interval; FI-lab, Frailty Index-laboratory; ROC-AUC, area under the receiver-operating characteristic curve;

STRATIFY, St. Thomas's Risk Assessment Tool in Falling Elderly Inpatients.

[a]All models include age and sex as covariates.

[b]The polypharmacy score ranges from 0 to 6, with a higher score indicating more medications in use.

[c]A total of 6 items: 5 STRATIFY items and 1 item on whether FI-lab is higher than the cut-off.

[d]A total of 8 items: 7 items of fall risk assessment tool and 1 item on whether the FI-lab is higher than 0.4.

Supplementary Figure 1

Frequency distributions for the STRATIFY (A), standard non-laboratory Frailty Index (FI-clinical) (B), and Frailty Index-laboratory (FI-lab) (C) (n=5984). STRATIFY = St. Thomas's Risk Assessment Tool in Falling Elderly Inpatients