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Supplementary Methods
Frailty assessment.

The 28 items used to construct the frailty index included functional limitations (based on self-reported difficulties in activities of daily living, instrumental activities of daily living, and other activities), self-reported health status and alterations, components of depressive symptoms (based on 10-item version of the Center for Epidemiologic Studies Depression Scale), medical conditions (based on self-reported diagnosis by physicians), and cognitive status (based on a combination of external physician diagnosis and cognition score). These items came from self-reported information by study participants and objective measurements.

The functional limitations were derived from the Activities of Daily Living (ADLs) and Instrumental Activities of Daily Living (IADLs), as well as other self-reported subjective activities limitations. Self-reported health status and alterations were derived using the self-rating of participants' overall health status and this question's response included five categories (from excellent to poor). Components of depressive symptoms were extracted from 10-item version of the Center for Epidemiologic Studies Depression Scale, which included 10 questions concerning indicators of participants' feelings much of the time over the week prior to the interview, with each question consisting of 2 response categories (yes or no). The medical conditions were extracted from self-reported physician diagnosis of relevant diseases, with confirmation procedure applied at each wave. Such procedure was applied to help participants confirm whether they had been diagnosed of the disease at previous wave. The cognitive status was measured based on a combination of self-reported diagnosis and cognition score. We defined dementia cases using either a self-reported physician diagnosis or an alternative approach based on cognition scores. For the CHARLS, we defined dementia as the existence of cognitive impairment. Cognitive impairment was defined as a score that was 1.5 SD below the mean of the population stratified by educational background. These approaches

had been validated

Fitting process of group-based trajectory modelling.

We used a GBTM to determine frailty index (FI) scores among middle-aged and older population in China. The data preparation, group-based trajectory modelling (GBTM), and visualizations were conducted in SAS (version 9.4) and R (version 4.2.1).

GBTM can be implemented using iterative procedures and its implementation requires the prior decision based on knowledge of the field of research, as well as statistical inference. To better illustrate the implementation process, we summarize the GBTM fitting process for this study in the following four steps:

- Step 1: Definition of the problem and specification of the number of trajectory subgroups.

We hypothesized that FI among middle-aged and older population have heterogeneous patterns of change. Since previous studies have explored the pattern of heterogeneous changes in FI, we assumed that the number of each FI trajectory was in two or more groups.

- Step 2: Model specification.

Considering FI is a continuous variable, we selected the censored normal model for fitting our GBTM model. During this process, we assessed the polynomial function of linear, quadratic and cubic, and tried the grouping number from 1 to 5 in each function form. This approach was employed ensure the model has the maximum adaptability and flexibility.

- Step 3: Model determination.

After the number of groups and orders are determined, the GBTM initially employs Bayesian estimation to verify whether the coefficients of the highest term of the polynomial in each group of every model tested are statistically significantly non-zero. If the highest term coefficient of any group is not significantly different from zero, indicating limited impact on the model, the polynomial order of that group should be reduced from the maximum by one. Then, the model should be re-estimated using Bayesian estimation until the coefficients of the highest term of the polynomial in all groups are statistically significantly non-zero. This iterative process ensures that the final design of the model not only accurately reflects the actual data but also avoids overfitting, providing the most precise interpretation and prediction for the observed data.

- Step 4: Model selection and interpretation.

This step aims to select the optimal model from the fifteen models obtained in step 3. Considering that GBTM is an unsupervised clustering model, selecting the best model requires specific evaluation criteria. The average posterior probability is an important indicator for choosing the optimal model. However, previous research has shown that using the average posterior probability as the sole criterion for evaluating model fit may lead to false classifications in GBTM. Therefore, we consider multiple criteria to select the best model. Below are the criteria used to choose the best fitting model:

1. Necessary criteria

1.1. high mean posterior probabilities (≥0.7);

1.2. acceptable proportion of the population (≥5.0%);

1.3. lowest Bayesian information criterion.

2. Advanced criteria

2.1. prior knowledge of the research.

Population attributable fractions for cross-sectional.

The population attributable fractions (PAF) were defined for binary outcomes as the proportion of unfavorable outcomes that would have been prevented if the exposure of interest were eliminated from the population. We can learn easily about the PAF through standard counterfactual notation, the PAF is defined as:

$$PAF = 1 - \frac{Pr(Y_0 = 1)}{Pr(Y = 1)} \qquad (1)$$

where $Pr\ (Y = 1)$ is the factual outcome prevalence, and $Pr\ (Y_0 = 1)$ is the counterfactual outcome prevalence had the exposure been eliminated (set to 0) for everyone. For instance, if the factual outcome prevalence is 20 % and the counterfactual outcome prevalence is 5 %, then through Eq. (1) calculated 25 % of all outcomes would have been prevented, had the exposure been eliminated.

In studies with binary outcomes, the PAF is defined as in Eq. (1). The factual outcome prevalence, $Pr\ (Y = 1)$, can be estimated as the observed (sample) outcome prevalence. To estimate the counterfactual outcome prevalence, $Pr\ (Y_0 = 1)$, it is usually assumed that a set of observed covariates Z is sufficient for confounding control. Under this assumption, $Pr\ (Y_0 = 1)$ can be obtained by averaging the outcome prevalence among the unexposed, at a given value of Z, over the population distribution of Z:

$$Pr\ (Y_0 = 1) = E\{Pr(Y = 1|X = 0, Z)\} \qquad (2)$$

where X is the exposure of interest. In practice, $Pr(Y = 1|X = 0, Z)$ is usually estimated with a logistic regression model:

$$logit\{Pr(Y = 1|X = 0, Z)\} = g(X, Z; \beta) \qquad (3)$$

where $g()$ is a specified function indexed by the parameter vector β. For example, $g()$ could be specified as $\beta_0 + \beta_1 X + \beta_2 Z$. However, $g()$ could also involve interactions and higher order terms. The model in Eq. (3) is fitted to obtain an estimate of β. Then, for each subject i with covariate vector Z_i we use $expit\{g(X = 0, Z_i; \hat{\beta})\}$ as a prediction of $Pr(Y = 1|X = 0, Z_i)$. These predictions are averaged to obtain an estimate of $Pr\ (Y_0 = 1)$:

$$\widehat{Pr}(Y_0 = 1) = \frac{1}{n}\sum_{i=1}^{n} expit\{g(X = 0, Z_i; \hat{\beta})\} \qquad (4)$$

The estimates of $Pr\ (Y = 1)$and $Pr\ (Y_0 = 1)$ are plugged into Eq. (1), to produce an estimate of the PAF. The standard error for the resulting estimate can be obtained by combining the sandwich formula with the delta method.

Supplementary Table S1 . Baseline characteristics of the study population by inclusion and exclusion

Characteristics	Exclusion	Inclusion	*P* value
N	8758	8947	
Baseline solid cooking fuel, *n* (%)	4610 (55.02)	4755 (53.15)	0.014
Age, years	60.91 (11.56)	57.44 (8.41)	<0.001
BMI, kg/m^2	23.35 (4.18)	23.60 (3.95)	<0.001
Males, *n* (%)	3958 (45.22)	4513 (50.48)	<0.001
Married, *n* (%)	7282 (83.24)	8165 (91.26)	<0.001
Smoker, *n* (%)	3258 (37.84)	3673 (41.06)	<0.001
Drinker, *n* (%)	3148 (36.63)	3675 (41.09)	<0.001
Education, *n* (%)			<0.001
Low education	6153 (71.38)	5547 (62.00)	
Middle education	2258 (26.19)	3183 (35.58)	
High education	209 (2.42)	217 (2.43)	

Ambient $PM_{2.5}$, μg /m^3	48.61 (16.73)	50.12 (16.48)	<0.001
House area, m^2	100.00 [67.00, 130.00]	100.00 [70.00, 144.00]	<0.001
Multi-story building, *n* (%)	3400 (39.80)	3451 (38.58)	0.102

Note. BMI, body mass index; FI, frailty index.

Supplementary Table S2 . The definitions for the duration of solid fuel exposure

Item definition [a] [b]	Categories
Self-reported never using solid fuel in all waves	0 years
Self-reported using solid fuel in some waves	1–6 years
Self-reported using solid fuel in all waves	≥ 7 years

Note. [a] Item definition was based on self-reported information.[b] In this definition, we assumed that there would be no change in fuel type between any two consecutive surveys. It was worth noting that both the duration and frequency of use highlighted the long-term effects of using solid fuel. Although we acknowledged that calculating the duration of solid fuel use based on the frequency of solid fuel usage might have introduced bias in our findings, it remained an important and widely accepted method in prior studies. Moreover, we considered that directly using the number of times solid fuel was self-reported to represent its long-term effects might have more easily led to misinterpretation among readers. Therefore, we chose to use the duration of solid fuel use to represent its long-term effects.

Supplementary Table S3 . The definitions for the cooking fuel type switching

Baseline survey	Follow-up surveys	Categories
Using clean cooking fuel	Mainly using clean cooking fuel	Persistent clean fuel
Using solid cooking fuel	Mainly using solid cooking fuel	Persistent solid fuel
Using clean cooking fuel	Mainly using solid cooking fuel	Clean-to-solid fuel
Using solid cooking fuel	Mainly using clean cooking fuel	Solid-to-clean fuel

Supplementary Table S4 . Components of constructed 28-Item frailty index

Item number	Item definition [a]	Scoring
1	Self-reported difficulties in bathing because of health and memory problems.	Yes=1.00; No=0.00
2	Self-reported difficulties in dressing because of health and memory problems.	Yes=1.00; No=0.00
3	Self-reported difficulties in getting in/out of bed because of health and memory problems.	Yes=1.00; No=0.00
4	Self-reported difficulties in eating because of health and memory problems.	Yes=1.00; No=0.00
5	Self-reported difficulties in finishing daily activities of using the toilet because of health and memory problems.	Yes=1.00; No=0.00
6	Total number (0-4) of self-reported difficulties in finishing daily activities including bathing, dressing, eating, getting in/out of bed.	Any difficulties=1.00; No difficulties=0.00
7	Self-reported difficulties in shopping for groceries because of health and memory problems.	Yes=1.00; No=0.00
8	Self-reported difficulties in preparing hot meal because of health and memory	Yes=1.00; No=0.00

	problems.	
9	Self-reported difficulties in taking prescribed medications because of health and memory problems.	Yes=1.00; No=0.00
10	Self-reported difficulties in managing money because of health and memory problems.	Yes=1.00; No=0.00
11	Self-reported difficulties in getting up from a chair because of health and memory problems.	Yes=1.00; No=0.00
12	Self-reported difficulties in climbing several flights of stairs because of health and memory problems.	Yes=1.00; No=0.00
13	Self-reported difficulties in lifting or carrying weights over 10 jin because of health and memory problems.	Yes=1.00; No=0.00
14	Self-reported difficulties in walking 100 meters because of health and memory problems.	Yes=1.00; No=0.00
15	Self-reported rating of health status.	Poor=1.00; Fair=0.75; Good=0.50; Very Good=0.25;

		Excellent=0.00
16	Change in self-reported rating of health status.	Worse=1.00; Better/Same=0.00
17	Feeling that everything is an effort much of time.	Yes=1.00; No=0.00
18	Feeling depressed much of time.	Yes=1.00; No=0.00
19	Feeling happy much of time.	Yes=1.00; No=0.00
20	Feeling lonely much of time.	Yes=1.00; No=0.00
21	Feeling that could not get going much of time.	Yes=1.00; No=0.00
22	Self-reported diagnosis of hypertension by a doctor.	Yes=1.00; No=0.00
23	Self-reported diagnosis of stroke by a doctor.	Yes=1.00; No=0.00
24	Self-reported diagnosis of cancer by a doctor.	Yes=1.00; No=0.00
25	Self-reported diagnosis of diabetes by a doctor.	Yes=1.00; No=0.00
26	Self-reported diagnosis of arthritis by a doctor.	Yes=1.00; No=0.00
27	Self-reported diagnosis of chronic lung disease by physician.	Yes=1.00; No=0.00
28	Cognitive status, based on cognition score.	Dementia=1.00; Cognitive healthy=0.00

Note. [a] Item definition was based on self-reported information or objective measurements or both.

Supplementary Table S5 . The model fitting process of group-based trajectory modelling

Group	Polynomial degree	Log-Lik	BIC1	BIC2	Group percentage	Mean posterior probabilities
1	1	-80413.39	-80427.04	-80428.98	100	1
1	2	-80356.09	-80374.29	-80376.88	100	1
1	3	-80335.43	-80358.18	-80361.42	100	1
2	1 1	-74675.35	-74702.64	-74706.54	79.28/20.72	0.98/0.93
2	2 2	-74457.92	-74494.31	-74499.50	79.71/20.29	0.98/0.94
2	3 3	-74424.02	-74469.52	-74476.00	79.74/20.26	0.98/0.94
3	1 1 1	-72764.61	-72805.55	-72811.39	64.70/28.79/6.50	0.95/0.88/0.93
3	2 2 2	-72464.38	-72518.97	-72526.76	64.75/29.12/6.14	0.95/0.89/0.94
3	**3 3 2**	**-72418.53**	**-72482.22**	**-72491.31**	**64.70/29.09/6.20**	**0.95/0.89/0.94**
4	1 1 1 1	-72150.45	-72205.04	-72212.83	53.94/30.95/11.78/3.33	0.91/0.83/0.86/0.92
4	1 2 2 2	-71801.96	-71870.20	-71879.93	53.45/31.28/12.03/3.24	0.91/0.83/0.87/0.93
4	3 3 2 2	-71747.96	-71829.85	-71841.53	53.56/31.27/11.93/3.24	0.91/0.83/0.87/0.93

5	1 1 1 1 1	-71970.81	-72039.06	-72048.78	47.00/31.70/14.17/5.10/2.03	0.88/0.77/0.80/0.82/0.91
5	1 2 2 2 2	-71047.59	-71134.03	-71146.35	50.10/32.52/8.92/5.38/3.08	0.91/0.82/0.84/0.84/0.93
5	3 3 2 3 2	-70976.94	-71081.58	-71096.50	50.02/32.82/9.17/4.97/3.03	0.91/0.82/0.84/0.86/0.94

Note. Log-Lik, the maximum Log-Likelihood; BIC, Bayesian Information Criterion. The best fitting model was highlighted in bold characters.

Supplementary Table S6 . The estimated parameters for the best fitting group-based trajectory modelling

Trajectory Group	parameter	estimate	standard error	t	*P* value
Low-stable Group	Intercept	2.442	0.025	98.853	<0.001
Low-stable Group	Linear	-0.010	0.021	-0.509	0.611
Low-stable Group	Quadratic	-0.020	0.003	-6.181	<0.001
Low-stable Group	Cubic	0.011	0.002	6.244	<0.001
Moderate-increasing Group	Intercept	5.701	0.048	118.139	<0.001
Moderate-increasing Group	Linear	0.266	0.033	8.059	<0.001
Moderate-increasing Group	Quadratic	-0.062	0.005	-12.006	<0.001
Moderate-increasing Group	Cubic	0.019	0.003	6.779	<0.001
Fast-increasing Group	Intercept	10.352	0.096	108.136	<0.001
Fast-increasing Group	Linear	1.440	0.023	62.318	<0.001
Fast-increasing Group	Quadratic	-0.184	0.009	-20.323	<0.001

Supplementary Table S7. Baseline characteristics of the study population by before and after interpolation

Characteristics	After interpolation	Before interpolation	*P* value
N	8947	8946	
BMI, kg/m^2	23.74 [21.25, 27.08]	23.18 [20.98, 25.78]	<0.001
Males, *n* (%)	4516 (50.48)	4513 (50.48)	1.000
Rural, *n* (%)	6998 (78.22)	6995 (78.21)	1.000
Smoker, *n* (%)	3673 (41.05)	3673 (41.06)	1.000
Drinker, *n* (%)	3677 (41.10)	3675 (41.09)	1.000
Baseline solid heating fuel, *n* (%)	6051 (67.63)	4898 (65.28)	0.002
House area, m^2	100.00 [70.00,140.00]	100.00 [70.00,144.00]	0.057
Multi-story building	3453 (38.59)	3451 (38.58)	0.997

Note. BMI, body mass index.

Supplementary Table S8 . The missing values of baseline characteristics

Covariates	Missing, *n* (%)
BMI	1088 (12.161)
Sex	7 (0.078)
Residential location	3 (0.034)
Smoking status	1 (0.011)
Drinking status	3 (0.034)
Heating fuel types	1444 (16.139)
House area	150 (1.677)
Household building types	2 (0.022)

Note. BMI, body mass index.

Supplementary Table S9 . Baseline characteristics of the study population by baseline cooking fuel types

Characteristics	Clean cooking fuel	Solid cooking fuel	*P* value
N	4192	4755	
Age, years	56.80 (8.38)	58.01 (8.41)	<0.001
BMI, kg/m^2	24.09 (3.95)	23.22 (3.90)	<0.001
Males, *n* (%)	2057 (49.12)	2456 (51.68)	0.016
Rural, *n* (%)	2511 (59.90)	4484 (94.36)	<0.001
Married, *n* (%)	3829 (91.34)	4336 (91.19)	0.828
Smoker, *n* (%)	1604 (38.27)	2069 (43.51)	<0.001
Drinker, *n* (%)	1696 (40.47)	1979 (41.64)	0.271
Education, *n* (%)			<0.001
Low education	2132 (50.86)	3415 (71.82)	
Middle education	1870 (44.61)	1313 (27.61)	
High education	190 (4.53)	27 (0.57)	

Ambient $PM_{2.5}$, μg /m^3	50.08 (16.39)	50.15 (16.55)	0.834
Baseline solid heating fuel, *n* (%)	1325 (38.10)	3573 (88.77)	<0.001
House area, m^2	100.00 [70.00, 144.00]	100.00 [72.00, 147.25]	0.685
Multi-story building, *n* (%)	2300 (54.87)	1151 (24.22)	<0.001

Note. BMI, body mass index; FI, frailty index.

Supplementary Table S10 . Adjusted association between cooking fuel use and the frailty trajectories using multiple imputation approach

Variables	Events *n* (%)	Moderate-increasing *vs.* Low-stable [a]		Fast-increasing *vs.* Low-stable	
		OR (95% *CI*) [b]	*P* value	*OR* (95% CI)	*P* value
Baseline cooking fuel types					
Clean fuel	4192 (46.85)	1.00 (Reference)		1.00 (Reference)	
Solid fuel	4755 (53.15)	1.35 (1.21, 1.52)	<0.001	1.73 (1.39, 2.16)	<0.001
Baseline cooking solid fuel types					
Clean fuel	4192 (46.85)	1.00 (Reference)		1.00 (Reference)	
Biomass fuel	3776 (42.20)	1.32 (1.17, 1.48)	<0.001	1.70 (1.35, 2.14)	<0.001
Fossil fuel	979 (10.94)	1.48 (1.25, 1.75)	<0.001	1.86 (1.35, 2.57)	<0.001
Duration of solid fuel use					
0 years	3344 (37.38)	1.00 (Reference)		1.00 (Reference)	
1–6 years	3509 (39.22)	1.38 (1.21, 1.57)	<0.001	2.01 (1.54, 2.64)	<0.001

≥ 7 years	2094 (23.40)	1.89 (1.63, 2.19)	<0.001	3.27 (2.44, 4.40)	<0.001
P for trend [c]			<0.001		<0.001
Switching cooking fuel types					
Persistent clean fuel	3704 (41.40)	1.00 (Reference)		1.00 (Reference)	
Solid-to-clean fuel	2261 (25.27)	1.29 (1.12, 1.47)	<0.001	1.58 (1.19, 2.08)	0.001
Persistent solid fuel	2494 (27.88)	1.71 (1.49, 1.96)	<0.001	2.64 (2.02, 3.45)	<0.001
Clean-to-solid fuel	488 (5.45)	1.59 (1.28, 1.98)	<0.001	2.21 (1.48, 3.30)	<0.001
Persistent solid fuel	2494 (27.88)	1.00 (Reference)		1.00 (Reference)	
Clean-to-solid fuel	488 (5.45)	0.93 (0.75, 1.16)	0.520	0.84 (0.57, 1.23)	0.363
Persistent clean fuel	3704 (41.40)	0.58 (0.51, 0.67)	<0.001	0.38 (0.29, 0.50)	<0.001
Solid-to-clean fuel	2261 (25.27)	0.75 (0.66, 0.85)	<0.001	0.60 (0.48, 0.75)	0.001

Note. [a] "Low Stable" as the reference trajectory. [b] OR (95% CI) was estimated using multinomial logistic regression. Adjusted covariates include age, BMI, sex, residential location, marital status, smoking status, drinking status, education, ambient $PM_{2.5}$, and heating fuel types. [c] *P* for trend: trend test with the exposure treated as an ordered variable. *OR*, odds ratio; *CI*, confidence interval.

Supplementary Table S11 . Adjusted estimates the burden of frailty development attributed to solid cooking fuel use using multiple imputation approach

Variables	No. of case	Population attributable fraction, % (95 % *CI*) [b]
Moderate-increasing vs. Low-stable [a]	2603	10.73 (6.78, 14.68)
Fast-increasing vs. Low-stable	555	26.25 (16.74, 35.77)

Note. [a] "Low Stable" as the reference trajectory. [b] Adjusted covariates include age, BMI, sex, residential location, marital status, smoking status, drinking status, education, ambient $PM_{2.5}$, and heating fuel types. FI, frailty index; *CI*, confidence interval.

Supplementary Table S12 . Adjusted association between cooking fuel use and the frailty trajectories using sampling weighted

Variables	Events *n* (%)	Moderate-increasing *vs.* Low-stable [a]		Fast-increasing *vs.* Low-stable	
		OR (95% *CI*) [b]	*P* value	*OR* (95% *CI*)	*P* value
Baseline cooking fuel types					
Clean fuel	4192 (46.85)	1.00 (Reference)		1.00 (Reference)	
Solid fuel	4755 (53.15)	1.20 (1.02, 1.40)	0.024	1.51 (1.12, 2.04)	0.007
Baseline cooking solid fuel types					
Clean fuel	4192 (46.85)	1.00 (Reference)		1.00 (Reference)	
Biomass fuel	3776 (42.20)	1.14 (0.97, 1.34)	0.109	1.47 (1.07, 2.02)	0.019
Fossil fuel	979 (10.94)	1.35 (1.09, 1.68)	0.006	1.64 (1.11, 2.44)	0.013
Duration of solid fuel use					
0 years	3344 (37.38)	1.00 (Reference)		1.00 (Reference)	
1–6 years	3509 (39.22)	1.23 (1.03, 1.48)	0.026	1.87 (1.29, 2.71)	<0.001

≥ 7 years	2094 (23.40)	1.69 (1.38, 2.07)	<0.001	2.74 (1.87, 4.03)	<0.001
P for trend [c]			<0.001		<0.001
Switching cooking fuel types					
Persistent clean fuel	3704 (41.40)	1.00 (Reference)		1.00 (Reference)	
Solid-to-clean fuel	2261 (25.27)	1.11 (0.92, 1.34)	0.267	1.44 (0.98, 2.12)	0.062
Persistent solid fuel	2494 (27.88)	1.52 (1.26, 1.84)	0.013	2.22 (1.54, 3.18)	<0.001
Clean-to-solid fuel	488 (5.45)	1.48 (1.13, 1.94)	0.005	2.05 (1.25, 3.37)	0.005
Persistent solid fuel	2494 (27.88)	1.00 (Reference)		1.00 (Reference)	
Clean-to-solid fuel	488 (5.45)	0.97 (0.75, 1.27)	0.828	0.92 (0.58, 1.47)	0.742
Persistent clean fuel	3704 (41.40)	0.66 (0.54, 0.79)	<0.001	0.45 (0.31, 0.65)	<0.001
Solid-to-clean fuel	2261 (25.27)	0.73 (0.62, 0.86)	<0.001	0.65 (0.48, 0.87)	0.004

Note. [a] "Low Stable" as the reference trajectory. [b] OR (95% CI) was estimated using multinomial logistic regression. Adjusted covariates include age, BMI, sex, residential location, marital status, smoking status, drinking status, education, ambient $PM_{2.5}$, and heating fuel types. [c] *P* for trend: trend test with the exposure treated as an ordered variable. *OR*, odds ratio; *CI*, confidence interval.

Supplementary Table S13 . Adjusted estimates of the burden of frailty development attributed to solid cooking fuel use were calculated using sampling weighted

Variables	No. of case	Population attributable fraction, % (95 % *CI*) [b]
Moderate-increasing vs. Low-stable [a]	1945	7.18 (-3.35, 17.70)
Fast-increasing vs. Low-stable	423	21.39 (-3.80, 46.59)

Note. [a] "Low Stable" as the reference trajectory. [b] Adjusted covariates include age, BMI, sex, residential location, marital status, smoking status, drinking status, education, ambient $PM_{2.5}$, and heating fuel types. FI, frailty index; *CI*, confidence interval.

Supplementary Table S14 . Association between cooking fuel use and the frailty trajectories with adjustments for early-life exposure to solid cooking fuel

Variables	Events *n* (%)	Moderate-increasing *vs.* Low-stable [a]		Fast-increasing *vs.* Low-stable	
		OR (95% *CI*) [b]	*P* value	*OR* (95% *CI*)	*P* value
Baseline cooking fuel types					
Clean fuel	4192 (46.85)	1.00 (Reference)		1.00 (Reference)	
Solid fuel	4755 (53.15)	1.27 (1.09, 1.47)	0.002	1.46 (1.10, 1.94)	0.010
Baseline cooking solid fuel types					
Clean fuel	4192 (46.85)	1.00 (Reference)		1.00 (Reference)	
Biomass fuel	3776 (42.20)	1.25 (1.06, 1.46)	0.007	1.46 (1.08, 1.98)	0.015
Fossil fuel	979 (10.94)	1.31 (1.07, 1.60)	0.009	1.46 (0.99, 2.14)	0.057
Duration of solid fuel use					
0 years	3344 (37.38)	1.00 (Reference)		1.00 (Reference)	
1–6 years	3509 (39.22)	1.20 (1.01, 1.41)	0.035	1.84 (1.30, 2.59)	<0.001
≥ 7 years	2094 (23.40)	1.74 (1.43, 2.11)	<0.001	2.70 (1.83, 3.99)	<0.001

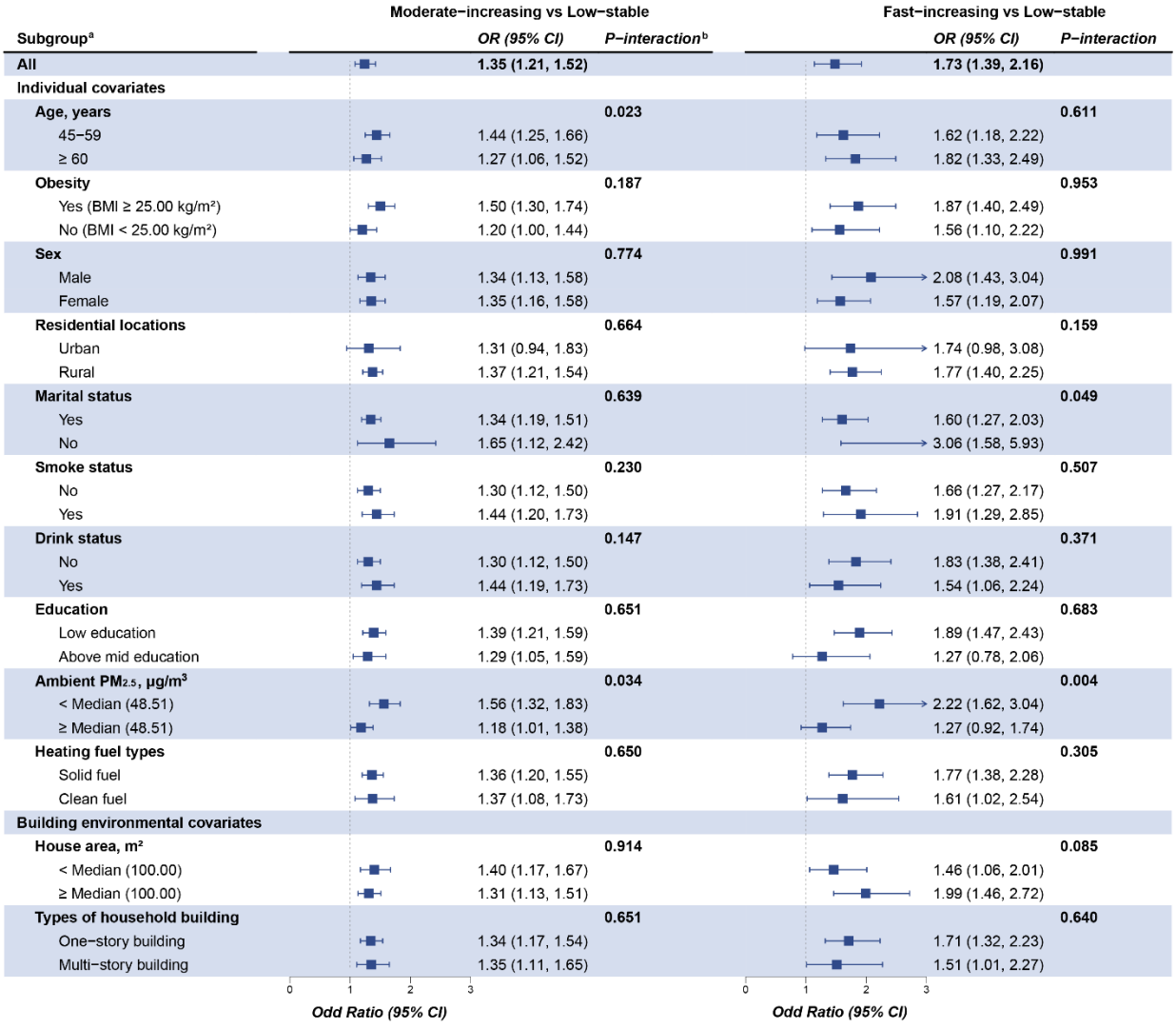
P for trend [c]			<0.001		<0.001
Switching cooking fuel types					
Persistent clean fuel	3704 (41.40)	1.00 (Reference)		1.00 (Reference)	
Solid-to-clean fuel	2261 (25.27)	1.15 (0.96, 1.37)	0.118	1.40 (0.98, 1.99)	0.064
Persistent solid fuel	2494 (27.88)	1.58 (1.32, 1.90)	<0.001	2.13 (1.50, 3.03)	<0.001
Clean-to-solid fuel	488 (5.45)	1.29 (0.98, 1.70)	0.068	1.93 (1.18, 3.16)	0.009
Persistent solid fuel	2494 (27.88)	1.00 (Reference)		1.00 (Reference)	
Clean-to-solid fuel	488 (5.45)	0.73 (0.62, 0.86)	<0.001	0.66 (0.49, 0.88)	0.006
Persistent clean fuel	3704 (41.40)	0.63 (0.53, 0.76)	<0.001	0.47 (0.33, 0.67)	<0.001
Solid-to-clean fuel	2261 (25.27)	0.82 (0.62, 1.07)	0.147	0.91 (0.56, 1.46)	0.681

Note. [a] "Low Stable" as the reference trajectory. [b] *OR* (95% *CI*) was estimated using multinomial logistic regression. Adjusted covariates include age, BMI, sex, residential location, marital status, smoking status, drinking status, education, ambient $PM_{2.5}$, heating fuel types, and early-life solid cooking fuel exposure. [c] *P* for trend: trend test with the exposure treated as an ordered variable. *OR*, odds ratio; *CI*, confidence interval.

Supplementary Table S15 . Estimated the burden of frailty development attributed to solid cooking fuel use with adjustments for early-life exposure to solid cooking fuel

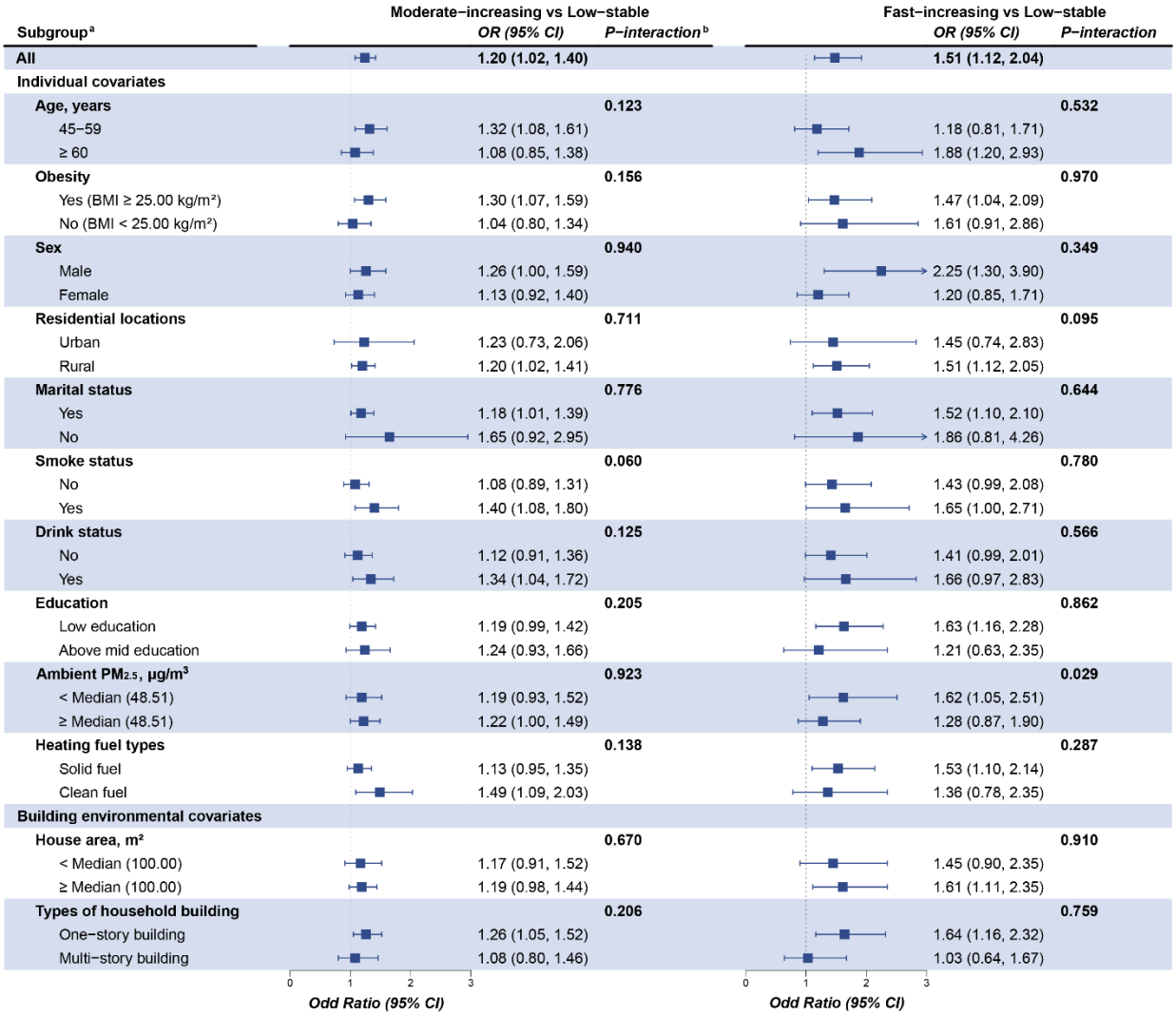
Variables	No. of case	Population attributable fraction, % (95 % *CI*) [b]
Moderate-increasing *vs.* Low-stable [a]	1572	8.55 (3.38, 13.71)
Fast-increasing *vs.* Low-stable	327	17.46 (4.25, 30.67)

Note. [a] "Low Stable" as the reference trajectory. [b] Adjusted covariates include age, BMI, sex, residential location, marital status, smoking status, drinking status, education, ambient $PM_{2.5}$, heating fuel types ,and early-life solid cooking fuel exposure. FI, frailty index; *CI*, confidence interval.



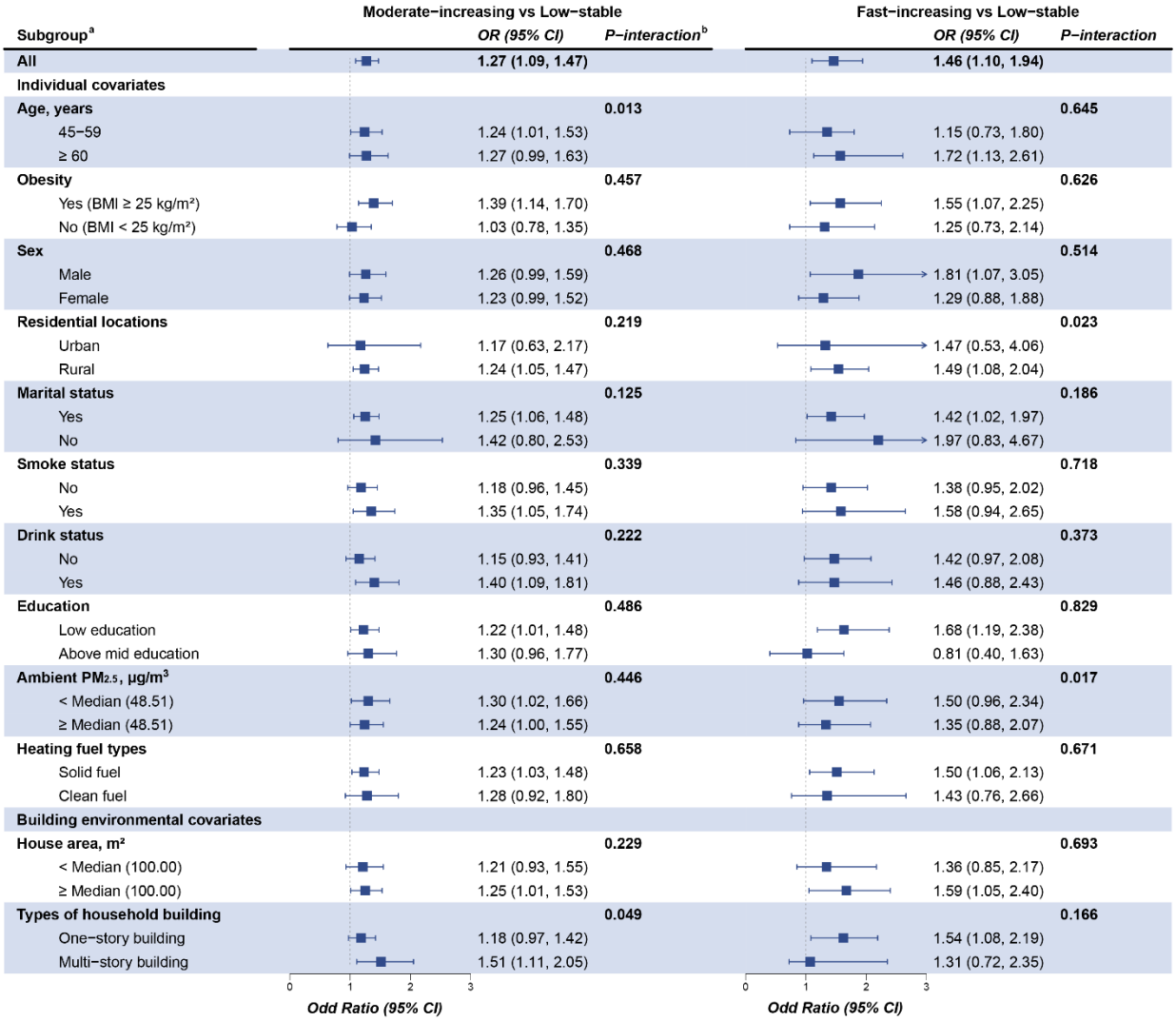
Supplementary Figure S1 . Adjusted association of baseline cooking fuel use with the frailty trajectories stratified by baseline characteristics using multiple imputation approach.

Note. [a] Each stratification was adjusted for all factors (age, BMI, sex, residential location, marital status, smoking status, drinking status, education, ambient $PM_{2.5}$, and heating fuel types) except the stratification factor itself. [b] *P* for interaction was assessed by combining the variables' cross-product term (baseline cooking fuel types × baseline characteristics) in the same model. *OR*, odds ratio; *CI*, confidence interval.



Supplementary Figure S2 . Adjusted association of baseline cooking fuel use with the frailty trajectories stratified by baseline characteristics using sampling weighted.

Note. [a] Each stratification was adjusted for all factors (age, BMI, sex, residential location, marital status, smoking status, drinking status, education, ambient $PM_{2.5}$, and heating fuel types) except the stratification factor itself. [b] *P* for interaction was assessed by combining the variables' cross-product term (baseline cooking fuel types × baseline characteristics) in the same model. *OR*, odds ratio; *CI*, confidence interval.



Supplementary Figure S3 . Association of baseline cooking fuel use with the frailty trajectories stratified by baseline characteristics with adjustments for early-life exposure to solid cooking fuel.

Note. [a] Each stratification was adjusted for all factors (age, BMI, sex, residential location, marital status, smoking status, drinking status, education, ambient $PM_{2.5}$, heating fuel types, and early-life solid cooking fuel exposure) except the stratification factor itself. [b] *P* for interaction was assessed by combining the variables' cross-product term (baseline cooking fuel types × baseline characteristics) in the same model. *OR*, odds ratio; *CI*, confidence interval.