Cognitive Impairment with Modified Self-Reported Physical Frailty among Middle-Aged and Older Adults in China: A Harmonized Repeated Cross-Sectional Analysis of CHARLS 2013, 2015 and 2018

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Abstract: Background: This study estimated the prevalence and correlates of cognitive impairment with modified self-reported physical frailty among middle-aged and older Chinese adults. Methods: Harmonized repeated cross-sectional data from CHARLS 2013, 2015, and 2018 were analyzed; the 2020 wave was excluded because comparable walking and lifting items were unavailable. Cognition was scored from orientation, serial subtraction, figure drawing, and immediate and delayed recall, and education-specific impairment cutoffs were derived from weighted 2013 20th percentiles. Modified physical frailty was defined as at least two of exhaustion, slowness, and weakness. Weighted prevalence, age-sex standardization, missing-data sensitivity analyses, and weighted GEE logistic models were used. Results: The analytic sample included 24,437 observations from 13,588 individuals. Weighted prevalence was 8.29% in 2013, 10.50% in 2015, and 16.93% in 2018. Older age, female sex, and higher depressive-symptom burden were associated with higher odds of cognitive frailty. Conclusions: Cognitive impairment with modified self-reported physical frailty affected about one in ten middle-aged and older Chinese adults, emphasizing the need for comparable measurement and transparent missing-data handling.

Keywords: Cognitive frailty; Physical frailty; Cognitive impairment; CHARLS

I. Introduction

Population ageing is reshaping health systems worldwide and increasing the burden of dementia, disability, multi-morbidity, and frailty. China is experiencing this transition at exceptional speed, creating a need for reliable population-level evidence on early geriatric risk states that precede disability and dementia.

Cognitive frailty has been proposed to capture the coexistence of physical frailty and cognitive impairment in people without dementia. The construct is clinically attractive because it links two age-related vulnerability domains that share biological pathways, predict adverse outcomes, and may respond to multi-domain interventions.

Published estimates of cognitive frailty vary widely because studies differ in age range, cognitive instruments, frailty definitions, dementia exclusion, and survey-design handling. In repeated population surveys, additional uncertainty arises when item names, file structures, and questionnaire modules differ across waves.

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The China Health and Retirement Longitudinal Study (CHARLS) provides nationally relevant data on adults aged 45 years and older and their spouses. However, harmonized analysis of cognitive frailty requires careful alignment of cognition, physical-function, depression, weight, and demographic variables across waves. This study aimed to estimate the prevalence and adjusted correlates of cognitive impairment with modified self-reported physical frailty in CHARLS 2013, 2015, and 2018, while explicitly evaluating the comparability of the 2020 wave.

II. Methods

Study design and data source. We conducted a repeated cross-sectional analysis of CHARLS 2013, 2015, and 2018. Health-status, cognition, demographic, and weight files were harmonized within each wave using participant, household, and community identifiers. Observations and unique individuals were reported separately because some participants contributed records to more than one wave.

Wave comparability. The 2020 wave was inspected for comparability. It contained cognitive and CESD items but did not contain variables with meanings directly comparable to difficulty walking 1 km, difficulty walking 100 m, and difficulty lifting or carrying 5 kg. Therefore, 2020 was excluded from the primary cognitive-frailty endpoint rather than redefining physical frailty only for that wave. The cross-wave comparability assessment is shown in Table 1.

Table 1. Cross-wave measurement comparability assessment.

Wave(s)	Measurement Comparability	Primary Analysis Decision
2013–2018	Orientation, serial subtraction, figure drawing, immediate recall, delayed recall; walking/lifting items available	Included in primary cognitive-frailty analysis
2020	Cognitive and CESD items available, but walking 1 km / walking 100 m / lifting 5 kg variables were not available with comparable item meanings	Excluded from primary cognitive-frailty analysis

Study population. Eligible observations were from respondents aged 45 years or older with a positive individual weight, a non-missing community identifier, and non-missing education group. Primary cognitive-frailty analyses additionally required complete cognitive-score components, complete modified physical-frailty components, and no self-reported or doctor-diagnosed memory-related disease where available.

Cognitive function and cognitive impairment. Cognitive function was scored from five comparable domains: orientation (0–5), serial-7 subtraction (0–5), figure drawing (0–1), immediate word recall (0–10), and delayed word recall (0–10), yielding a total score from 0 to 31. Cognitive impairment was defined using education-specific weighted 2013 20th-percentile cutoffs from the 2013 reference distribution: Primary or below: ≤6, Middle school: ≤13, High school or above: ≤15. These cutoffs were then applied consistently to 2013, 2015, and 2018. When at least one cognitive item was observed in the cognitive module, non-correct or unassessed components were scored as 0; records with no usable cognitive information were excluded.

Modified self-reported physical frailty. Because the complete Fried phenotype was not consistently available, a three-component modified phenotype was constructed from comparable self-reported items. Exhaustion was defined from the CESD effort and could-not-get-going items. Slowness was defined as reported difficulty walking 1 km or 100 m. Weakness was defined as reported difficulty lifting or carrying more than 5 kg. Modified physical frailty was defined as at least two of the three components.

This outcome should be interpreted as a modified self-reported frailty phenotype rather than the complete Fried phenotype.

Cognitive frailty phenotype. The primary endpoint was cognitive impairment coexisting with modified self-reported physical frailty among observations without memory-related disease. We use the term cognitive frailty phenotype as shorthand for this operational definition.

Covariates. Covariates included age, sex, education group, marital status, depressive-symptom score, chronic disease count in sensitivity analysis, survey wave, individual weight, community identifier, and individual identifier. To reduce overlap between the depression covariate and the exhaustion component of frailty, the primary regression used CESD-8 after removing the two exhaustion items. A CESD-10 model was retained as a sensitivity analysis.

Statistical analysis. Weighted prevalence estimates and 95% confidence intervals were estimated using individual weights and community-cluster robust standard errors. Age-sex-standardized prevalence used the pooled primary analytic sample distribution across age group and sex as the standard population. Adjusted associations were estimated with weighted generalized estimating equation logistic models clustered by participant identifier to account for repeated observations. Missing-data sensitivity analyses included comparison of included and excluded eligible observations and inverse-probability-of-complete-case weighting; the corresponding results are shown in Tables 3 and 9. Cognitive-threshold sensitivity analyses used 15th, 20th, and 25th percentile cutoffs. Reporting was aligned with STROBE guidance.

III. Results

Sample derivation and comparability. Source health-status records included 18455 observations in 2013, 20967 in 2015, 19752 in 2018, and 19367 in 2020. The primary analytic sample included 24437 observations from 13588 unique individuals across 2013–2018. The 2020 wave was not used for cognitive-frailty estimation because comparable walking and lifting items were unavailable. The wave-specific sample construction is summarized in Tables 2–3 and Figure 1.

Table 2. Wave-specific construction of the primary analytic sample.

Wave	Source records	Excluded Age <45/ Missing	Excluded Missing Weight/Cluster	Excluded Missing Education	Excluded Incomplete Cognition	Excluded Incomplete Modified Frailty	Excluded Memory-Related Disease	Final Observations	Unique Individuals
2013	18455	360	343	9	1784	7702	167	8090	8090
2015	20967	1346	271	2349	1060	7832	114	7995	7995
2018	19752	232	1723	0	1366	7828	251	8352	8352

Note: Exclusions are sequential within each wave. The 2020 wave was inspected but excluded from primary cognitive-frailty estimation because comparable modified physical-frailty items were unavailable.

Table 3. Comparison of eligible observations included and excluded from the primary analysis.

Group	Records	Unique Individuals	Age Mean	Female %	Primary or Below %	Married/ Partnered %	CESD-8 No Exhaustion Mean
Included in primary analysis	24437	13588	63.64	59.29	70.51	82.13	8.35
Eligible but excluded for incomplete outcome data or memory-related disease	28104	16032	59.93	44.97	55.47	86.70	5.72

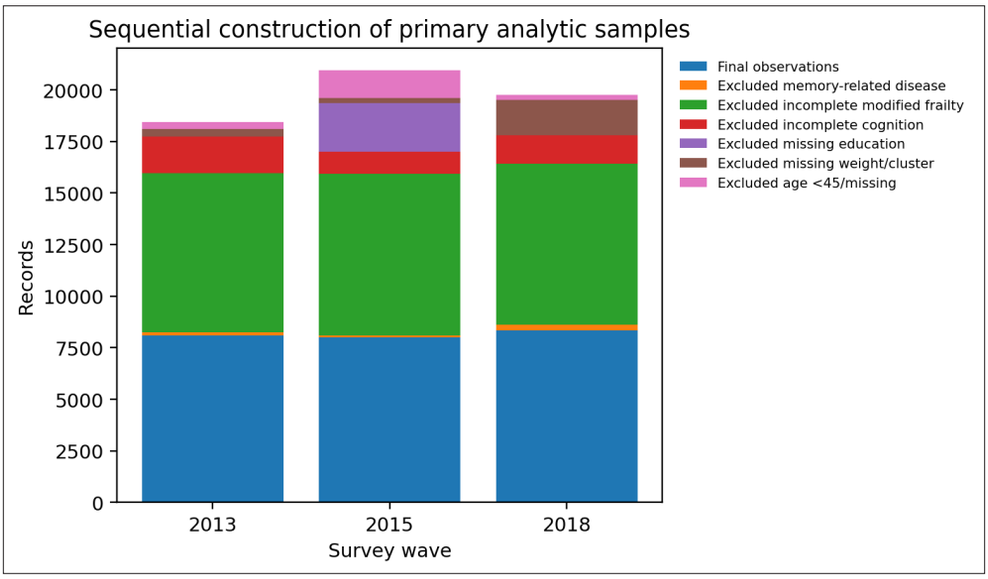

Figure 1. Sequential construction of primary analytic samples by CHARLS wave.

Analytic sample characteristics. Weighted mean age increased across waves, and women comprised slightly more than half of the weighted analytic samples. Primary education or below remained the largest education group in each wave. Weighted mean cognitive score and modified frailty score are shown in Table 4.

Table 4. Weighted characteristics of primary analytic samples.

Characteristic	2013	2015	2018
Observations	8090.00	7995.00	8352.00
Unique individuals	8090.00	7995.00	8352.00
Age, mean	62.10	63.44	65.21
Education, years mean	4.89	5.02	5.03
Cognitive score, mean	12.63	12.20	11.45
Modified frailty score, mean	0.85	0.92	1.06
CESD-8 without exhaustion, mean	7.77	7.97	9.15
Female, %	59.04	59.49	59.35
Primary education or below, %	70.97	70.18	70.38
Married/partnered, %	83.24	82.59	80.73

Weighted prevalence. Weighted cognitive-frailty prevalence was 8.29 (7.36–9.22) in 2013, 10.50 (9.41–11.60) in 2015, and 16.93 (15.69–18.17) in 2018. Cognitive impairment and modified physical frailty were both more common than their combined phenotype. These estimates are presented in Table 5 and Figure 2.

Table 5. Weighted prevalence of cognitive impairment, modified self-reported physical frailty, and cognitive frailty. Values are weighted percent (95% CI).

Outcome	2013	2015	2018
Cognitive frailty phenotype	8.29 (7.36–9.22)	10.50 (9.41–11.60)	16.93 (15.69–18.17)
Cognitive impairment	25.21 (23.55–26.86)	28.12 (26.19–30.05)	38.75 (36.59–40.90)
Modified self-reported physical frailty	23.14 (21.76–24.52)	25.76 (24.25–27.28)	31.08 (29.55–32.62)

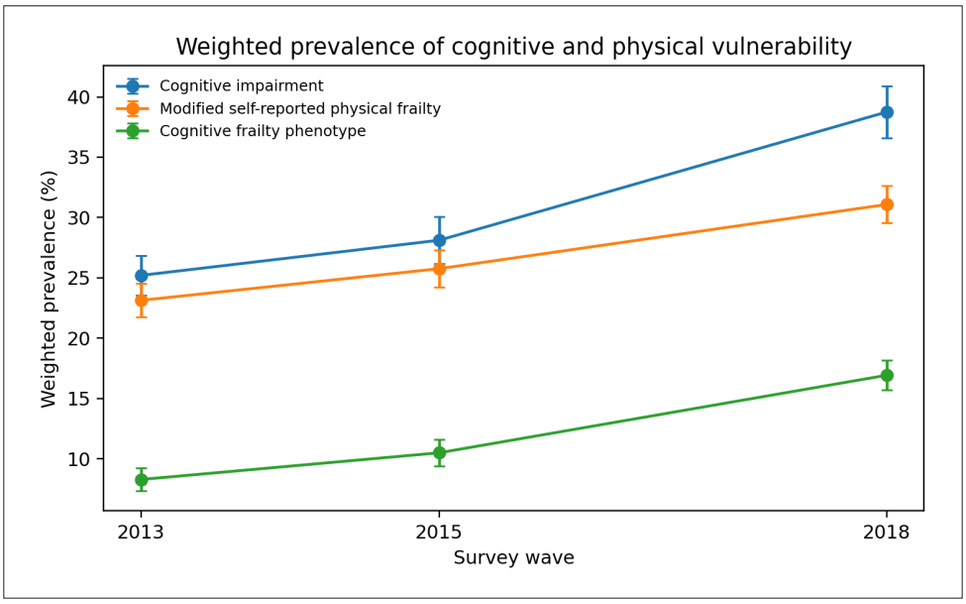

Figure 2. Weighted prevalence of cognitive impairment, modified self-reported physical frailty, and cognitive frailty.

Age-sex-standardized prevalence was 8.89%, 10.58%, and 15.78% in 2013, 2015, and 2018, respectively.Table 6 and Figure 3 compare crude weighted and age-sex-standardized cognitive-frailty prevalence.

Table 6. Age-sex-standardized cognitive-frailty prevalence.

Wave	Age-Sex-Standardized Prevalence (%)
2013	8.89
2015	10.58
2018	15.78

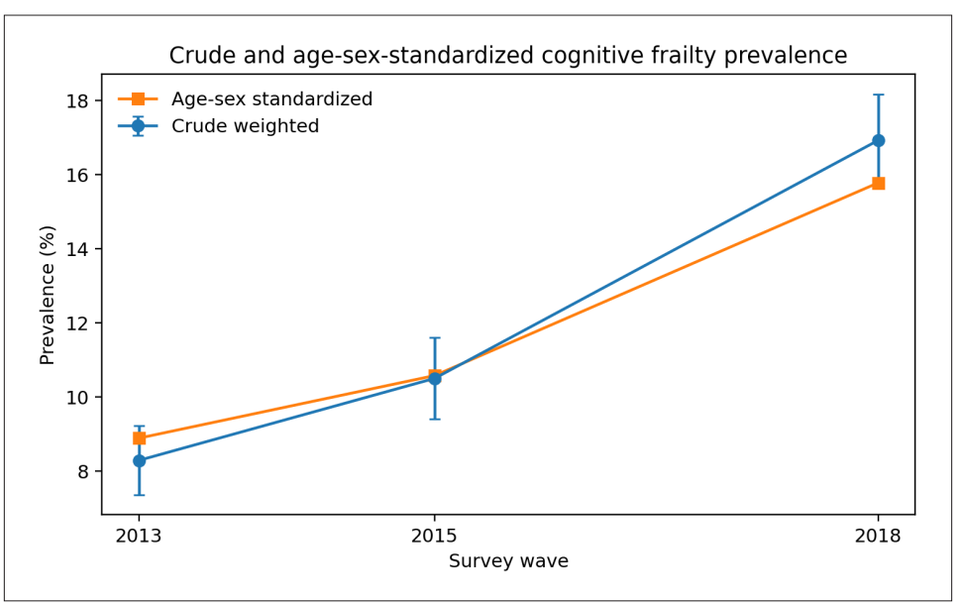

Figure 3. Crude weighted and age-sex-standardized cognitive-frailty prevalence.

Subgroup patterns. Cognitive frailty was consistently more common among women and increased strongly with age. In pooled analyses, prevalence was lowest among adults aged 45–59 years and highest among those aged 80 years or older, with higher prevalence among women than men within most age groups (Figure 4).

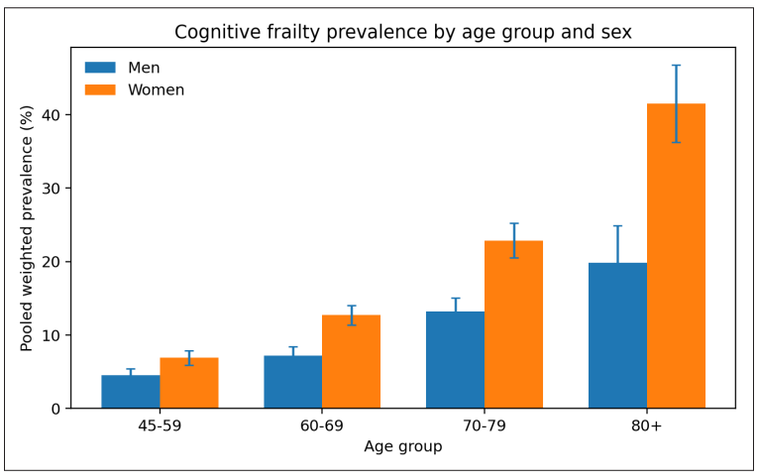

Figure 4. Pooled cognitive-frailty prevalence by age group and sex.

Adjusted correlates. The primary weighted GEE model included 23176 observations, 2803 cognitive-frailty events, and 13260 individual clusters. Older age was associated with higher odds of cognitive frailty (OR 1.99 (1.87–2.12)). Women had higher odds than men (OR 1.61 (1.43–1.82)). Each one-point increase in CESD-8 score excluding exhaustion items was associated with higher odds (OR 1.13 (1.12–1.14)). Education and survey-wave estimates are summarized in Table 7 and Figure 5.

Table 7. Primary weighted GEE logistic regression for cognitive frailty.

Term	Adjusted OR (95% CI)	P Value
Age, per 10-year increase	1.99 (1.87–2.12)	<0.001
Women vs men	1.61 (1.43–1.82)	<0.001
CESD-8 score excluding exhaustion items, per point	1.13 (1.12–1.14)	<0.001
Survey wave 2015 vs 2013	1.16 (1.02–1.31)	0.021
Survey wave 2018 vs 2013	1.67 (1.48–1.89)	<0.001
Middle school vs primary or below	0.84 (0.70–1.00)	0.052
High school or above vs primary or below	0.73 (0.57–0.93)	0.012

Note: Primary model n=23176; events=2803; individual clusters=13260. CESD-8 excludes the effort and could-not-get-going items used to define exhaustion.

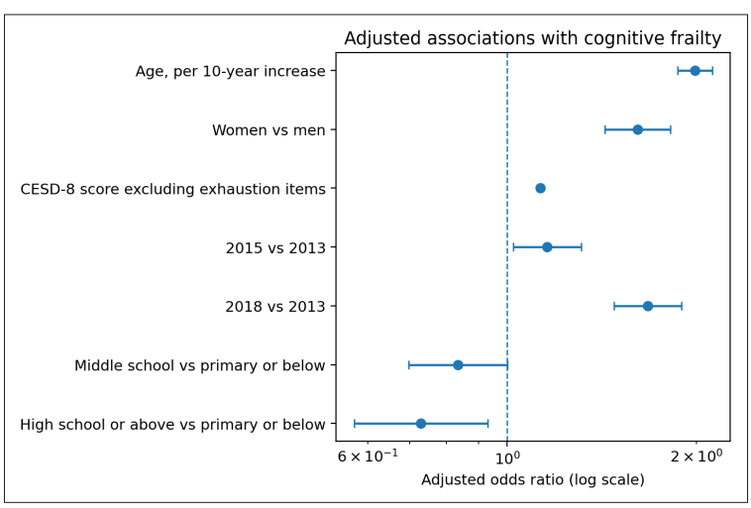

Figure 5. Adjusted odds ratios for cognitive frailty in the primary weighted GEE logistic regression model.

Sensitivity analyses. Cognitive-threshold sensitivity analyses showed that absolute prevalence varied as expected when 15th or 25th percentile cognitive cutoffs were used, but the age and sex patterns were similar. The cognitive-threshold sensitivity results are shown in Table 8. Inverse-probability weighting for complete-case inclusion produced estimates close to the complete-case analysis, as shown in Table 9. A CESD-10 sensitivity model yielded similar direction of association but was considered secondary because CESD-10 includes the exhaustion items used in the frailty definition.

Table 8. Cognitive-threshold sensitivity analyses for cognitive-frailty prevalence. Values are weighted percent (95% CI).

Wave	15th Percentile	20th Percentile	25th Percentile
2013	6.78 (5.97–7.59)	8.29 (7.36–9.22)	9.54 (8.56–10.52)
2015	8.86 (7.90–9.82)	10.50 (9.41–11.60)	11.84 (10.68–13.00)
2018	15.34 (14.15–16.54)	16.93 (15.69–18.17)	18.47 (17.17–19.78)

Table 9. Inverse-probability-weighted complete-case sensitivity analysis. Values are weighted percent (95% CI).

Wave	IPW-Weighted Cognitive Frailty Prevalence, % (95% CI)
2013	7.17 (6.33–8.00)
2015	9.19 (8.24–10.15)
2018	14.74 (13.58–15.90)

IV. Discussion

In this harmonized repeated cross-sectional analysis of CHARLS 2013, 2015, and 2018, cognitive impairment with modified self-reported physical frailty affected approximately one in ten middle-aged and older Chinese adults. The prevalence was clinically meaningful and was higher in 2018 than in 2013 and 2015 after age-sex standardization.

This study highlights the importance of cross-wave measurement comparability. Cognitive testing could be harmonized across the primary waves, including the separately stored 2018 cognition file. In contrast, the 2020 health-status module did not contain physical-function items with meanings comparable to walking 1 km, walking 100 m, and lifting/carrying 5 kg. Excluding 2020 from the primary endpoint avoided treating questionnaire-structure differences as epidemiological change.

The pronounced age gradient is consistent with evidence that physical frailty and cognitive impairment become more common in later life. Women had higher odds of cognitive frailty than men, aligning with prior evidence that women often have greater frailty burden despite longer survival. Depressive symptoms remained associated with cognitive frailty even after removing exhaustion items from the CESD score, suggesting that the association was not entirely explained by measurement overlap.

The operational definition requires careful interpretation. The frailty phenotype was based on self-reported exhaustion, walking difficulty, and lifting difficulty rather than measured gait speed, grip strength, weight loss, and physical activity. Therefore, the estimates should not be interpreted

as prevalence of the complete Fried physical frailty phenotype. The more precise interpretation is cognitive impairment coexisting with modified self-reported physical frailty.

The findings support integrated assessment of cognition, mobility, strength-related function, and depressive symptoms in geriatric and public-health settings. Frailty, cognitive decline, vascular risk, inflammation, and depression may share interrelated mechanisms that are relevant to prevention and risk stratification. Multi-domain interventions involving physical activity, nutrition, cognitive training, vascular risk management, and broader healthy-ageing strategies have shown promise in related populations. Whether such strategies reduce cognitive-frailty incidence or progression in China should be tested in longitudinal and intervention studies.

This study has limitations. First, formal dementia adjudication was not available in the public-use files, and memory-related disease was an imperfect exclusion criterion. Second, the physical frailty definition was modified and self-reported. Third, complete-case exclusions were substantial; we therefore reported selection comparisons and inverse-probability sensitivity analyses, but residual selection bias remains possible. Fourth, survey design was approximated using individual weights and cluster-robust methods because a consistently harmonized stratification variable was not available across the working files. Fifth, repeated cross-sectional analyses cannot determine causality or individual-level progression.

V. Conclusion

Cognitive impairment with modified self-reported physical frailty affected approximately one in ten middle-aged and older Chinese adults in harmonized CHARLS 2013, 2015 and 2018 samples. Higher prevalence was observed among older adults and women, and depressive symptoms remained associated after reducing overlap with the frailty definition. Future work should prioritize prospective trajectories, stronger dementia exclusion, objective frailty phenotyping, and intervention-oriented risk stratification.

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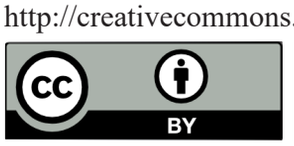

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