

Supplementary Materials

Supplementary Table 1	Items used to construct the frailty index.....	2
Supplementary Table 2	Numbers and rates of participants with missing data in the analyses of baseline frailty status	4
Supplementary Table 3	Number of incident cases of cognitive impairment and no cognitive impairment and follow-up time in the analyses of baseline frailty status	6
Supplementary Table 4	Characteristics of the included participants in the analyses of baseline frailty status when using data not being imputed	7
Supplementary Table 5	Characteristics of the included participants at baseline frailty status and excluded participants completely lost to follow-up	9
Supplementary Table 6	Association between baseline frailty status and cognitive impairment by age	10
Supplementary Table 7	Association between baseline frailty status and cognitive impairment by sex	11
Supplementary Table 8	Association between baseline frailty status and cognitive impairment by educational attainment	12
Supplementary Table 9	Association between baseline frailty status and cognitive impairment by total household income	13
Supplementary Table 10	Association between baseline continuous frailty index and cognitive impairment	14
Supplementary Table 11	Association between baseline frailty status and cognitive impairment when using competing risk model	15
Supplementary Table 12	Association between baseline frailty status and cognitive impairment after excluding participants who developed cognitive impairment during the first year of follow-up	16
Supplementary Table 13	Association between baseline frailty status and cognitive impairment using data not being imputed	17
Supplementary Table 14	Association between baseline frailty status and cognitive impairment when using frailty index cutoffs of 0.10 and 0.25 to define frailty status	18
Supplementary Table 15	Association between baseline frailty status and cognitive impairment when using the lowest quartile of cognitive scores to define cognitive impairment	19
Supplementary Table 16	Numbers and rates of participants with missing data in the analyses of frailty trajectory classes	20
Supplementary Table 17	Number of cases of cognitive impairment and no cognitive impairment in the analyses frailty trajectory	22
Supplementary Table 18	Fit indices of frailty trajectory model	23
Supplementary Table 19	Characteristics of the included participants in the analyses of frailty trajectory classes when using data not being imputed	24
Supplementary Table 20	Association between frailty trajectory classes and cognitive impairment by age	26
Supplementary Table 21	Association between frailty trajectory classes and cognitive impairment by sex	27
Supplementary Table 22	Association between frailty trajectory classes and cognitive impairment by educational attainment	28
Supplementary Table 23	Association between frailty trajectory classes and cognitive impairment by total household income	29
Supplementary Table 24	Association between frailty trajectory classes and cognitive impairment using data not being imputed	30
Supplementary Table 25	Association between frailty trajectory classes and cognitive impairment when using frailty index cutoffs of 0.10 and 0.25 to define frailty status	31
Supplementary Figure 1	Participant selection processes across the five studies	32

Supplementary Table 1 Items used to construct the frailty index

Item	Description					Cutoff
	HRS	ELSA	SHARE	CHARLS	KLoSA	
1	Self-reported hypertension diagnosed by doctors					Yes = 1, No = 0
2	Self-reported diabetes diagnosed by doctors					Yes = 1, No = 0
3	Self-reported diagnosed heart disease by doctors					Yes = 1, No = 0
4	Self-reported diagnosed stroke by doctors					Yes = 1, No = 0
5	Self-reported diagnosed cancer by doctors					Yes = 1, No = 0
6	Self-reported arthritis diagnosed by doctors					Yes = 1, No = 0
7	Self-reported chronic lung disease diagnosed by doctors					Yes = 1, No = 0
8	Self-reported any emotional, nervous, or psychiatric problems diagnosed by doctors					Yes = 1, No = 0
9	Self-reported eyesight		Self-reported eyesight for seeing thing up close		Self-reported eyesight	Blind or poor = 1, Fair = 0.75, Good = 0.50, Very good = 0.25, Excellent = 0 (HRS, ELSA, SHARE, CHARLS); Blind, very poor, or poor = 1, Fair = 0.75, Good = 0.50, Very good = 0.25 (KLoSA)
10	Self-reported hearing (while using hearing aid if appropriate)					Deaf or poor = 1, Fair = 0.75, Good = 0.50, Very good = 0.25, Excellent = 0 (HRS, ELSA, SHARE, CHARLS); Very poor, or poor = 1, Fair = 0.75, Good = 0.50, Very good = 0.25 (KLoSA)
11	Self-reported health status					Poor = 1, Fair = 0.75, Good = 0.50, Very good = 0.25, Excellent = 0
12	ADL: Any difficulty in dressing					Yes = 1, No = 0

13	ADL: Any difficulty in bathing or showering				Yes = 1, No = 0
14	ADL: Any difficulty in eating				Yes = 1, No = 0
15	ADL: Any difficulty in getting in/out of bed				Yes = 1, No = 0
16	ADL: Any difficulty in using the toilet				Yes = 1, No = 0
17	IADL: Any difficulty in managing money				Yes = 1, No = 0
18	IADL: Any difficulty in taking medications				Yes = 1, No = 0
19	IADL: Any difficulty in shopping				Yes = 1, No = 0
20	IADL: Any difficulty in preparing meals				Yes = 1, No = 0
21	Mobility: Any difficulty in walking 100 yards or one block			-	Yes = 1, No = 0
22	Mobility: Any difficulty in getting up from a chair after sitting for long periods			-	Yes = 1, No = 0
23	Mobility: difficulty in climbing several flights of stairs without resting			-	Yes = 1, No = 0
24	Mobility: Any difficulty in lifting or carrying weights over 10 pounds/jins			-	Yes = 1, No = 0
25	Mobility: Any difficulty in picking up a coin from the table			-	Yes = 1, No = 0
26	Mobility: Any difficulty in stooping, kneeling, or crouching			-	Yes = 1, No = 0
27	Mobility: Any difficulty in reaching arms above shoulder level			-	Yes = 1, No = 0
					(CESD-8 $\geq$ 4) = 1, (CESD-8 < 4) = 0
					(HRS, ELSA);
					(EURO-D $\geq$ 4) = 1, (EURO-D < 4) =
					0 (SHARE);
					(CESD-10 $\geq$ 10) = 1, (CESD-10 <
					10) = 0 (CHARLS);
					(CESD-10A $\geq$ 10) or taking an
					antidepressant = 1, (CESD-10A <
					10) or not taking an
					antidepressant = 0 (KLoSA);
					(CESD-9 $\geq$ 5) = 1, (CESD-9 < 5) = 0
28	Depression: CESD-8 (range: 0–8)	Depression: EURO-D (range: 0–12)	Depression: CESD-10 (range: 0–30)	Depression: CESD-10A (range: 0– 30) or taking an antidepressant	

HRS: Health and Retirement Study; ELSA: English Longitudinal Study of Ageing; SHARE: Survey of Health: Ageing and Retirement in Europe; CHARLS: China Health and Retirement Longitudinal Study; KLoSA: Korean Longitudinal Study of Aging; ADL: activity of daily living; IADL: instrumental activities of daily living; CESD: Center for Epidemiologic Studies Depression Scale; EURO-D: European Depression Scale.

Supplementary Table 2 Numbers and rates of participants with missing data in the analyses of baseline frailty status

Characteristic	HRS				ELSA				SHARE			
	Robust (n=881) (n, %)	Pre-frail (n=3789) (n, %)	Frail (n=2767) (n, %)	Total (n=7434) (n, %)	Robust (n=2027) (n, %)	Pre-frail (n=2981) (n, %)	Frail (n=1033) (n, %)	Total (n=6041) (n, %)	Robust (n=6544) (n, %)	Pre-frail (n=10522) (n, %)	Frail (n=4434) (n, %)	Total (n=21500) (n, %)
Age (years)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Age group	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Sex	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Marital status	1 (0.11)	0 (0)	2 (0.07)	3 (0.04)	1 (0.05)	0 (0)	0 (0)	1 (0.02)	2 (0.03)	1 (0.01)	0 (0)	3 (0.01)
Living region	3 (0.34)	27 (0.71)	8 (0.29)	38 (0.51)	-	-	-	-	343 (5.24)	487 (4.63)	182 (4.1)	1012 (4.71)
Labour force status	0 (0)	0 (0)	0 (0)	0 (0)	10 (0.49)	9 (0.30)	5 (0.48)	24 (0.40)	66 (1.01)	104 (0.99)	65 (1.47)	235 (1.09)
Educational attainment	1 (0.11)	1 (0.03)	0 (0)	2 (0.03)	172 (8.49)	270 (9.06)	96 (9.29)	538 (8.91)	0 (0)	0 (0)	0 (0)	0 (0)
Total household income (tertiles)	0 (0)	0 (0)	0 (0)	0 (0)	61 (3.01)	48 (1.61)	8 (0.77)	117 (1.94)	845 (12.91)	1150 (10.93)	325 (7.33)	2320 (10.79)
BMI (kg/m ²)	7 (0.79)	32 (0.84)	33 (1.19)	72 (0.97)	527 (26.00)	534 (17.91)	205 (19.85)	1266 (20.96)	68 (1.04)	122 (1.16)	110 (2.48)	300 (1.4)
BMI group	7 (0.79)	32 (0.84)	33 (1.19)	72 (0.97)	527 (26.00)	534 (17.91)	205 (19.85)	1266 (20.96)	68 (1.04)	122 (1.16)	110 (2.48)	300 (1.4)
Smoking status	8 (0.91)	16 (0.42)	19 (0.69)	43 (0.58)	0 (0)	1 (0.03)	1 (0.10)	2 (0.03)	5 (0.08)	19 (0.18)	40 (0.90)	64 (0.3)
Drinking status	0 (0)	0 (0)	0 (0)	0 (0)	135 (6.66)	221 (7.41)	101 (9.78)	457 (7.56)	5 (0.08)	19 (0.18)	40 (0.90)	64 (0.3)
Physical activity	0 (0)	8 (0.21)	4 (0.14)	12 (0.16)	0 (0)	1 (0.03)	0 (0)	1 (0.02)	6 (0.09)	24 (0.23)	42 (0.95)	72 (0.33)

Supplementary Table 2 Continued Numbers and rates of participants with missing data in the analyses of baseline frailty status

Characteristic	CHARLS				KLoSA			
	Robust (n=1402) (n, %)	Pre-frail (n=4023) (n, %)	Frail (n=1149) (n, %)	Total (n=6574) (n, %)	Robust (n=1631) (n, %)	Pre-frail (n=2055) (n, %)	Frail (n=413) (n, %)	Total (n=4099) (n, %)
Age (years)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Age group	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Sex	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Marital status	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Living region	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Labour force status	12 (0.86)	50 (1.24)	16 (1.39)	78 (1.19)	6 (0.37)	3 (0.15)	0 (0)	9 (0.22)
Educational attainment	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Total household income (tertiles)	606 (43.22)	1364 (33.91)	315 (27.42)	2285 (34.76)	0 (0)	0 (0)	0 (0)	0 (0)
BMI (kg/m ²)	213 (15.19)	530 (13.17)	142 (12.36)	885 (13.46)	28 (1.72)	30 (1.46)	9 (2.18)	67 (1.63)
BMI group	213 (15.19)	530 (13.17)	142 (12.36)	885 (13.46)	28 (1.72)	30 (1.46)	9 (2.18)	67 (1.63)
Smoking status	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Drinking status	0 (0)	3 (0.07)	0 (0)	3 (0.05)	0 (0)	0 (0)	0 (0)	0 (0)
Physical activity	-	-	-	-	0 (0)	0 (0)	0 (0)	0 (0)

HRS: Health and Retirement Study; ELSA: English Longitudinal Study of Ageing; SHARE: Survey of Health, Ageing and Retirement in Europe; CHARLS: China Health and Retirement Longitudinal Study; KLoSA: Korean Longitudinal Study of Aging; BMI: body mass index.

The covariate “living region” was not available in ELSA, so it was not included in the analysis.

The missing rates for the covariate “physical activity” in CHARLS exceeded 50%, so it was excluded from the analysis.

Supplementary Table 3 Number of incident cases of cognitive impairment and no cognitive impairment and follow-up time in the analyses of baseline frailty status

Study	Cognitive impairment (n, %)	No cognitive impairment (n, %)	Total (n)	Follow-up time (median [IQR], years)
HRS	1366 (18.38)	6071 (81.62)	7437	5.50 (2.33)
ELSA	898 (14.87)	5143 (85.13)	6041	4.09 (0.17)
SHARE	3495 (16.26)	18005 (83.74)	21500	10.00 (5.17)
CHARLS	1545 (23.50)	5029 (76.50)	6574	6.92 (0.58)
KLoSA	1495 (25.44)	4382 (74.56)	5877	7.92 (2.33)
Total	8799 (18.55)	38630 (81.45)	47429	-

HRS: Health and Retirement Study; ELSA: English Longitudinal Study of Ageing; SHARE: Survey of Health, Ageing and Retirement in Europe; CHARLS: China Health and Retirement Longitudinal Study; KLoSA: Korean Longitudinal Study of Aging; IQR: interquartile range.

Supplementary Table 4 Characteristics of the included participants in the analyses of baseline frailty status when using data not being imputed

Characteristic	HRS				ELSA				SHARE			
	Robust (n=862)	Pre-frail (n=3707)	Frail (n=2703)	Total (n=7272)	Robust (n=1315)	Pre-frail (n=2051)	Frail (n=681)	Total (n=4047)	Robust (n=5341)	Pre-frail (n=8854)	Frail (n=3882)	Total (n=18077)
Age (years) (mean, SD)	69.8 (7.2)	72.8 (7.3)	74.7 (8.6)	73.2 (8.0)	64.6 (7.1)	68.3 (7.8)	71.0 (8.2)	67.5 (8.0)	60.8 (8.2)	65.5 (9.5)	70.2 (10.3)	65.1 (9.9)
Age group (n, %)												
50–64	70 (8.1)	164 (4.4)	125 (4.6)	359 (4.9)	715 (54.4)	710 (34.6)	159 (23.3)	1584 (39.1)	3728 (69.8)	4441 (50.2)	1248 (32.1)	9417 (52.1)
65–74	602 (69.8)	2130 (57.5)	1250 (46.2)	3982 (54.8)	460 (35.0)	840 (41.0)	272 (39.9)	1572 (38.8)	1230 (23.0)	2743 (31.0)	1167 (30.1)	5140 (28.4)
≥75	190 (22.0)	1413 (38.1)	1328 (49.1)	2931 (40.3)	140 (10.6)	501 (24.4)	250 (36.7)	891 (22.0)	383 (7.2)	1670 (18.9)	1467 (37.8)	3520 (19.5)
Sex (n, %)												
Female	469 (54.4)	2054 (55.4)	1732 (64.1)	4255 (58.5)	637 (48.4)	1102 (53.7)	446 (65.5)	2185 (54.0)	2729 (51.1)	4893 (55.3)	2566 (66.1)	10188 (56.4)
Male	393 (45.6)	1653 (44.6)	971 (35.9)	3017 (41.5)	678 (51.6)	949 (46.3)	235 (34.5)	1862 (46.0)	2612 (48.9)	3961 (44.7)	1316 (33.9)	7889 (43.6)
Marital status (n, %)												
Unmarried	254 (29.5)	1259 (34.0)	1268 (46.9)	2781 (38.2)	266 (20.2)	545 (26.6)	272 (39.9)	1083 (26.8)	1277 (23.9)	2668 (30.1)	1566 (40.3)	5511 (30.5)
Married	608 (70.5)	2448 (66.0)	1435 (53.1)	4491 (61.8)	1049 (79.8)	1506 (73.4)	409 (60.1)	2964 (73.2)	4064 (76.1)	6186 (69.9)	2316 (59.7)	12566 (69.5)
Living region (n, %)												
Rural	622 (72.2)	2628 (70.9)	1831 (67.7)	5081 (69.9)	-	-	-	-	3359 (62.9)	5451 (61.6)	2484 (64.0)	11294 (62.5)
Urban	240 (27.8)	1079 (29.1)	872 (32.3)	2191 (30.1)	-	-	-	-	1982 (37.1)	3403 (38.4)	1398 (36.0)	6783 (37.5)
Labour force status (n, %)												
Unemployed or unable to work	78 (9.0)	243 (6.6)	211 (7.8)	532 (7.3)	74 (5.6)	106 (5.2)	108 (15.9)	288 (7.1)	483 (9.0)	1031 (11.6)	674 (17.4)	2188 (12.1)
Employed or self-employed	220 (25.5)	534 (14.4)	166 (6.1)	920 (12.7)	553 (42.1)	565 (27.5)	61 (9.0)	1179 (29.1)	2629 (49.2)	2371 (26.8)	325 (8.4)	5325 (29.5)
Retired	564 (65.4)	2930 (79.0)	2326 (86.1)	5820 (80.0)	688 (52.3)	1380 (67.3)	512 (75.2)	2580 (63.8)	2229 (41.7)	5452 (61.6)	2883 (74.3)	10564 (58.4)
Educational attainment (n, %)												
Below high school	61 (7.1)	462 (12.5)	559 (20.7)	1082 (14.9)	144 (11.0)	426 (20.8)	243 (35.7)	813 (20.1)	1187 (22.2)	2965 (33.5)	1857 (47.8)	6009 (33.2)
High school or above	801 (92.9)	3245 (87.5)	2144 (79.3)	6190 (85.1)	1171 (89.0)	1625 (79.2)	438 (64.3)	3234 (79.9)	4154 (77.8)	5889 (66.5)	2025 (52.2)	12068 (66.8)
Total household income (tertiles) (n, %)												
Low	167 (19.4)	970 (26.2)	1191 (44.1)	2328 (32.0)	250 (19.0)	566 (27.6)	311 (45.7)	1127 (27.8)	1311 (24.5)	3541 (40.0)	2258 (58.2)	7110 (39.3)
Medium	316 (36.7)	1545 (41.7)	1042 (38.5)	2903 (39.9)	413 (31.4)	709 (34.6)	238 (34.9)	1360 (33.6)	1595 (29.9)	2766 (31.2)	1078 (27.8)	5439 (30.1)
High	379 (44.0)	1192 (32.2)	470 (17.4)	2041 (28.1)	652 (49.6)	776 (37.8)	132 (19.4)	1560 (38.5)	2435 (45.6)	2547 (28.8)	546 (14.1)	5528 (30.6)
BMI (kg/m ²) (mean, SD)	25.7 (4.1)	27.5 (4.9)	29.3 (6.5)	27.9 (5.6)	26.7 (4.2)	28.3 (4.9)	31.2 (5.9)	28.3 (5.1)	25.8 (4.1)	27.2 (4.6)	28.9 (5.8)	27.2 (4.9)
BMI group (n, %)												
<18.5	14 (1.6)	41 (1.1)	35 (1.3)	90 (1.2)	9 (0.7)	18 (0.9)	3 (0.4)	30 (0.7)	53 (1.0)	100 (1.1)	47 (1.2)	200 (1.1)
18.5 – <25	374 (43.4)	1112 (30.0)	657 (24.3)	2143 (29.5)	462 (35.1)	507 (24.7)	84 (12.3)	1053 (26.0)	2416 (45.2)	2858 (32.3)	949 (24.4)	6223 (34.4)
25 – <30	353 (41.0)	1541 (41.6)	929 (34.4)	2823 (38.8)	604 (45.9)	893 (43.5)	229 (33.6)	1726 (42.6)	2204 (41.3)	3792 (42.8)	1433 (36.9)	7429 (41.1)
≥30	121 (14.0)	1013 (27.3)	1082 (40.0)	2216 (30.5)	240 (18.3)	633 (30.9)	365 (53.6)	1238 (30.6)	668 (12.5)	2104 (23.8)	1453 (37.4)	4225 (23.4)
Smoking status (n, %)												
Never	425 (49.3)	1637 (44.2)	1068 (39.5)	3130 (43.0)	597 (45.4)	777 (37.9)	197 (28.9)	1571 (38.8)	2904 (54.4)	4755 (53.7)	2208 (56.9)	9867 (54.6)
Ever	437 (50.7)	2070 (55.8)	1635 (60.5)	4142 (57.0)	718 (54.6)	1274 (62.1)	484 (71.1)	2476 (61.2)	2437 (45.6)	4099 (46.3)	1674 (43.1)	8210 (45.4)
Drinking status (n, %)												
Never	284 (32.9)	1524 (41.1)	1539 (56.9)	3347 (46.0)	78 (5.9)	182 (8.9)	166 (24.4)	426 (10.5)	584 (10.9)	1207 (13.6)	812 (20.9)	2603 (14.4)
Ever	578 (67.1)	2183 (58.9)	1164 (43.1)	3925 (54.0)	1237 (94.1)	1869 (91.1)	515 (75.6)	3621 (89.5)	4757 (89.1)	7647 (86.4)	3070 (79.1)	15474 (85.6)
Physical activity (n, %)												
Non-vigorous	380 (44.1)	2280 (61.5)	2217 (82.0)	4877 (67.1)	631 (48.0)	1408 (68.6)	617 (90.6)	2656 (65.6)	1829 (34.2)	4309 (48.7)	3068 (79.0)	9206 (50.9)
Vigorous	482 (55.9)	1427 (38.5)	486 (18.0)	2395 (32.9)	684 (52.0)	643 (31.4)	64 (9.4)	1391 (34.4)	3512 (65.8)	4545 (51.3)	814 (21.0)	8871 (49.1)

Supplementary Table 4 Continued Characteristics of the included participants in the analyses of baseline frailty status when using data not being imputed

Characteristic	CHARLS				KLoSA			
	Robust (n=699)	Pre-frail (n=2348)	Frail (n=737)	Total (n=3784)	Robust (n=696)	Pre-frail (n=4256)	Frail (n=786)	Total (n=5738)
Age (years) (mean, SD)	60.9 (7.1)	62.1 (7.5)	63.3 (7.5)	62.1 (7.5)	57.4 (6.8)	65.2 (9.6)	72.9 (8.9)	65.3 (10.0)
Age group (n, %)								
50–64	514 (73.5)	1562 (66.5)	450 (61.1)	2526 (66.8)	594 (85.3)	2102 (49.4)	134 (17.0)	2830 (49.3)
65–74	151 (21.6)	617 (26.3)	226 (30.7)	994 (26.3)	88 (12.6)	1367 (32.1)	305 (38.8)	1760 (30.7)
≥75	34 (4.9)	169 (7.2)	61 (8.3)	264 (7.0)	14 (2.0)	787 (18.5)	347 (44.1)	1148 (20.0)
Sex (n, %)								
Female	231 (33.0)	972 (41.4)	404 (54.8)	1607 (42.5)	298 (42.8)	2267 (53.3)	507 (64.5)	3072 (53.5)
Male	468 (67.0)	1376 (58.6)	333 (45.2)	2177 (57.5)	398 (57.2)	1989 (46.7)	279 (35.5)	2666 (46.5)
Marital status (n, %)								
Unmarried	92 (13.2)	299 (12.7)	132 (17.9)	523 (13.8)	52 (7.5)	832 (19.5)	298 (37.9)	1182 (20.6)
Married	607 (86.8)	2049 (87.3)	605 (82.1)	3261 (86.2)	644 (92.5)	3424 (80.5)	488 (62.1)	4556 (79.4)
Living region (n, %)								
Rural	272 (38.9)	920 (39.2)	246 (33.4)	1438 (38.0)	561 (80.6)	3119 (73.3)	584 (74.3)	4264 (74.3)
Urban	427 (61.1)	1428 (60.8)	491 (66.6)	2346 (62.0)	135 (19.4)	1137 (26.7)	202 (25.7)	1474 (25.7)
Labour force status (n, %)								
Unemployed or unable to work	7 (1.0)	49 (2.1)	16 (2.2)	72 (1.9)	133 (19.1)	1228 (28.9)	325 (41.3)	1686 (29.4)
Employed or self-employed	435 (62.2)	1397 (59.5)	384 (52.1)	2216 (58.6)	479 (68.8)	1950 (45.8)	132 (16.8)	2561 (44.6)
Retired	257 (36.8)	902 (38.4)	337 (45.7)	1496 (39.5)	84 (12.1)	1078 (25.3)	329 (41.9)	1491 (26.0)
Educational attainment (n, %)								
Below high school	586 (83.8)	2106 (89.7)	699 (94.8)	3391 (89.6)	235 (33.8)	2620 (61.6)	636 (80.9)	3491 (60.8)
High school or above	113 (16.2)	242 (10.3)	38 (5.2)	393 (10.4)	461 (66.2)	1636 (38.4)	150 (19.1)	2247 (39.2)
Total household income (tertiles) (n, %)								
Low	168 (24.0)	672 (28.6)	275 (37.3)	1115 (29.5)	282 (40.5)	1637 (38.5)	287 (36.5)	2206 (38.4)
Medium	219 (31.3)	769 (32.8)	243 (33.0)	1231 (32.5)	71 (10.2)	1162 (27.3)	342 (43.5)	1575 (27.4)
High	312 (44.6)	907 (38.6)	219 (29.7)	1438 (38.0)	343 (49.3)	1457 (34.2)	157 (20.0)	1957 (34.1)
BMI (kg/m ²) (mean, SD)	23.0 (3.6)	23.8 (15.0)	23.7 (3.8)	23.6 (12.1)	23.0 (2.2)	23.3 (2.7)	23.3 (3.3)	23.2 (2.8)
BMI group (n, %)								
<18.5	40 (5.7)	165 (7.0)	56 (7.6)	261 (6.9)	7 (1.0)	166 (3.9)	47 (6.0)	220 (3.8)
18.5 – <25	495 (70.8)	1484 (63.2)	427 (57.9)	2406 (63.6)	580 (83.3)	3080 (72.4)	524 (66.7)	4184 (72.9)
25 – <30	144 (20.6)	593 (25.3)	207 (28.1)	944 (24.9)	104 (14.9)	964 (22.7)	191 (24.3)	1259 (21.9)
≥30	20 (2.9)	106 (4.5)	47 (6.4)	173 (4.6)	5 (0.7)	46 (1.1)	24 (3.1)	75 (1.3)
Smoking status (n, %)								
Never	346 (49.5)	1209 (51.5)	420 (57.0)	1975 (52.2)	422 (60.6)	2841 (66.8)	566 (72.0)	3829 (66.7)
Ever	353 (50.5)	1139 (48.5)	317 (43.0)	1809 (47.8)	274 (39.4)	1415 (33.2)	220 (28.0)	1909 (33.3)
Drinking status (n, %)								
Never	381 (54.5)	1278 (54.4)	432 (58.6)	2091 (55.3)	21 (3.0)	193 (4.5)	69 (8.8)	283 (4.9)
Ever	318 (45.5)	1070 (45.6)	305 (41.4)	1693 (44.7)	675 (97.0)	4063 (95.5)	717 (91.2)	5455 (95.1)
Physical activity (n, %)								
Non-vigorous	-	-	-	-	368 (52.9)	2702 (63.5)	569 (72.4)	3639 (63.4)
Vigorous	-	-	-	-	328 (47.1)	1554 (36.5)	217 (27.6)	2099 (36.6)

HRS: Health and Retirement Study; ELSA: English Longitudinal Study of Ageing; SHARE: Survey of Health, Ageing and Retirement in Europe; CHARLS: China Health and Retirement Longitudinal Study; KLoSA: Korean Longitudinal Study of Aging; SD: standard deviation; BMI: body mass index.

Unmarried status includes separated, divorced, widowed, and never married; married status includes married and partnered.

The covariate “living region” was not available in ELSA, so it was not included in the analysis.

The missing rates for the covariate “physical activity” in CHARLS exceeded 50%, so it was excluded from the analysis.

Supplementary Table 5 Characteristics of the included participants at baseline frailty status and excluded participants completely lost to follow-up

Characteristics	HRS			ELSA			SHARE			CHARLS			KLoSA		
	Included (n=7437)	Excluded (n=3689)	P	Included (n=6041)	Excluded (n=868)	P	Included (n=21500)	Excluded (n=6691)	P	Included (n=6574)	Excluded (n=543)	P	Included (n=5877)	Excluded (n=161)	P
Age (years) (mean, SD)	73.2 (7.95)	54.5 (4.85)	0	66.5 (8.65)	68.9 (11.4)	<0.001	64.7 (9.92)	62.4 (9.22)	<0.001	60.8 (7.34)	62.2 (8.95)	0.001	65.5 (10.1)	62.9 (11.3)	0.004
Age group (n, %)			0			<0.001			<0.001			<0.001			<0.001
50 - 64	368 (4.95)	45 (1.22)		2663 (44.1)	343 (39.5)		11578 (53.9)	4289 (64.1)		4772 (72.6)	360 (66.3)		2855 (48.6)	105 (65.2)	
65 - 74	4073 (54.8)	3585 (97.2)		2150 (35.6)	219 (25.2)		5910 (27.5)	1598 (23.9)		1442 (21.9)	111 (20.4)		1803 (30.7)	26 (16.1)	
≥ 75	2996 (40.3)	59 (1.60)		1228 (20.3)	306 (35.3)		4012 (18.7)	804 (12.0)		360 (5.48)	72 (13.3)		1219 (20.7)	30 (18.6)	
Sex (n, %)			<0.001			0.766			0.012			<0.001			0.561
Female	4361 (58.6)	2032 (55.1)		3346 (55.4)	486 (56.0)		12178 (56.6)	3673 (54.9)		2804 (42.7)	288 (53.0)		3167 (53.9)	91 (56.5)	
Male	3076 (41.4)	1657 (44.9)		2695 (44.6)	382 (44.0)		9322 (43.4)	3018 (45.1)		3770 (57.3)	255 (47.0)		2710 (46.1)	70 (43.5)	
Marital status (n, %)			<0.001			<0.001			<0.001			<0.001			<0.001
Unmarried	2839 (38.2)	1252 (33.9)		1610 (26.7)	282 (32.5)		6040 (28.1)	1401 (20.9)		738 (11.2)	90 (16.6)		1249 (21.3)	55 (34.2)	
Married	4598 (61.8)	2437 (66.1)		4431 (73.3)	586 (67.5)		15460 (71.9)	5290 (79.1)		5836 (88.8)	453 (83.4)		4628 (78.7)	106 (65.8)	
Living region (n, %)			<0.001			-			<0.001			<0.001			<0.001
Rural	5212 (70.1)	2947 (79.9)		-	-		13393 (62.3)	4357 (65.1)		2911 (44.3)	343 (63.2)		4361 (74.2)	141 (87.6)	
Urban	2225 (29.9)	742 (20.1)		-	-		8107 (37.7)	2334 (34.9)		3663 (55.7)	200 (36.8)		1516 (25.8)	20 (12.4)	
Labour force status (n, %)			0			0.007			<0.001			<0.001			0.657
Unemployed or unable to work	544 (7.31)	591 (16.0)		461 (7.63)	87 (10.0)		2632 (12.2)	937 (14.0)		114 (1.73)	21 (3.87)		1743 (29.7)	48 (29.8)	
Employed or self-employed	936 (12.6)	2532 (68.6)		2036 (33.7)	256 (29.5)		6664 (31.0)	2427 (36.3)		4103 (62.4)	250 (46.0)		2606 (44.3)	76 (47.2)	
Retired	5957 (80.1)	566 (15.3)		3544 (58.7)	525 (60.5)		12204 (56.8)	3327 (49.7)		2357 (35.9)	272 (50.1)		1528 (26.0)	37 (23.0)	
Educational attainment (n, %)			<0.001			<0.001			0.292			<0.001			0.047
Below high school	1120 (15.1)	452 (12.3)		1222 (20.2)	276 (31.8)		6973 (32.4)	2217 (33.1)		5607 (85.3)	428 (78.8)		3612 (61.5)	86 (53.4)	
High school or above	6317 (84.9)	3237 (87.7)		4819 (79.8)	592 (68.2)		14527 (67.6)	4474 (66.9)		967 (14.7)	115 (21.2)		2265 (38.5)	75 (46.6)	
Total household income (tertiles) (n, %)			<0.001			<0.001			<0.001			0.324			<0.001
Low	2383 (32.0)	893 (24.2)		1719 (28.5)	332 (38.2)		8281 (38.5)	2167 (32.4)		1743 (26.5)	144 (26.5)		2245 (38.2)	44 (27.3)	
Medium	2983 (40.1)	1069 (29.0)		2037 (33.7)	280 (32.3)		6455 (30.0)	2251 (33.6)		2113 (32.1)	190 (35.0)		1646 (28.0)	38 (23.6)	
High	2071 (27.8)	1727 (46.8)		2285 (37.8)	256 (29.5)		6764 (31.5)	2273 (34.0)		2718 (41.3)	209 (38.5)		1986 (33.8)	79 (49.1)	
BMI (kg/m ²) (mean, SD)	27.9 (5.59)	29.6 (6.37)	<0.001	28.3 (5.08)	28.1 (5.25)	0.319	27.1 (4.88)	26.7 (4.50)	<0.001	23.8 (12.2)	23.6 (4.11)	0.527	23.2 (2.77)	23.3 (2.62)	0.978
BMI group (n, %)			<0.001			0.001			<0.001			0.079			0.124
< 18.5	91 (1.22)	24 (0.65)		41 (0.68)	14 (1.61)		240 (1.12)	74 (1.11)		396 (6.02)	41 (7.55)		222 (3.78)	3 (1.86)	
18.5 - <25	2193 (29.5)	801 (21.7)		1574 (26.1)	257 (29.6)		7481 (34.8)	2494 (37.3)		4176 (63.5)	358 (65.9)		4284 (72.9)	129 (80.1)	
25 - <30	2893 (38.9)	1368 (37.1)		2577 (42.7)	332 (38.2)		8807 (41.0)	2711 (40.5)		1690 (25.7)	115 (21.2)		1293 (22.0)	26 (16.1)	
≥ 30	2260 (30.4)	1496 (40.6)		1849 (30.6)	265 (30.5)		4972 (23.1)	1412 (21.1)		312 (4.75)	29 (5.34)		78 (1.33)	3 (1.86)	
Smoking status (n, %)			0.560			0.004			<0.001			<0.001			0.191
Never	3201 (43.0)	1610 (43.6)		2406 (39.8%)	301 (34.7%)		11734 (54.6)	3477 (52.0)		3491 (53.1)	349 (64.3)		3927 (66.8)	116 (72.0)	
Ever	4236 (57.0)	2079 (56.4)		3635 (60.2%)	567 (65.3%)		9766 (45.4)	3214 (48.0)		3083 (46.9)	194 (35.7)		1950 (33.2)	45 (28.0)	
Drinking status (n, %)			<0.001			<0.001			0.021			<0.001			1
Never	3420 (46.0)	999 (27.1)		654 (10.8%)	136 (15.7%)		3084 (14.3)	1037 (15.5)		3642 (55.4)	354 (65.2)		291 (4.95)	8 (4.97)	
Ever	4017 (54.0)	2690 (72.9)		5387 (89.2%)	732 (84.3%)		18416 (85.7)	5654 (84.5)		2932 (44.6)	189 (34.8)		5586 (95.0)	153 (95.0)	
Physical activity (n, %)			<0.001			<0.001			0.239			-			0.526
Non-vigorous	4993 (67.1)	2061 (55.9)		3989 (66.0%)	661 (76.2%)		10764 (50.1)	3294 (49.2)		-	-		3744 (63.7)	107 (66.5)	
Vigorous	2444 (32.9)	1628 (44.1)		2052 (34.0%)	207 (23.8%)		10736 (49.9)	3397 (50.8)		-	-		2133 (36.3)	54 (33.5)	

HRS: Health and Retirement Study; ELSA: English Longitudinal Study of Ageing; SHARE: Survey of Health, Ageing and Retirement in Europe; CHARLS: China Health and Retirement Longitudinal Study; KLoSA: Korean Longitudinal Study of Aging; SD: standard deviation; BMI: body mass index.

Unmarried status includes separated, divorced, widowed, and never married; married status includes married and partnered.

The covariate “living region” was not available in ELSA, so it was not included in the analysis.

The missing rates for the covariate “physical activity” in CHARLS exceeded 50%, so it was excluded from the analysis.

Supplementary Table 6 Association between baseline frailty status and cognitive impairment by age

Age	HRS (n=7437)		ELSA (n=6041)		SHARE (n=21500)		CHARLS (n=6574)		KLoSA (n=5877)	
	HR (95% CI)	P	HR (95% CI)	P	HR (95% CI)	P	HR (95% CI)	P	HR (95% CI)	P
50–64										
Robust	Reference		Reference		Reference		Reference		Reference	
Pre-frail	0.94 (0.42–2.09)	0.882	1.23 (0.98–1.55)	0.072	1.30 (1.16–1.45)	<0.001	1.16 (0.99–1.36)	0.062	1.35 (1.10–1.67)	0.004
Frail	1.43 (0.61–3.37)	0.414	1.80 (1.28–2.53)	0.001	1.29 (1.10–1.52)	0.002	1.67 (1.37–2.02)	<0.001	2.38 (1.71–3.31)	<0.001
65–74										
Robust	Reference		Reference		Reference		Reference		Reference	
Pre-frail	1.54 (1.16–2.04)	0.003	1.06 (0.79–1.41)	0.705	1.46 (1.23–1.74)	<0.001	1.24 (0.90–1.70)	0.189	1.36 (0.81–2.30)	0.242
Frail	2.49 (1.86–3.34)	<0.001	1.50 (1.05–2.14)	0.026	2.00 (1.63–2.45)	<0.001	1.54 (1.08–2.18)	0.016	2.05 (1.18–3.56)	0.01
≥75										
Robust	Reference		Reference		Reference		Reference		Reference	
Pre-frail	1.01 (0.70–1.46)	0.960	1.29 (0.81–2.05)	0.284	0.94 (0.75–1.19)	0.626	0.91 (0.49–1.68)	0.758	2.10 (0.29–15.16)	0.461
Frail	1.14 (0.78–1.67)	0.487	1.40 (0.85–2.33)	0.190	1.36 (1.06–1.74)	0.016	0.69 (0.33–1.44)	0.322	3.21 (0.44–23.28)	0.249
P for interaction	<0.001		0.666		<0.001		0.171		0.947	

HRS: Health and Retirement Study; ELSA: English Longitudinal Study of Ageing; SHARE: Survey of Health, Ageing and Retirement in Europe; CHARLS: China Health and Retirement Longitudinal Study; KLoSA: Korean Longitudinal Study of Aging; HR: hazard ratio; CI: confidence interval.

HR was adjusted for sex, marital status, living region, labour force status, educational attainment, total household income, body mass index, smoking status, drinking status, and physical activity (“living region” was removed in ELSA and “physical activity” was removed in CHARLS).

P for interaction: likelihood ratio test was used to detect group differences.

Supplementary Table 7 Association between baseline frailty status and cognitive impairment by sex

Sex	HRS (n=7437)		ELSA (n=6041)		SHARE (n=21500)		CHARLS (n=6574)		KLoSA (n=5877)	
	HR (95% CI)	P	HR (95% CI)	P	HR (95% CI)	P	HR (95% CI)	P	HR (95% CI)	P
Female										
Robust	Reference		Reference		Reference		Reference		Reference	
Pre-frail	1.28 (0.96–1.70)	0.095	1.22 (0.95–1.56)	0.112	1.27 (1.12–1.45)	<0.001	1.33 (1.06–1.66)	0.013	1.46 (1.12–1.90)	0.005
Frail	1.94 (1.44–2.59)	<0.001	1.47 (1.09–1.98)	0.012	1.65 (1.42–1.91)	<0.001	1.64 (1.28–2.09)	<0.001	2.26 (1.66–3.07)	<0.001
Male										
Robust	Reference		Reference		Reference		Reference		Reference	
Pre-frail	1.49 (1.07–2.05)	0.017	1.14 (0.91–1.43)	0.265	1.29 (1.14–1.46)	<0.001	1.06 (0.89–1.27)	0.495	1.22 (0.92–1.60)	0.164
Frail	1.78 (1.26–2.52)	0.001	1.77 (1.30–2.42)	<0.001	1.43 (1.21–1.69)	<0.001	1.53 (1.22–1.93)	<0.001	2.05 (1.42–2.97)	<0.001
P for interaction	0.064		0.541		0.252		0.190		0.509	

HRS: Health and Retirement Study; ELSA: English Longitudinal Study of Ageing; SHARE: Survey of Health, Ageing and Retirement in Europe; CHARLS: China Health and Retirement Longitudinal Study; KLoSA: Korean Longitudinal Study of Aging; HR: hazard ratio; CI: confidence interval.

HR was adjusted for age, marital status, living region, labour force status, educational attainment, total household income, body mass index, smoking status, drinking status, and physical activity (“living region” was removed in ELSA and “physical activity” was removed in CHARLS).

P for interaction: likelihood ratio test was used to detect group differences.

Supplementary Table 8 Association between baseline frailty status and cognitive impairment by educational attainment

Educational attainment	HRS (n=7437)		ELSA (n=6041)		SHARE (n=21500)		CHARLS (n=6574)		KLoSA (n=5877)	
	HR (95% CI)	P	HR (95% CI)	P	HR (95% CI)	P	HR (95% CI)	P	HR (95% CI)	P
Below high school										
Robust	Reference		Reference		Reference		Reference		Reference	
Pre-frail	1.61 (0.94–2.76)	0.084	1.30 (0.91–1.84)	0.149	1.18 (1.04–1.35)	0.012	1.14 (0.99–1.32)	0.074	1.46 (1.10–1.93)	0.009
Frail	1.84 (1.06–3.17)	0.030	1.31 (0.87–1.98)	0.188	1.41 (1.21–1.64)	<0.001	1.48 (1.25–1.75)	<0.001	2.34 (1.71–3.20)	<0.001
High school or above										
Robust	Reference		Reference		Reference		Reference		Reference	
Pre-frail	1.29 (1.02–1.63)	0.032	1.10 (0.91–1.33)	0.318	1.34 (1.19–1.51)	<0.001	1.48 (0.91–2.41)	0.112	1.28 (0.99–1.66)	0.061
Frail	1.93 (1.51–2.47)	<0.001	1.76 (1.36–2.27)	<0.001	1.69 (1.45–1.98)	<0.001	3.22 (1.65–6.29)	0.001	1.83 (1.13–2.94)	0.013
P for interaction	0.051		0.013		0.005		0.284		0.431	

HRS: Health and Retirement Study; ELSA: English Longitudinal Study of Ageing; SHARE: Survey of Health, Ageing and Retirement in Europe; CHARLS: China Health and Retirement Longitudinal Study; KLoSA: Korean Longitudinal Study of Aging; HR: hazard ratio; CI: confidence interval.

HR was adjusted for age, sex, marital status, living region, labour force status, total household income, body mass index, smoking status, drinking status, and physical activity (“living region” was removed in ELSA and “physical activity” was removed in CHARLS).

P for interaction: likelihood ratio test was used to detect group differences.

Supplementary Table 9 Association between baseline frailty status and cognitive impairment by total household income

Total household income	HRS (n=7437)		ELSA (n=6041)		SHARE (n=21500)		CHARLS (n=6574)		KLoSA (n=5877)	
	HR (95% CI)	P	HR (95% CI)	P	HR (95% CI)	P	HR (95% CI)	P	HR (95% CI)	P
Low										
Robust	Reference		Reference		Reference		Reference		Reference	
Pre-frail	1.07 (0.76–1.50)	0.686	1.27 (0.91–1.77)	0.163	1.17 (1.01–1.35)	0.039	0.95 (0.73–1.23)	0.682	1.38 (1.02–1.88)	0.038
Frail	1.44 (1.02–2.03)	0.036	1.60 (1.09–2.34)	0.016	1.42 (1.20–1.67)	<0.001	1.23 (0.92–1.64)	0.155	2.14 (1.47–3.11)	<0.001
Medium										
Robust	Reference		Reference		Reference		Reference		Reference	
Pre-frail	1.38 (0.96–1.97)	0.079	1.12 (0.86–1.46)	0.404	1.30 (1.12–1.51)	0.001	1.42 (1.11–1.81)	0.005	1.36 (0.79–2.34)	0.264
Frail	2.01 (1.39–2.92)	<0.001	1.57 (1.12–2.22)	0.009	1.49 (1.23–1.80)	<0.001	1.90 (1.43–2.52)	<0.001	2.08 (1.18–3.67)	0.012
High										
Robust	Reference		Reference		Reference		Reference		Reference	
Pre-frail	1.78 (1.14–2.77)	0.011	1.14 (0.86–1.51)	0.346	1.36 (1.15–1.61)	<0.001	1.13 (0.90–1.42)	0.279	1.28 (0.97–1.68)	0.081
Frail	2.47 (1.52–4.00)	<0.001	1.71 (1.10–2.66)	0.016	2.01 (1.57–2.58)	<0.001	1.55 (1.16–2.07)	0.003	2.29 (1.52–3.44)	<0.001
P for interaction	0.056		0.860		0.072		0.257		0.714	

HRS: Health and Retirement Study; ELSA: English Longitudinal Study of Ageing; SHARE: Survey of Health, Ageing and Retirement in Europe; CHARLS: China Health and Retirement Longitudinal Study; KLoSA: Korean Longitudinal Study of Aging; HR: hazard ratio; CI: confidence interval.

HR was adjusted for age, sex, marital status, living region, labour force status, educational attainment, body mass index, smoking status, drinking status, and physical activity (“living region” was removed in ELSA and “physical activity” was removed in CHARLS).

P for interaction: likelihood ratio test was used to detect group differences.

Supplementary Table 10 Association between baseline continuous frailty index and cognitive impairment

Study	HR (95% CI) (unadjusted)	P	HR (95% CI) (adjusted)	P
HRS (n=7437)	12.30 (8.78–17.3)	<0.001	5.65 (3.84–8.31)	<0.001
ELSA (n=6041)	6.77 (4.33–10.6)	<0.001	3.71 (2.16–6.36)	<0.001
SHARE (n=21500)	9.60 (7.60–12.10)	<0.001	3.31 (2.49–4.39)	<0.001
CHARLS (n=6574)	7.24 (4.69–11.20)	<0.001	3.59 (2.26–5.72)	<0.001
KLoSA (n=5877)	23.10 (14.0–38.20)	<0.001	15.70 (8.65–28.40)	<0.001

HRS: Health and Retirement Study; ELSA: English Longitudinal Study of Ageing; SHARE: Survey of Health- Ageing and Retirement in Europe; CHARLS: China Health and Retirement Longitudinal Study; KLoSA: Korean Longitudinal Study of Aging; HR: hazard ratio; CI: confidence interval.

HR was adjusted for age, sex, marital status, living region, labour force status, educational attainment, total household income, body mass index, smoking status, drinking status, and physical activity (“living region” was removed in ELSA and “physical activity” was removed in CHARLS).

Supplementary Table 11 Association between baseline frailty status and cognitive impairment when using competing risk model

Study	Robust	Pre-frail				Frail			
		HR (95% CI) (unadjusted)	P	HR (95% CI) (adjusted)	P	HR (95% CI) (unadjusted)	P	HR (95% CI) (adjusted)	P
HRS (n=7437)	Reference	1.47 (1.19–1.81)	<0.001	1.35 (1.09–1.68)	0.007	2.11 (1.71–2.60)	<0.001	1.63 (1.30–2.06)	<0.001
SHARE (n=21500)	Reference	1.44 (1.32–1.57)	<0.001	1.24 (1.13–1.35)	<0.001	1.77 (1.61–1.94)	<0.001	1.31 (1.17–1.46)	<0.001
CHARLS (n=6574)	Reference	1.24 (1.08–1.42)	0.002	1.13 (0.99–1.30)	0.068	1.79 (1.53–2.09)	<0.001	1.44 (1.23–1.69)	<0.001
KLoSA (n=5877)	Reference	1.46 (1.22–1.75)	<0.001	1.34 (1.11–1.62)	0.002	2.13 (1.73–2.62)	<0.001	1.94 (1.55–2.44)	<0.001

HRS: Health and Retirement Study; ELSA: English Longitudinal Study of Ageing; SHARE: Survey of Health, Ageing and Retirement in Europe; CHARLS: China Health and Retirement Longitudinal Study; KLoSA: Korean Longitudinal Study of Aging; HR: hazard ratio; CI: confidence interval.

HR was adjusted for age, sex, marital status, living region, labour force status, educational attainment, total household income, body mass index, smoking status, drinking status, and physical activity (“living region” was removed in ELSA and “physical activity” was removed in CHARLS).

As the mortality data for ELSA was unavailable from Wave 7, competing risk models were therefore not developed.

Supplementary Table 12 Association between baseline frailty status and cognitive impairment after excluding participants who developed cognitive impairment during the first year of follow-up

Study	Robust	Pre-frail				Frail			
		HR (95% CI) (unadjusted)	P	HR (95% CI) (adjusted)	P	HR (95% CI) (unadjusted)	P	HR (95% CI) (adjusted)	P
HRS (n=7259)	Reference	1.52 (1.23–1.88)	<0.001	1.35 (1.09–1.68)	0.006	2.54 (2.06–3.14)	<0.001	1.87 (1.50–2.34)	<0.001
ELSA (n=6041)	Reference	1.27 (1.08–1.48)	0.003	1.17 (0.99–1.38)	0.068	1.97 (1.64–2.36)	<0.001	1.55 (1.25–1.92)	<0.001
SHARE (n=21230)	Reference	1.56 (1.43–1.70)	<0.001	1.28 (1.18–1.40)	<0.001	2.34 (2.13–2.58)	<0.001	1.56 (1.40–1.74)	<0.001
CHARLS (n=6529)	Reference	1.28 (1.12–1.47)	<0.001	1.17 (1.02–1.34)	0.027	1.96 (1.67–2.29)	<0.001	1.55 (1.31–1.82)	<0.001
KLoSA (n=5811)	Reference	1.53 (1.27–1.84)	<0.001	1.34 (1.11–1.63)	0.002	2.64 (2.14–3.26)	<0.001	2.16 (1.72–2.72)	<0.001

HRS: Health and Retirement Study; ELSA: English Longitudinal Study of Ageing; SHARE: Survey of Health, Ageing and Retirement in Europe; CHARLS: China Health and Retirement Longitudinal Study; KLoSA: Korean Longitudinal Study of Aging; HR: hazard ratio; CI: confidence interval.

HR was adjusted for age, sex, marital status, living region, labour force status, educational attainment, total household income, body mass index, smoking status, drinking status, and physical activity (“living region” was removed in ELSA and “physical activity” was removed in CHARLS).

Supplementary Table 13 Association between baseline frailty status and cognitive impairment using data not being imputed

Study	Robust	Pre-frail				Frail			
		HR (95% CI) (unadjusted)	P	HR (95% CI) (adjusted)	P	HR (95% CI) (adjusted)	P	HR (95% CI) (unadjusted)	P
HRS (n=7272)	Reference	1.48 (1.20–1.83)	<0.001	1.32 (1.07–1.64)	<0.001	2.51 (2.03–3.10)	0.011	1.86 (1.48–2.33)	<0.001
ELSA (n=4047)	Reference	1.13 (0.94–1.37)	0.194	1.04 (0.85–1.27)	0.695	1.62 (1.29–2.04)	<0.001	1.30 (1.00–1.70)	0.054
SHARE (n=18077)	Reference	1.53 (1.40–1.68)	<0.001	1.27 (1.15–1.40)	<0.001	2.30 (2.08–2.55)	<0.001	1.58 (1.40–1.78)	<0.001
CHARLS (n=3784)	Reference	1.18 (0.99–1.41)	0.069	1.10 (0.92–1.32)	0.280	1.61 (1.31–1.98)	<0.001	1.33 (1.08–1.64)	0.008
KLoSA (n=5738)	Reference	1.50 (1.25–1.81)	<0.001	1.33 (1.10–1.61)	0.004	2.51 (2.03–3.11)	<0.001	2.09 (1.65–2.64)	<0.001

HRS: Health and Retirement Study; ELSA: English Longitudinal Study of Ageing; SHARE: Survey of Health, Ageing and Retirement in Europe; CHARLS: China Health and Retirement Longitudinal Study; KLoSA: Korean Longitudinal Study of Aging; HR: hazard ratio; CI: confidence interval.

HR was adjusted for age, sex, marital status, living region, labour force status, educational attainment, total household income, body mass index, smoking status, drinking status, and physical activity (“living region” was removed in ELSA and “physical activity” was removed in CHARLS).

Supplementary Table 14 Association between baseline frailty status and cognitive impairment when using frailty index cutoffs of 0.10 and 0.25 to define frailty status

Study	Robust	Pre-frail				Frail			
		HR (95% CI) (unadjusted)	P	HR (95% CI) (adjusted)	P	HR (95% CI) (unadjusted)	P	HR (95% CI) (adjusted)	P
HRS (n=7437)	Reference	1.32 (1.12–1.55)	0.001	1.20 (1.02–1.42)	0.033	2.18 (1.86–2.56)	<0.001	1.66 (1.39–1.98)	<0.001
ELSA (n=6041)	Reference	1.18 (1.01–1.37)	0.032	1.09 (0.93–1.28)	0.278	1.83 (1.55–2.17)	<0.001	1.46 (1.19–1.77)	<0.001
SHARE (n=21500)	Reference	1.51 (1.39–1.63)	<0.001	1.24 (1.14–1.34)	<0.001	2.19 (2.00–2.39)	<0.001	1.49 (1.34–1.65)	<0.001
CHARLS (n=6574)	Reference	1.22 (1.08–1.37)	<0.001	1.09 (0.97–1.23)	<0.001	1.83 (1.59–2.10)	<0.001	1.45 (1.25–1.67)	<0.001
KLoSA (n=5877)	Reference	1.26 (1.11–1.43)	<0.001	1.14 (1.00–1.31)	<0.001	2.14 (1.83–2.51)	<0.001	1.82 (1.52–2.19)	<0.001

HRS: Health and Retirement Study; ELSA: English Longitudinal Study of Ageing; SHARE: Survey of Health, Ageing and Retirement in Europe; CHARLS: China Health and Retirement Longitudinal Study; KLoSA: Korean Longitudinal Study of Aging; HR: hazard ratio; CI: confidence interval.

HR was adjusted for age, sex, marital status, living region, labour force status, educational attainment, total household income, body mass index, smoking status, drinking status, and physical activity (“living region” was removed in ELSA and “physical activity” was removed in CHARLS).

Supplementary Table 15 Association between baseline frailty status and cognitive impairment when using the lowest quartile of cognitive scores to define cognitive impairment

Study	Robust	Pre-frail				Frail			
		HR (95% CI) (unadjusted)	P	HR (95% CI) (adjusted)	P	HR (95% CI) (unadjusted)	P	HR (95% CI) (adjusted)	P
HRS (n=7090)	Reference	1.81 (1.51–2.16)	<0.001	1.47 (1.23–1.76)	<0.001	2.87 (2.40–3.43)	<0.001	1.89 (1.57–2.29)	<0.001
ELSA (n=5595)	Reference	1.53 (1.33–1.76)	<0.001	1.15 (1.00–1.33)	0.059	2.41 (2.05–2.84)	<0.001	1.42 (1.18–1.72)	<0.001
SHARE (n=19024)	Reference	2.57 (1.89–3.49)	<0.001	1.23 (1.14–1.33)	<0.001	5.54 (3.91–7.83)	<0.001	1.37 (1.24–1.51)	<0.001
CHARLS (n=6999)	Reference	1.36 (1.21–1.52)	<0.001	1.22 (1.09–1.37)	<0.001	1.85 (1.62–2.12)	<0.001	1.41 (1.22–1.62)	<0.001
KLoSA (n=5424)	Reference	3.29 (2.61–4.15)	<0.001	1.90 (1.50–2.41)	<0.001	7.57 (5.88–9.74)	<0.001	2.81(2.16–3.67)	<0.001

HRS: Health and Retirement Study; ELSA: English Longitudinal Study of Ageing; SHARE: Survey of Health, Ageing and Retirement in Europe; CHARLS: China Health and Retirement Longitudinal Study; KLoSA: Korean Longitudinal Study of Aging; HR: hazard ratio; CI: confidence interval.

HR was adjusted for age, sex, marital status, living region, labour force status, educational attainment, total household income, body mass index, smoking status, drinking status, and physical activity (“living region” was removed in ELSA and “physical activity” was removed in CHARLS).

Supplementary Table 16 Numbers and rates of participants with missing data in the analyses of frailty trajectory classes

Characteristic	HRS				ELSA				SHARE			
	Class 1 (n=1379) (n, %)	Class 2 (n=1985) (n, %)	Class 3 (n=270) (n, %)	Total (n=3634) (n, %)	Class 1 (n=1147) (n, %)	Class 2 (n=3439) (n, %)	Class 3 (n=355) (n, %)	Total (n=4941) (n, %)	Class 1 (n=1831) (n, %)	Class 2 (n=3937) (n, %)	Class 3 (n=435) (n, %)	Total (n=6203) (n, %)
Age (years)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Age group	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Sex	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Marital status	1 (0.07)	1 (0.05)	0 (0)	2 (0.06)	0 (0)	1 (0.03)	0 (0)	1 (0.02)	0 (0)	1 (0.03)	0 (0)	1 (0.02)
Living region	8 (0.58)	12 (0.6)	1 (0.37)	21 (0.58)	-	-	-	-	71 (3.88)	224 (5.69)	13 (2.99)	308 (4.97)
Labour force status	0 (0)	0 (0)	0 (0)	0 (0)	3 (0.26)	13 (0.38)	1 (0.28)	17 (0.34)	11 (0.6)	37 (0.94)	4 (0.92)	52 (0.84)
Educational attainment	0 (0)	1 (0.05)	0 (0)	1 (0.03)	113 (9.85)	283 (8.23)	39 (10.99)	435 (8.8)	0 (0)	0 (0)	0 (0)	0 (0)
Total household income (tertiles)	0 (0)	0 (0)	0 (0)	0 (0)	10 (0.87)	79 (2.3)	5 (1.41)	94 (1.9)	167 (9.12)	474 (12.04)	32 (7.36)	673 (10.85)
BMI (kg/m ²)	11 (0.8)	14 (0.71)	2 (0.74)	27 (0.74)	201 (17.52)	712 (20.7)	80 (22.54)	993 (20.1)	25 (1.37)	35 (0.89)	11 (2.53)	71 (1.14)
BMI group	11 (0.8)	14 (0.71)	2 (0.74)	27 (0.74)	201 (17.52)	712 (20.7)	80 (22.54)	993 (20.1)	25 (1.37)	35 (0.89)	11 (2.53)	71 (1.14)
Smoking status	8 (0.58)	10 (0.5)	3 (1.11)	21 (0.58)	2 (0.17)	0 (0)	0 (0)	2 (0.04)	3 (0.16)	5 (0.13)	1 (0.23)	9 (0.15)
Drinking status	0 (0)	0 (0)	0 (0)	0 (0)	79 (6.89)	227 (6.6)	38 (10.7)	344 (6.96)	3 (0.16)	5 (0.13)	1 (0.23)	9 (0.15)
Physical activity	3 (0.22)	2 (0.1)	0 (0)	5 (0.14)	0 (0)	0 (0)	0 (0)	0 (0)	5 (0.27)	5 (0.13)	1 (0.23)	11 (0.18)

Supplementary Table 16 Continued Numbers and rates of participants with missing data in the analyses of frailty trajectory classes

Characteristic	CHARLS				KLoSA			
	Robust (n=996) (n, %)	Pre-frail (n=2208) (n, %)	Frail (n=229) (n, %)	Total (n=3433) (n, %)	Robust (n=1631) (n, %)	Pre-frail (n=2055) (n, %)	Frail (n=413) (n, %)	Total (n=4099) (n, %)
Age (years)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Age group	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Sex	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Marital status	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Living region	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Labour force status	12 (1.20)	17 (0.77)	2 (0.87)	31 (0.9)	6 (0.37)	3 (0.15)	0 (0)	9 (0.22)
Educational attainment	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Total household income (tertiles)	282 (28.31)	801 (36.28)	60 (26.2)	1143 (33.29)	0 (0)	0 (0)	0 (0)	0 (0)
BMI (kg/m ²)	131 (13.15)	235 (10.64)	33 (14.41)	399 (11.62)	28 (1.72)	30 (1.46)	9 (2.18)	67 (1.63)
BMI group	131 (13.15)	235 (10.64)	33 (14.41)	399 (11.62)	28 (1.72)	30 (1.46)	9 (2.18)	67 (1.63)
Smoking status	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Drinking status	0 (0)	1 (0.05)	0 (0)	1 (0.03)	0 (0)	0 (0)	0 (0)	0 (0)
Physical activity	-	-	-	-	0 (0)	0 (0)	0 (0)	0 (0)

HRS: Health and Retirement Study; ELSA: English Longitudinal Study of Ageing; SHARE: Survey of Health, Ageing and Retirement in Europe; CHARLS: China Health and Retirement Longitudinal Study; KLoSA: Korean Longitudinal Study of Aging; BMI: body mass index.

The covariate “living region” was not available in ELSA, so it was not included in the analysis.

The missing rates for the covariate “physical activity” in CHARLS exceeded 50%, so it was excluded from the analysis.

Supplementary Table 17 Number of cases of cognitive impairment and no cognitive impairment in the analyses frailty trajectory

Study	Cognitive impairment (n, %)	No cognitive impairment (n, %)	Total (n)
HRS	635 (17.47)	2999 (82.53)	3634
ELSA	753 (15.24)	4188 (84.76)	4941
SHARE	1103 (17.78)	5100 (82.22)	6203
CHARLS	1039 (30.27)	2394 (69.73)	3433
KLoSA	1187 (28.96)	2912 (71.04)	4099
Total	4717 (21.14)	17593 (78.86)	22310

HRS: Health and Retirement Study; ELSA: English Longitudinal Study of Ageing; SHARE: Survey of Health, Ageing and Retirement in Europe; CHARLS: China Health and Retirement Longitudinal Study; KLoSA: Korean Longitudinal Study of Aging.

Supplementary Table 18 Fit indices of frailty trajectory model

Study	Number of class	AIC	BIC	SABIC	Entropy	Proportion of each class (%)	Average posterior probability of each class (%)
HRS (n=3634)	2	-24890.76	-24853.57	-24872.64	0.90	74.30/25.70	98.02/94.55
	3	-29051.90	-28996.12	-29024.71	0.90	37.95/54.62/7.43	94.00/96.01/96.64
	4	-31244.02	-31169.65	-31207.78	0.88	39.63/35.55/19.65/5.17	91.24/94.16/93.19/98.37
	5	-32189.71	-32096.74	-32144.40	0.88	37.59/21.99/31.07/7.10/2.26	90.39/91.60/93.71/94.34/96.15
ELSA (n=4941)	2	-28283.29	-28244.26	-28263.32	0.94	81.74/18.26	98.89/95.74
	3	-31878.86	-31820.31	-31848.91	0.92	69.60/23.21/7.18	97.20/92.78/96.32
	4	-33809.69	-33731.63	-33769.76	0.90	11.19/26.84/58.77/3.20	94.76/90.00/95.85/96.62
	5	-34727.68	-34630.1	-34677.76	0.87	13.66/28.03/49.08/7.02/2.21	89.71/86.02/93.38/93.36/97.61
SHARE (n=6203)	2	-44423.38	-44382.98	-44402.05	0.93	78.95/21.05	98.57/95.58
	3	-49398.94	-49338.35	-49366.94	0.90	29.52/63.47/7.01	92.65/96.81/96.17
	4	-51493.47	-51412.68	-51450.81	0.86	31.18/50.99/13.70/4.13	88.21/94.12/91.70/95.39
	5	-52260.78	-52159.79	-52207.45	0.85	46.72/14.77/4.80/31.37/2.34	92.58/89.34/90.14/86.61/95.01
CHARLS (n=3433)	2	-26248.93	-26212.08	-26231.15	0.91	79.00/21.00	98.13/95.02
	3	-28210.59	-28155.32	-28183.92	0.88	29.01/64.32/6.67	91.18/95.79/94.60
	4	-29046.12	-28972.42	-29010.55	0.84	30.76/53.28/12.64/3.32	86.66/93.11/91.33/94.01
	5	-29524.29	-29432.17	-29479.83	0.86	3.06/30.91/52.40/10.84/2.80	84.52/87.51/93.29/88.70/96.24
KLoSA (n=4099)	2	-5134.92	-5071.74	-5103.51	0.87	74.60/25.40	96.97/93.45
	3	-7411.23	-7316.45	-7364.12	0.82	50.13/39.79/10.08	92.32/89.62/93.69
	4	-8192.95	-8066.58	-8130.13	0.81	38.50/43.55/14.91/3.05	90.52/86.53/88.66/91.19
	5	-8775.43	-8617.47	-8696.91	0.82	35.79/43.57/12.86/4.22/3.56	90.91/86.41/86.41/82.89/91.99

HRS: Health and Retirement Study; ELSA: English Longitudinal Study of Ageing; SHARE: Survey of Health: Ageing and Retirement in Europe; CHARLS: China Health and Retirement Longitudinal Study; KLoSA: Korean Longitudinal Study of Aging; AIC: Akaike information criterion; BIC: Bayesian information criterion; SABIC: sample-size adjusted Bayesian information criterion.

Supplementary Table 19 Characteristics of the included participants in the analyses of frailty trajectory classes when using data not being imputed

Characteristic	HRS				ELSA				SHARE			
	Class 1 (n=1350)	Class 2 (n=1945)	Class 3 (n=264)	Total (n=3559)	Class 1 (n=801)	Class 2 (n=2350)	Class 3 (n=218)	Total (n=3369)	Class 1 (n=1582)	Class 2 (n=3244)	Class 3 (n=381)	Total (n=5207)
Age (years) (mean, SD)	73.1 (6.0)	71.7 (5.3)	72.8 (8.0)	72.3 (5.8)	69.8 (7.8)	65.8 (7.2)	69.7 (8.2)	67.0 (7.7)	65.4 (8.1)	60.7 (7.3)	69.2 (8.9)	62.7 (8.2)
Age group (n, %)												
50–64	27 (2.0)	38 (2.0)	15 (5.7)	80 (2.2)	221 (27.6)	1088 (46.3)	62 (28.4)	1371 (40.7)	720 (45.5)	2301 (70.9)	116 (30.4)	3137 (60.2)
65–74	819 (60.7)	1395 (71.7)	147 (55.7)	2361 (66.3)	330 (41.2)	930 (39.6)	89 (40.8)	1349 (40.0)	641 (40.5)	814 (25.1)	150 (39.4)	1605 (30.8)
≥75	504 (37.3)	512 (26.3)	102 (38.6)	1118 (31.4)	250 (31.2)	332 (14.1)	67 (30.7)	649 (19.3)	221 (14.0)	129 (4.0)	115 (30.2)	465 (8.9)
Sex (n, %)												
Female	859 (63.6)	1087 (55.9)	190 (72.0)	2136 (60.0)	480 (59.9)	1183 (50.3)	143 (65.6)	1806 (53.6)	1066 (67.4)	1856 (57.2)	290 (76.1)	3212 (61.7)
Male	491 (36.4)	858 (44.1)	74 (28.0)	1423 (40.0)	321 (40.1)	1167 (49.7)	75 (34.4)	1563 (46.4)	516 (32.6)	1388 (42.8)	91 (23.9)	1995 (38.3)
Marital status (n, %)												
Unmarried	505 (37.4)	565 (29.0)	132 (50.0)	1202 (33.8)	261 (32.6)	533 (22.7)	90 (41.3)	884 (26.2)	532 (33.6)	823 (25.4)	169 (44.4)	1524 (29.3)
Married	845 (62.6)	1380 (71.0)	132 (50.0)	2357 (66.2)	540 (67.4)	1817 (77.3)	128 (58.7)	2485 (73.8)	1050 (66.4)	2421 (74.6)	212 (55.6)	3683 (70.7)
Living region (n, %)												
Rural	914 (67.7)	1379 (70.9)	182 (68.9)	2475 (69.5)	-	-	-	-	971 (61.4)	1954 (60.2)	253 (66.4)	3178 (61.0)
Urban	436 (32.3)	566 (29.1)	82 (31.1)	1084 (30.5)	-	-	-	-	611 (38.6)	1290 (39.8)	128 (33.6)	2029 (39.0)
Labour force status (n, %)												
Unemployed or unable to work	80 (5.9)	104 (5.3)	29 (11.0)	213 (6.0)	70 (8.7)	115 (4.9)	52 (23.9)	237 (7.0)	191 (12.1)	304 (9.4)	60 (15.7)	555 (10.7)
Employed or self-employed	124 (9.2)	317 (16.3)	10 (3.8)	451 (12.7)	145 (18.1)	855 (36.4)	14 (6.4)	1014 (30.1)	359 (22.7)	1556 (48.0)	31 (8.1)	1946 (37.4)
Retired	1146 (84.9)	1524 (78.4)	225 (85.2)	2895 (81.3)	586 (73.2)	1380 (58.7)	152 (69.7)	2118 (62.9)	1032 (65.2)	1384 (42.7)	290 (76.1)	2706 (52.0)
Educational attainment (n, %)												
Below high school	200 (14.8)	154 (7.9)	77 (29.2)	431 (12.1)	217 (27.1)	334 (14.2)	82 (37.6)	633 (18.8)	516 (32.6)	623 (19.2)	171 (44.9)	1310 (25.2)
High school or above	1150 (85.2)	1791 (92.1)	187 (70.8)	3128 (87.9)	584 (72.9)	2016 (85.8)	136 (62.4)	2736 (81.2)	1066 (67.4)	2621 (80.8)	210 (55.1)	3897 (74.8)
Total household income (tertiles) (n, %)												
Low	415 (30.7)	382 (19.6)	142 (53.8)	939 (26.4)	288 (36.0)	499 (21.2)	109 (50.0)	896 (26.6)	669 (42.3)	789 (24.3)	248 (65.1)	1706 (32.8)
Medium	574 (42.5)	773 (39.7)	92 (34.8)	1439 (40.4)	284 (35.5)	778 (33.1)	77 (35.3)	1139 (33.8)	508 (32.1)	997 (30.7)	95 (24.9)	1600 (30.7)
High	361 (26.7)	790 (40.6)	30 (11.4)	1181 (33.2)	229 (28.6)	1073 (45.7)	32 (14.7)	1334 (39.6)	405 (25.6)	1458 (44.9)	38 (10.0)	1901 (36.5)
BMI (kg/m ²) (mean, SD)	29.3 (5.4)	26.9 (4.6)	31.3 (7.1)	28.1 (5.3)	30.1 (5.3)	27.2 (4.4)	31.8 (6.7)	28.2 (5.0)	28.4 (4.8)	26.2 (4.2)	30.3 (6.4)	27.2 (4.8)
BMI group (n, %)												
<18.5	8 (0.6)	21 (1.1)	1 (0.4)	30 (0.8)	5 (0.6)	20 (0.9)	0 (0.0)	25 (0.7)	19 (1.2)	27 (0.8)	5 (1.3)	51 (1.0)
18.5 – <25	277 (20.5)	651 (33.5)	36 (13.6)	964 (27.1)	121 (15.1)	730 (31.1)	27 (12.4)	878 (26.1)	353 (22.3)	1353 (41.7)	59 (15.5)	1765 (33.9)
25 – <30	508 (37.6)	833 (42.8)	100 (37.9)	1441 (40.5)	304 (38.0)	1069 (45.5)	74 (33.9)	1447 (43.0)	696 (44.0)	1323 (40.8)	140 (36.7)	2159 (41.5)
≥30	557 (41.3)	440 (22.6)	127 (48.1)	1124 (31.6)	371 (46.3)	531 (22.6)	117 (53.7)	1019 (30.2)	514 (32.5)	541 (16.7)	177 (46.5)	1232 (23.7)
Smoking status (n, %)												
Never	572 (42.4)	915 (47.0)	115 (43.6)	1602 (45.0)	280 (35.0)	999 (42.5)	58 (26.6)	1337 (39.7)	902 (57.0)	1822 (56.2)	240 (63.0)	2964 (56.9)
Ever	778 (57.6)	1030 (53.0)	149 (56.4)	1957 (55.0)	521 (65.0)	1351 (57.5)	160 (73.4)	2032 (60.3)	680 (43.0)	1422 (43.8)	141 (37.0)	2243 (43.1)
Drinking status (n, %)												
Never	636 (47.1)	663 (34.1)	179 (67.8)	1478 (41.5)	113 (14.1)	148 (6.3)	64 (29.4)	325 (9.6)	234 (14.8)	344 (10.6)	88 (23.1)	666 (12.8)
Ever	714 (52.9)	1282 (65.9)	85 (32.2)	2081 (58.5)	688 (85.9)	2202 (93.7)	154 (70.6)	3044 (90.4)	1348 (85.2)	2900 (89.4)	293 (76.9)	4541 (87.2)
Physical activity (n, %)												
Non-vigorous	961 (71.2)	988 (50.8)	232 (87.9)	2181 (61.3)	660 (82.4)	1295 (55.1)	203 (93.1)	2158 (64.1)	830 (52.5)	1132 (34.9)	276 (72.4)	2238 (43.0)
Vigorous	389 (28.8)	957 (49.2)	32 (12.1)	1378 (38.7)	141 (17.6)	1055 (44.9)	15 (6.9)	1211 (35.9)	752 (47.5)	2112 (65.1)	105 (27.6)	2969 (57.0)

Supplementary Table 19 Continued Characteristics of the included participants in the analyses of frailty trajectory classes when using data not being imputed

Characteristic	CHARLS				KLoSA			
	Class 1 (n=627)	Class 2 (n=1268)	Class 3 (n=146)	Total (n=2041)	Class 1 (n=1597)	Class 2 (n=2022)	Class 3 (n=404)	Total (n=4023)
Age (years) (mean, SD)	61.3 (6.5)	60.4 (6.5)	63.0 (6.1)	60.8 (6.5)	65.2 (8.9)	60.7 (7.7)	70.4 (8.4)	63.5 (8.9)
Age group (n, %)								
50–64	452 (72.1)	953 (75.2)	91 (62.3)	1496 (73.3)	773 (48.4)	1399 (69.2)	90 (22.3)	2262 (56.2)
65–74	149 (23.8)	276 (21.8)	50 (34.2)	475 (23.3)	554 (34.7)	527 (26.1)	177 (43.8)	1258 (31.3)
≥75	26 (4.1)	39 (3.1)	5 (3.4)	70 (3.4)	270 (16.9)	96 (4.7)	137 (33.9)	503 (12.5)
Sex (n, %)								
Female	320 (51.0)	445 (35.1)	99 (67.8)	864 (42.3)	942 (59.0)	1020 (50.4)	265 (65.6)	2227 (55.4)
Male	307 (49.0)	823 (64.9)	47 (32.2)	1177 (57.7)	655 (41.0)	1002 (49.6)	139 (34.4)	1796 (44.6)
Marital status (n, %)								
Unmarried	81 (12.9)	115 (9.1)	23 (15.8)	219 (10.7)	328 (20.5)	220 (10.9)	126 (31.2)	674 (16.8)
Married	546 (87.1)	1153 (90.9)	123 (84.2)	1822 (89.3)	1269 (79.5)	1802 (89.1)	278 (68.8)	3349 (83.2)
Living region (n, %)								
Rural	207 (33.0)	470 (37.1)	44 (30.1)	721 (35.3)	1131 (70.8)	1560 (77.2)	310 (76.7)	3001 (74.6)
Urban	420 (67.0)	798 (62.9)	102 (69.9)	1320 (64.7)	466 (29.2)	462 (22.8)	94 (23.3)	1022 (25.4)
Labour force status (n, %)								
Unemployed or unable to work	12 (1.9)	19 (1.5)	1 (0.7)	32 (1.6)	510 (31.9)	474 (23.4)	178 (44.1)	1162 (28.9)
Employed or self-employed	404 (64.4)	821 (64.7)	76 (52.1)	1301 (63.7)	651 (40.8)	1208 (59.7)	103 (25.5)	1962 (48.8)
Retired	211 (33.7)	428 (33.8)	69 (47.3)	708 (34.7)	436 (27.3)	340 (16.8)	123 (30.4)	899 (22.3)
Educational attainment (n, %)								
Below high school	562 (89.6)	1087 (85.7)	139 (95.2)	1788 (87.6)	1078 (67.5)	963 (47.6)	320 (79.2)	2361 (58.7)
High school or above	65 (10.4)	181 (14.3)	7 (4.8)	253 (12.4)	519 (32.5)	1059 (52.4)	84 (20.8)	1662 (41.3)
Total household income (tertiles) (n, %)								
Low	189 (30.1)	309 (24.4)	63 (43.2)	561 (27.5)	595 (37.3)	798 (39.5)	158 (39.1)	1551 (38.6)
Medium	214 (34.1)	432 (34.1)	40 (27.4)	686 (33.6)	497 (31.1)	354 (17.5)	158 (39.1)	1009 (25.1)
High	224 (35.7)	527 (41.6)	43 (29.5)	794 (38.9)	505 (31.6)	870 (43.0)	88 (21.8)	1463 (36.4)
BMI (kg/m ²) (mean, SD)	24.0 (4.4)	23.5 (13.3)	24.1 (3.8)	23.7 (10.8)	23.4 (2.7)	23.3 (2.4)	23.5 (3.2)	23.4 (2.6)
BMI group (n, %)								
<18.5	41 (6.5)	70 (5.5)	8 (5.5)	119 (5.8)	57 (3.6)	28 (1.4)	17 (4.2)	102 (2.5)
18.5 – <25	354 (56.5)	859 (67.7)	81 (55.5)	1294 (63.4)	1115 (69.8)	1560 (77.2)	260 (64.4)	2935 (73.0)
25 – <30	191 (30.5)	296 (23.3)	47 (32.2)	534 (26.2)	405 (25.4)	419 (20.7)	114 (28.2)	938 (23.3)
≥30	41 (6.5)	43 (3.4)	10 (6.8)	94 (4.6)	20 (1.3)	15 (0.7)	13 (3.2)	48 (1.2)
Smoking status (n, %)								
Never	364 (58.1)	622 (49.1)	99 (67.8)	1085 (53.2)	1119 (70.1)	1347 (66.6)	300 (74.3)	2766 (68.8)
Ever	263 (41.9)	646 (50.9)	47 (32.2)	956 (46.8)	478 (29.9)	675 (33.4)	104 (25.7)	1257 (31.2)
Drinking status (n, %)								
Never	372 (59.3)	651 (51.3)	90 (61.6)	1113 (54.5)	77 (4.8)	62 (3.1)	25 (6.2)	164 (4.1)
Ever	255 (40.7)	617 (48.7)	56 (38.4)	928 (45.5)	1520 (95.2)	1960 (96.9)	379 (93.8)	3859 (95.9)
Physical activity (n, %)								
Non-vigorous	-	-	-	-	998 (62.5)	1194 (59.1)	292 (72.3)	2484 (61.7)
Vigorous	-	-	-	-	599 (37.5)	828 (40.9)	112 (27.7)	1539 (38.3)

HRS: Health and Retirement Study; ELSA: English Longitudinal Study of Ageing; SHARE: Survey of Health, Ageing and Retirement in Europe; CHARLS: China Health and Retirement Longitudinal Study; KLoSA: Korean Longitudinal Study of Aging.

Class 1: medium-increasing, Class 2: low-increasing, Class 3: high-increasing (HRS, ELSA, SHARE, and CHARLS); Class 1: medium-fluctuating, Class 2: low-fluctuating, Class 3: high-fluctuating (KLoSA).

Unmarried status includes separated, divorced, widowed, and never married; married status includes married and partnered.

The covariate “living region” was not available in ELSA, so it was not included in the analysis.

The missing rates for the covariate “physical activity” in CHARLS exceeded 50%, so it was excluded from the analysis.

Supplementary Table 20 Association between frailty trajectory classes and cognitive impairment by age

Age	HRS (n=3634)		ELSA (n=4941)		SHARE (n=6203)		CHARLS (n=3433)		KLoSA (n=4099)	
	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	P
50–64										
Class 1	Reference		Reference		Reference		Reference		Reference	
Class 2	0.52 (0.03-8.60)	0.650	0.65 (0.43-0.99)	0.043	0.40 (0.31-0.51)	<0.001	0.62 (0.49-0.78)	<0.001	0.57 (0.46-0.70)	<0.001
Class 3	11.27 (0.15-827.12)	0.269	1.71 (0.91-3.18)	0.093	1.42 (0.90-2.23)	0.134	2.27 (1.52-3.41)	<0.001	4.44 (2.69-7.34)	<0.001
65–74										
Class 1	Reference		Reference		Reference		Reference		Reference	
Class 2	0.83 (0.59-1.15)	0.262	0.97 (0.65-1.47)	0.898	0.44 (0.32-0.60)	<0.001	0.87 (0.54-1.40)	0.567	0.46 (0.34-0.63)	<0.001
Class 3	1.47 (0.88-2.45)	0.141	1.08 (0.58-2.03)	0.806	2.42 (1.58-3.70)	<0.001	1.81 (0.97-3.40)	0.064	5.79 (3.87-8.68)	<0.001
≥75										
Class 1	Reference		Reference		Reference		Reference		Reference	
Class 2	0.38 (0.23-0.62)	<0.001	0.54 (0.32-0.93)	0.027	0.60 (0.33-1.11)	0.106	0.44 (0.13-1.47)	0.184	0.15 (0.06-0.39)	<0.001
Class 3	4.64 (2.37-9.09)	<0.001	1.54 (0.74-3.20)	0.247	2.86 (1.64-4.98)	<0.001	0.47 (0.05-4.89)	0.53	2.64 (1.63-4.29)	<0.001
P for interaction	0.379		0.888		0.079		0.297		0.033	

HRS: Health and Retirement Study; ELSA: English Longitudinal Study of Ageing; SHARE: Survey of Health, Ageing and Retirement in Europe; CHARLS: China Health and Retirement Longitudinal Study; KLoSA: Korean Longitudinal Study of Aging; OR: odds ratio; CI: confidence interval.

Class 1: medium-increasing, Class 2: low-increasing, Class 3: high-increasing (HRS, ELSA, SHARE, and CHARLS); Class 1: medium-fluctuating, Class 2: low-fluctuating, Class 3: high-fluctuating (KLoSA).

OR was adjusted for sex, marital status, living region, labour force status, educational attainment, total household income, body mass index, smoking status, drinking status, and physical activity (“living region” was removed in ELSA and “physical activity” was removed in CHARLS).

P for interaction: likelihood ratio test was used to detect group differences.

Supplementary Table 21 Association between frailty trajectory classes and cognitive impairment by sex

Sex	HRS (n=3634)		ELSA (n=4941)		SHARE (n=6203)		CHARLS (n=3433)		KLoSA (n=4099)	
	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	P
Female										
Class 1	Reference		Reference		Reference		Reference		Reference	
Class 2	0.74 (0.52-1.06)	0.102	0.74 (0.52-1.05)	0.092	0.45 (0.35-0.57)	<0.001	0.74 (0.55-0.98)	0.038	0.55 (0.44-0.68)	<0.001
Class 3	2.54 (1.57-4.10)	<0.001	1.28 (0.79-2.08)	0.321	2.35 (1.71-3.23)	<0.001	1.38 (0.90-2.10)	0.137	4.36 (3.17-6.00)	<0.001
Male										
Class 1	Reference		Reference		Reference		Reference		Reference	
Class 2	0.52 (0.34-0.79)	0.002	0.72 (0.50-1.05)	0.092	0.42 (0.31-0.55)	<0.001	0.56 (0.42-0.74)	<0.001	0.41 (0.31-0.54)	<0.001
Class 3	1.65 (0.83-3.28)	0.153	1.73 (0.97-3.10)	0.065	1.69 (1.05-2.72)	0.032	3.11 (1.81-5.34)	<0.001	4.15 (2.70-6.38)	<0.001
P for interaction	0.197		0.81		0.562		0.148		0.504	

HRS: Health and Retirement Study; ELSA: English Longitudinal Study of Ageing; SHARE: Survey of Health, Ageing and Retirement in Europe; CHARLS: China Health and Retirement Longitudinal Study; KLoSA: Korean Longitudinal Study of Aging; OR: odds ratio; CI: confidence interval.

Class 1: medium-increasing, Class 2: low-increasing, Class 3: high-increasing (HRS, ELSA, SHARE, and CHARLS); Class 1: medium-fluctuating, Class 2: low-fluctuating, Class 3: high-fluctuating (KLoSA).

OR was adjusted for age, marital status, living region, labour force status, educational attainment, total household income, body mass index, smoking status, drinking status, and physical activity ("living region" was removed in ELSA and "physical activity" was removed in CHARLS).

P for interaction: likelihood ratio test was used to detect group differences.

Supplementary Table 22 Association between frailty trajectory classes and cognitive impairment by educational attainment

Educational attainment	HRS (n=3634)		ELSA (n=4941)		SHARE (n=6203)		CHARLS (n=3433)		KLoSA (n=4099)	
	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	P
Below high school										
Class 1	Reference		Reference		Reference		Reference		Reference	
Class 2	0.88 (0.47-1.64)	0.682	0.83 (0.52-1.32)	0.437	0.47 (0.35-0.64)	<0.001	0.65 (0.53-0.81)	<0.001	0.52 (0.42-0.64)	<0.001
Class 3	1.44 (0.67-3.10)	0.353	1.69 (0.92-3.11)	0.092	2.46 (1.65-3.65)	<0.001	1.88 (1.33-2.65)	<0.001	4.11 (3.08-5.50)	<0.001
High school or above										
Class 1	Reference		Reference		Reference		Reference		Reference	
Class 2	0.59 (0.43-0.79)	0.001	0.68 (0.50-0.93)	0.015	0.41 (0.33-0.52)	<0.001	0.49 (0.21-1.17)	0.108	0.47 (0.35-0.62)	<0.001
Class 3	2.73 (1.73-4.29)	<0.001	1.35 (0.84-2.16)	0.217	1.97 (1.39-2.81)	<0.001	3.87 (1.09-13.71)	0.036	5.35 (3.13-9.14)	<0.001
P for interaction	0.655		0.128		0.309		0.193		0.863	

HRS: Health and Retirement Study; ELSA: English Longitudinal Study of Ageing; SHARE: Survey of Health, Ageing and Retirement in Europe; CHARLS: China Health and Retirement Longitudinal Study; KLoSA: Korean Longitudinal Study of Aging; OR: odds ratio; CI: confidence interval.

Class 1: medium-increasing, Class 2: low-increasing, Class 3: high-increasing (HRS, ELSA, SHARE, and CHARLS); Class 1: medium-fluctuating, Class 2: low-fluctuating, Class 3: high-fluctuating (KLoSA).

OR was adjusted for age, sex, marital status, living region, labour force status, total household income, body mass index, smoking status, drinking status, and physical activity ("living region" was removed in ELSA and "physical activity" was removed in CHARLS).

P for interaction: likelihood ratio test was used to detect group differences.

Supplementary Table 23 Association between frailty trajectory classes and cognitive impairment by total household income

Total household income	HRS (n=3634)		ELSA (n=4941)		SHARE (n=6203)		CHARLS (n=3433)		KLoSA (n=4099)	
	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	P
Low										
Class 1	Reference		Reference		Reference		Reference		Reference	
Class 2	0.76 (0.48-1.19)	0.229	0.70 (0.45-1.08)	0.106	0.50 (0.38-0.67)	<0.001	0.54 (0.38-0.79)	0.001	0.46 (0.35-0.60)	<0.001
Class 3	1.38 (0.77-2.46)	0.282	1.24 (0.71-2.16)	0.444	1.97 (1.38-2.80)	<0.001	2.19 (1.28-3.73)	0.004	4.47 (2.92-6.86)	<0.001
Medium										
Class 1	Reference		Reference		Reference		Reference		Reference	
Class 2	0.51 (0.33-0.79)	0.003	0.77 (0.51-1.16)	0.209	0.32 (0.23-0.43)	<0.001	0.61 (0.44-0.85)	0.003	0.43 (0.30-0.61)	<0.001
Class 3	4.11 (2.20-7.69)	<0.001	1.27 (0.68-2.37)	0.45	2.23 (1.36-3.65)	0.001	1.49 (0.82-2.69)	0.190	4.10 (2.69-6.24)	<0.001
High										
Class 1	Reference		Reference		Reference		Reference		Reference	
Class 2	0.68 (0.39-1.20)	0.186	0.77 (0.46-1.28)	0.312	0.52 (0.36-0.75)	0.001	0.81 (0.56-1.17)	0.262	0.61 (0.46-0.80)	<0.001
Class 3	2.77 (0.96-8.02)	0.06	2.74 (1.13-6.63)	0.025	2.38 (1.16-4.90)	0.019	2.59 (1.36-4.90)	0.004	5.35 (3.18-9.01)	<0.001
P for interaction	0.309		0.394		0.452		0.174		0.404	

HRS: Health and Retirement Study; ELSA: English Longitudinal Study of Ageing; SHARE: Survey of Health, Ageing and Retirement in Europe; CHARLS: China Health and Retirement Longitudinal Study; KLoSA: Korean Longitudinal Study of Aging; OR: hazard ratio; CI: confidence interval.

Class 1: medium-increasing, Class 2: low-increasing, Class 3: high-increasing (HRS, ELSA, SHARE, and CHARLS); Class 1: medium-fluctuating, Class 2: low-fluctuating, Class 3: high-fluctuating (KLoSA).

OR was adjusted for age, sex, marital status, living region, labour force status, educational attainment, body mass index, smoking status, drinking status—and physical activity (“living region” was removed in ELSA and “physical activity” was removed in CHARLS).

P for interaction: likelihood ratio test was used to detect group differences.

Supplementary Table 24 Association between frailty trajectory classes and cognitive impairment using data not being imputed

Study	Class 1	Class 2				Class 3			
		OR (95% CI) (unadjusted)	P	OR (95% CI) (adjusted)	P	OR (95% CI) (adjusted)	P	OR (95% CI) (unadjusted)	P
HRS (n=3559)	Reference	0.58 (0.48–0.70)	<0.001	0.63 (0.48–0.83)	0.001	3.32 (2.52–4.39)	<0.001	2.34 (1.58–3.46)	<0.001
ELSA (n=3369)	Reference	0.66 (0.53–0.81)	<0.001	0.65 (0.47–0.89)	0.007	1.28 (0.88–1.83)	0.186	1.28 (0.79–2.04)	0.315
SHARE (n=5207)	Reference	0.40 (0.34–0.46)	<0.001	0.42 (0.35–0.51)	<0.001	2.05 (1.62–2.58)	<0.001	1.99 (1.51–2.64)	<0.001
CHARLS (n=2041)	Reference	0.61 (0.50–0.75)	<0.001	0.63 (0.49–0.82)	0.001	2.23 (1.55–3.22)	<0.001	2.20 (1.46–3.35)	<0.001
KLoSA (n=4023)	Reference	0.52 (0.45–0.61)	<0.001	0.51 (0.43–0.60)	<0.001	3.51 (2.80–4.41)	<0.001	4.43 (3.43–5.74)	<0.001

HRS: Health and Retirement Study; ELSA: English Longitudinal Study of Ageing; SHARE: Survey of Health, Ageing and Retirement in Europe; CHARLS: China Health and Retirement Longitudinal Study; KLoSA: Korean Longitudinal Study of Aging; OR: hazard ratio; CI: confidence interval.

Class 1: medium-increasing, Class 2: low-increasing, Class 3: high-increasing (HRS, ELSA, SHARE, and CHARLS); Class 1: medium-fluctuating, Class 2: low-fluctuating, Class 3: high-fluctuating (KLoSA).

OR was adjusted for age, sex, marital status, living region, labour force status, educational attainment, body mass index, smoking status, drinking status, and physical activity (“living region” was removed in ELSA and “physical activity” was removed in CHARLS).

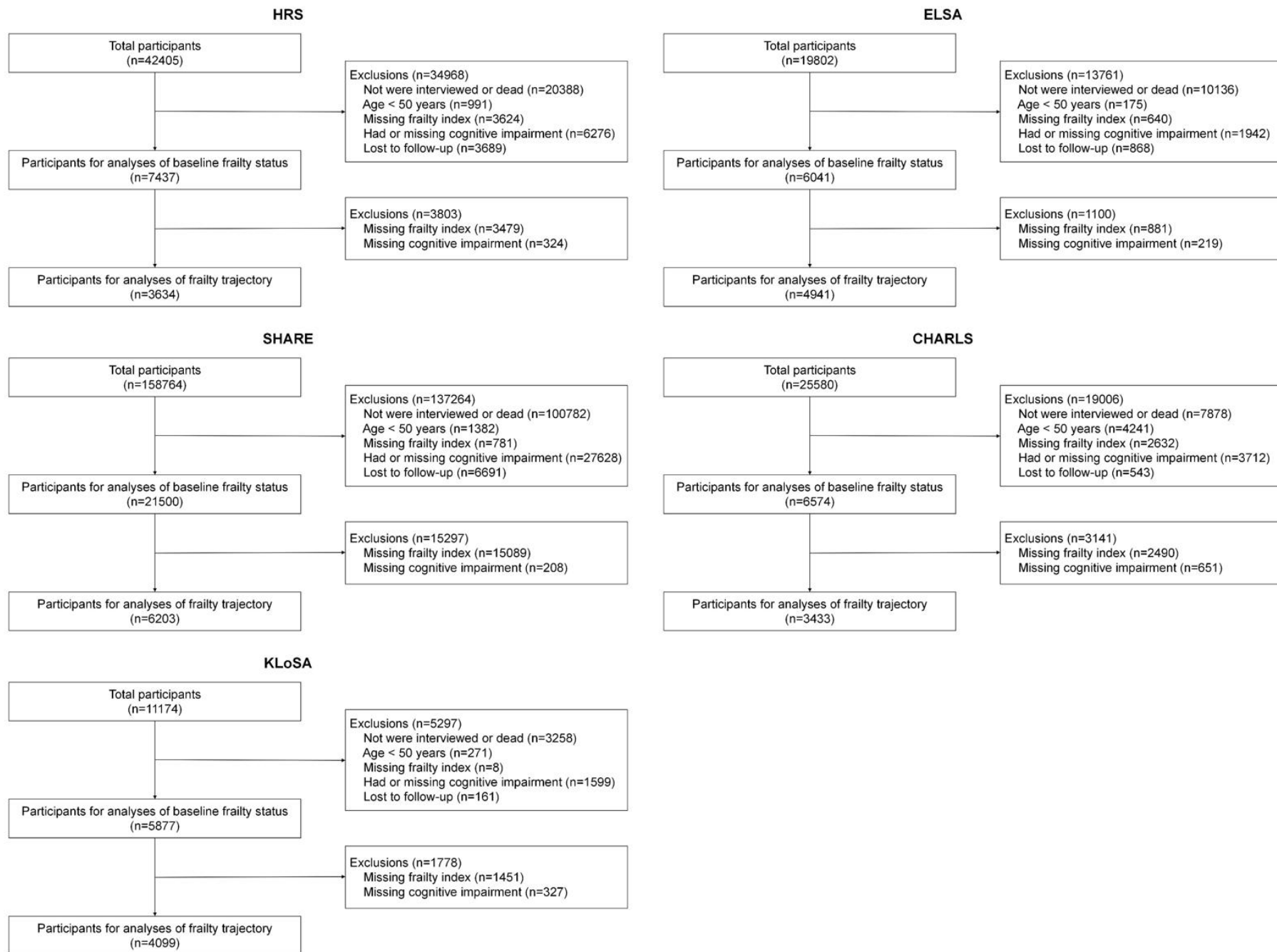
Supplementary Table 25 Association between frailty trajectory classes and cognitive impairment when using frailty index cutoffs of 0.10 and 0.25 to define frailty status

Study	Class 1	Class 2				Class 3			
		OR (95% CI) (unadjusted)	P	OR (95% CI) (adjusted)	P	OR (95% CI) (unadjusted)	P	OR (95% CI) (adjusted)	P
HRS (n=3634)	Reference	0.59 (0.49–0.71)	<0.001	0.64 (0.49–0.84)	0.001	3.25 (2.47–4.28)	<0.001	2.26 (1.53–3.33)	<0.001
ELSA (n=4941)	Reference	0.65 (0.54–0.77)	<0.001	0.73 (0.57–0.94)	0.016	1.67 (1.27–2.20)	<0.001	1.42 (0.98–2.06)	0.062
SHARE (n=6203)	Reference	0.41 (0.36–0.48)	<0.001	0.43 (0.36–0.52)	<0.001	2.13 (1.71–2.65)	<0.001	2.13 (1.64–2.76)	<0.001
CHARLS (n=3433)	Reference	0.56 (0.48–0.66)	<0.001	0.64 (0.53–0.79)	<0.001	2.17 (1.63–2.91)	<0.001	2.02 (1.45–2.81)	<0.001
KLoSA (n=4099)	Reference	0.51 (0.44–0.59)	<0.001	0.50 (0.42–0.59)	<0.001	3.48 (2.78–4.36)	<0.001	4.33 (3.36–5.59)	<0.001

HRS: Health and Retirement Study; ELSA: English Longitudinal Study of Ageing; SHARE: Survey of Health, Ageing and Retirement in Europe; CHARLS: China Health and Retirement Longitudinal Study; KLoSA: Korean Longitudinal Study of Aging; OR: hazard ratio; CI: confidence interval.

Class 1: medium-increasing, Class 2: low-increasing, Class 3: high-increasing (HRS, ELSA, SHARE, and CHARLS); Class 1: medium-fluctuating, Class 2: low-fluctuating, Class 3: high-fluctuating (KLoSA).

OR was adjusted for age, sex, marital status, living region, labour force status, educational attainment, body mass index, smoking status, drinking status, and physical activity (“living region” was removed in ELSA and “physical activity” was removed in CHARLS).



Supplementary Figure 1 Participant selection processes across the five studies