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Supplementary appendix

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Negative wealth shocks in later life and subsequent cognitive function among older adults: a population-based longitudinal harmonized study in China, England, Mexico, and the United States, 2012-2018

Tsai-Chin Cho, Xuexin Yu, Alden L. Gross, Yuan S. Zhang, Jinkook Lee, Kenneth M. Langa, Lindsay C. Kobayashi

Supplementary Material

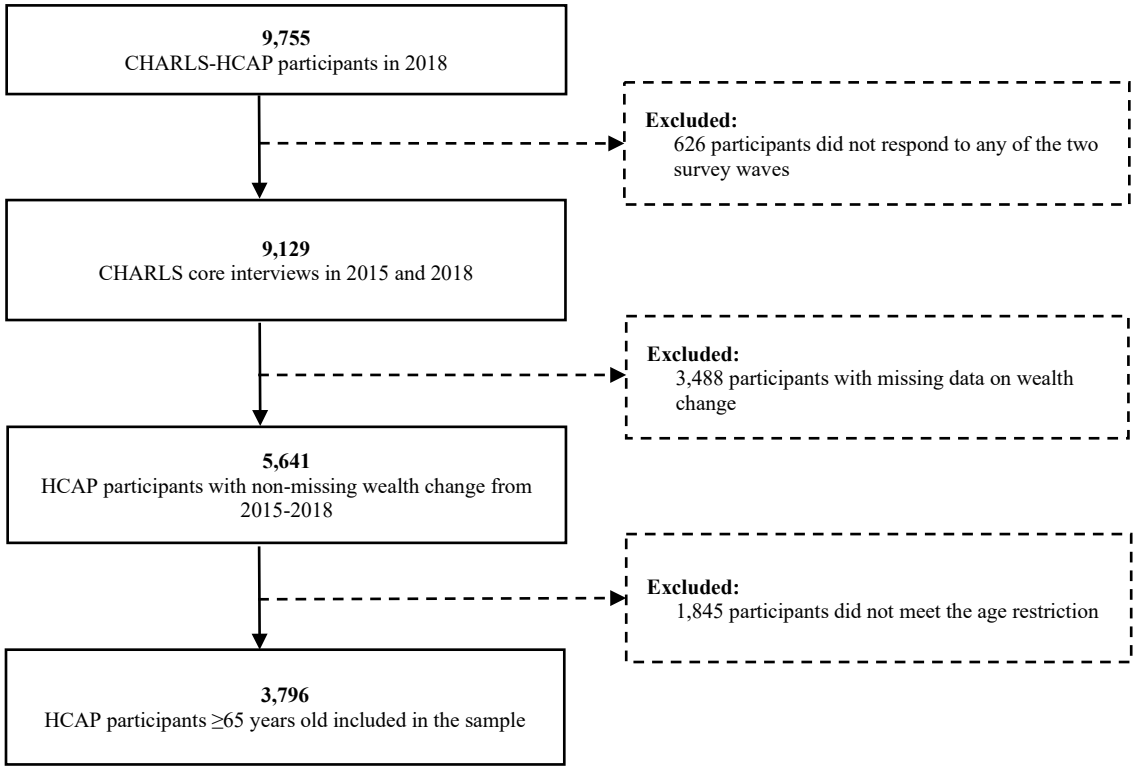
Supplemental Table 1. Summary of data sources for the outcome, exposure, and covariates

Country	Data sources		
	Outcome: generalized cognitive function (time point of sample recruited)	**Exposure: negative wealth shocks (time points of data collection)**	**Covariates (time point)**
China	CHARLS-HCAP[1] (2018)	CHARLS[2] (2015 & 2018)	CHARLS (2015)
England	ELSA-HCAP[3] (2016)	ELSA[4] (2012 & 2016)	ELSA (2012)
Mexico	Mex-Cog[5] (2016)	MHAS[6] (2012 & 2015/16)	MHAS (2012)
United States	HRS-HCAP[7] (2016)	HRS[8] (2012 & 2016)	HRS (2012)

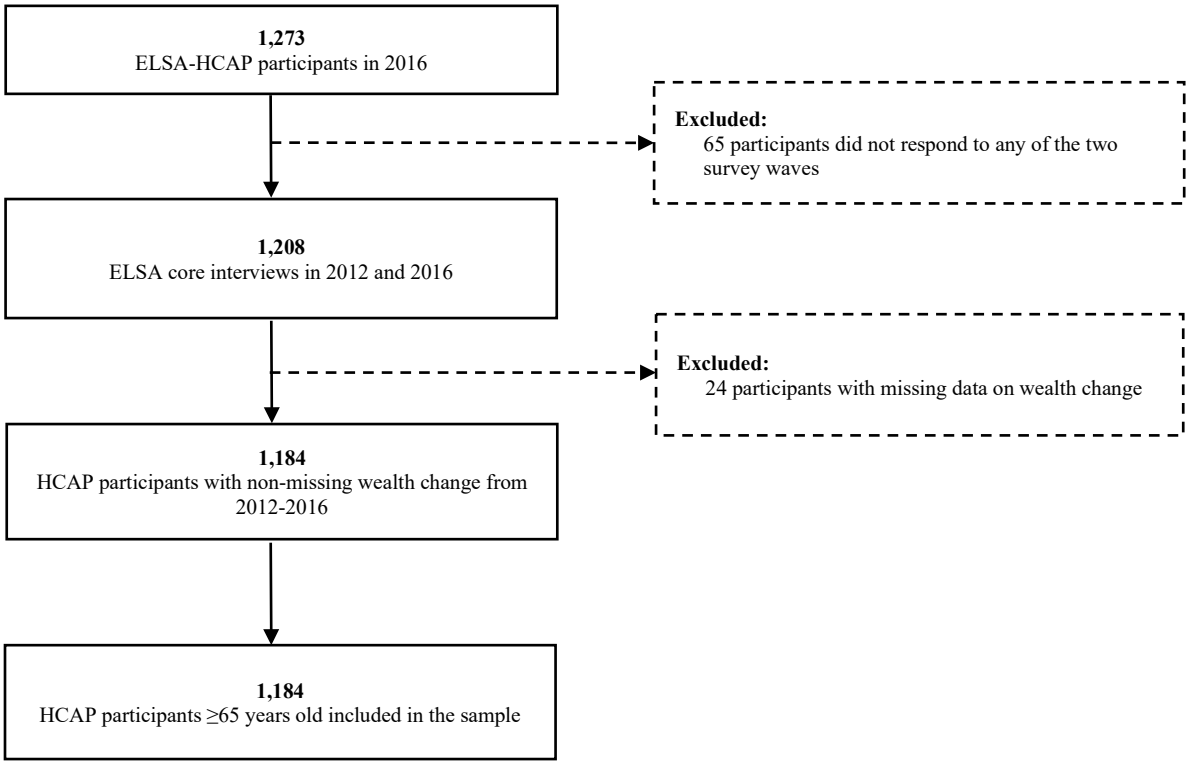
Note. The references for the datasets are as follows.

1. Meng Q, Wang H, Strauss J, et al. Validation of neuropsychological tests for the China Health and Retirement Longitudinal Study Harmonized Cognitive Assessment Protocol. *Int Psychogeriatr*. 2019;31(12):1709-1719. doi:10.1017/S1041610219000693
2. Zhao Y, Hu Y, Smith JP, Strauss J, Yang G. Cohort Profile: The China Health and Retirement Longitudinal Study (CHARLS). *International Journal of Epidemiology*. 2014;43(1):61-68. doi:10.1093/ije/dys203
3. Cadar D, Abell J, Matthews FE, et al. Cohort Profile Update: The Harmonised Cognitive Assessment Protocol Sub-study of the English Longitudinal Study of Ageing (ELSA-HCAP). *Int J Epidemiol*. 2020;50(3):725-726i. doi:10.1093/ije/dyaa227
4. Steptoe A, Breeze E, Banks J, Nazroo J. Cohort profile: the English longitudinal study of ageing. *Int J Epidemiol*. 2013;42(6):1640-1648. doi:10.1093/ije/dys168
5. Mejia-Arango S, Nevarez R, Michaels-Obregon A, et al. The Mexican Cognitive Aging Ancillary Study (Mex-Cog): Study Design and Methods. *Arch Gerontol Geriatr*. 2020;91:104210. doi:10.1016/j.archger.2020.104210
6. Wong R, Michaels-Obregon A, Palloni A. Cohort Profile: The Mexican Health and Aging Study (MHAS). *International Journal of Epidemiology*. 2017;46(2):e2. doi:10.1093/ije/dyu263
7. Langa KM, Ryan LH, McCammon RJ, et al. The Health and Retirement Study Harmonized Cognitive Assessment Protocol Project: Study Design and Methods. *Neuroepidemiology*. 2020;54(1):64-74. doi:10.1159/000503004
8. Sonnega A, Faul JD, Ofstedal MB, Langa KM, Phillips JW, Weir DR. Cohort Profile: the Health and Retirement Study (HRS). *International Journal of Epidemiology*. 2014;43(2):576-585. doi:10.1093/ije/dyu067

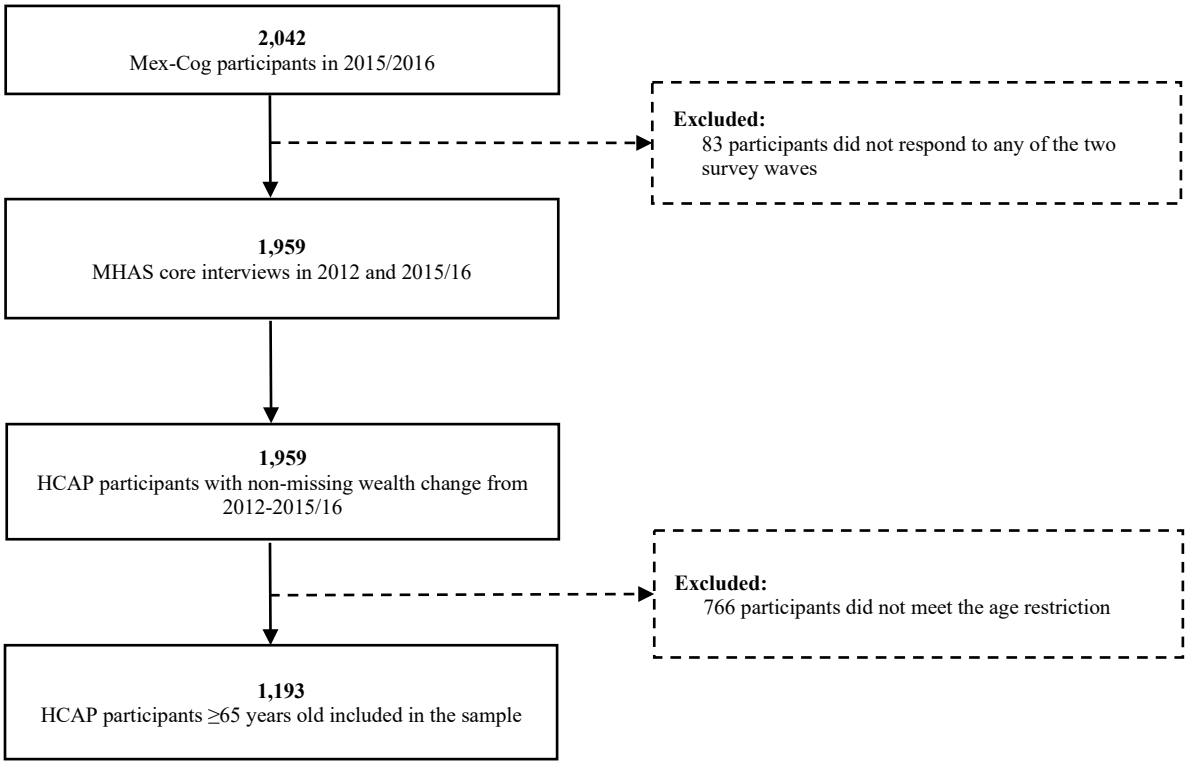
Supplemental Figure 1a. Flow diagram for the CHARLS-HCAP sample in China



Supplemental Figure 1b. Flow diagram for the ELSA-HCAP sample in England



Supplemental Figure 1c. Flow diagram for the Mex-Cog sample for Mexico



Supplemental Figure 1d. Flow diagram for the HRS-HCAP sample for the United States

Supplemental Table 2. Summary of wealth components incorporated in household wealth, by country

	HRS (US)	ELSA (England)	MHAS (Mexico)	CHARLS (China)
Primary and secondary home residence	x	x	x	x[a]
Farm or business assets	x	x	x	x[b]
Vehicles	x		x	x[c]
Non-housing financial wealth*	x	x	x	x
Debts**	x	x	x	x

* Non-housing financial wealth includes stocks, mutual funds, investment trusts, checking accounts, saving accounts, money market accounts, bonds, bond funds, CDs, government savings bonds, and treasury bills.

** Debts include mortgages and house loans on primary and secondary residences, mortgages and loans on vehicles, and other debts.

[a] Primary residence with % of ownership and value of other residential properties are considered.

[b] All fixed capital assets worth 500 yuan and more, as well as livestock are considered.

[c] In addition to vehicles, other durable assets worth 500 yuan and more are also considered.

Supplemental Table 3. Characteristics of CHARLS-HCAP participants aged ≥65, comparing older adults included in the study sample vs excluded from the sample due to missing wealth information in 2015

	Study sample N=3,796		Excluded sample N=2,366		P-value from testing difference in mean/median/%
Baseline characteristics					
Age (years); mean (SD)	68·5	(5·4)	69·1	(6·0)	<0·0001
Female; N (%)	1,890	(49·8)	1,232	(52·1)	0·08
Marital status; N (%)					
Married/partnered	3,001	(79·1)	1,904	(80·5)	
Separated/divorced	24	(0·6)	8	(0·3)	0·23
Widowed	747	(19·7)	436	(18·4)	
Never married	24	(0·6)	18	(0·8)	
Minority group; N (%)	2,427	(63·9)	1,396	(59·0)	0·0001
Median household size (persons)	2	(1; 2, 3)	3	(1; 2, 3)	0·01
Education attainment; N (%)					
Primary or below	3,555	93·7	2,185	92·4	
Secondary	195	5·1	136	5·8	0·05
Higher than secondary	46	1·2	45	1·9	
Father's education attainment; N (%)					
Less than primary	2,783	74·3	1,680	72·6	
Primary	784	20·9	507	21·9	0·23
Secondary or higher	178	4·8	128	5·5	
Mother's education attainment; N (%)					
Less than primary	3,625	96·4	2,251	96·7	
Primary	106	2·8	54	2·3	0·45
Secondary or higher	31	0·8	22	1·0	
Smoking status; N (%)					
Current smoker	1,057	27·9	607	25·8	
Former smoker	732	19·3	451	19·2	0·18
Never smoke	2,002	52·8	1,291	55·0	
BMI category (kg/m^2); N (%)					
Underweight/normal; <25	2,318	68·8	1,328	69·0	
Overweight; 25-29·9	889	26·4	509	26·5	0·93
Obese; >=30	160	4·8	87	4·5	
Number of self-reported diagnosed health conditions; N (%)					
0	824	24·1	538	26·4	
1	1,329	38·9	782	38·3	0·08
2	885	25·9	532	26·1	
>=3	376	11·0	188	9·2	
Number of self-reported general health; N (%)					
Excellent	47	1·2	21	0·9	
Very good	372	9·8	181	8·1	
Good	431	11·4	250	11·3	0·19
Fair	2,043	53·9	1,224	55·1	
Poor	901	23·8	547	24·6	
Positive for depressive symptoms; N (%)	1,376	36·3	752	34·1	0·09
Baseline memory score quartiles; N (%)					
<=25%	1,025	27·9	668	31·9	
26-50%	1,132	30·8	599	28·6	0·01
51-75%	1,016	27·6	529	25·3	
>75%	507	13·8	296	14·2	
Outcome					
GCF factor scores; mean (SD)	-1·3	(0·9)	-1·3	(1·0)	0·23

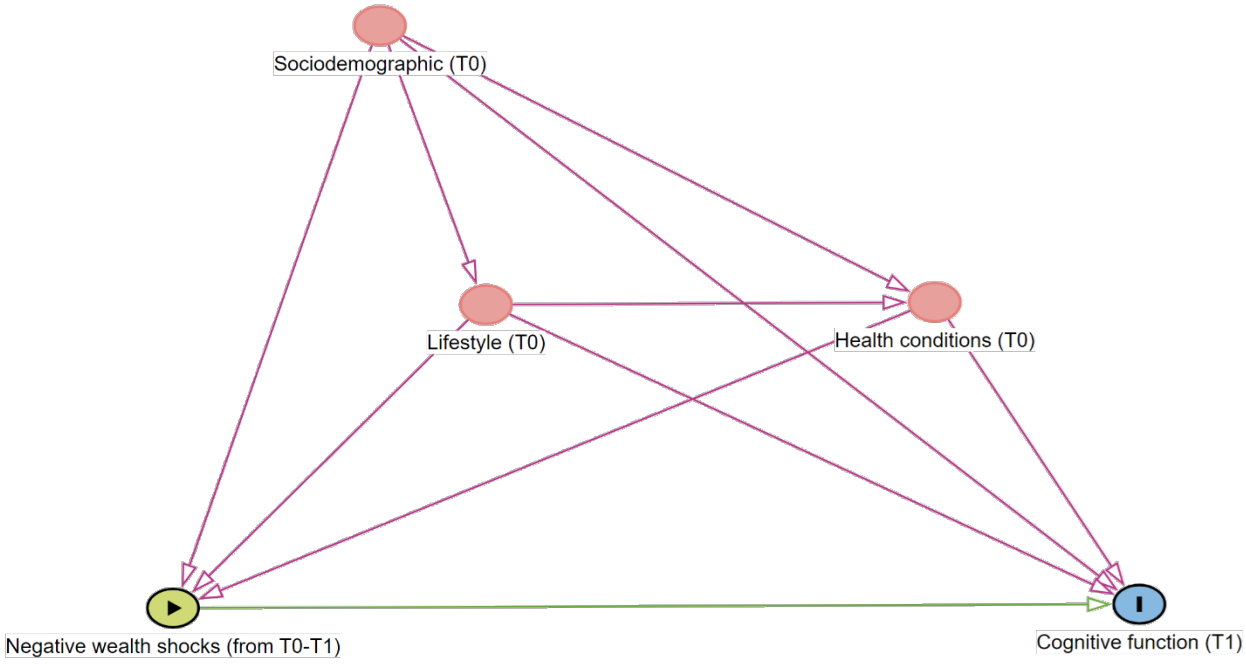
Note:
The baseline characteristics are obtained from the core interviews of the China Health and Retirement Longitudinal Study (CHARLS) in 2015. The outcome of GCF factor scores is constructed based on the CHARLS-HCAP in 2018. The participant characteristics in both samples are not imputed. All values are not sampling-weighted.

Supplemental Table 4. Characteristics of ELSA-HCAP participants aged ≥65, comparing older adults included in the study sample vs excluded from the sample due to missing wealth shocks

	Study sample N=1,184		Excluded sample N=24		P-value from testing difference in mean/median/%
Baseline characteristics					
Age (years); mean (SD)	72·0	(7·0)	71·5	(8·5)	0·82
Female; N (%)	646	54·6	17	70·8	0·11
Marital status; N (%)					
Married/partnered	808	68·3	10	41·7	
Separated/divorced	101	8·5	7	29·2	0·001
Widowed	220	18·6	7	29·2	
Never married	54	4·6	0	0·0	
Minority group; N (%)	38	3·2	0	0·0	0·37
Median household size (persons)	2	(1; 1, 2)	2	(1; 1, 2)	0·45
Education attainment; N (%)					
Primary or below	461	38·9	9	37·5	
Secondary	219	18·5	5	20·8	0·96
Higher than secondary	504	42·6	10	41·7	
Father's education attainment; N (%)					
Less than primary	25	2·2	0	0·0	
Primary	0	0·0	0	0·0	0·48
Secondary or higher	1,133	97·8	23	100·0	
Mother's education attainment; N (%)					
Less than primary	28	2·4	0	0·0	
Primary	0	0·0	0	0·0	0·44
Secondary or higher	1,144	97·6	24	100·0	
Smoking status; N (%)					
Current smoker	108	9·1	2	8·3	
Former smoker	646	54·6	15	62·5	0·73
Never smoke	430	36·3	7	29·2	
BMI category (kg/m^2); N (%)					
Underweight/normal; <25	253	24·1	6	26·1	
Overweight; 25-29·9	450	42·9	13	56·5	0·26
Obese; >=30	346	33·0	4	17·4	
Number of self-reported diagnosed health conditions; N (%)					
0	290	24·5	9	37·5	
1	430	36·3	10	41·7	0·26
2	333	28·1	3	12·5	
>=3	131	11·1	2	8·3	
Number of self-reported general health; N (%)					
Excellent	116	9·9	2	8·3	
Very good	332	28·3	6	25·0	
Good	400	34·0	9	37·5	0·99
Fair	247	21·0	5	20·8	
Poor	80	6·8	2	8·3	
Positive for depressive symptoms; N (%)	234	20·0	4	16·7	0·69
Baseline memory score quartiles; N (%)					
<=25%	511	43·5	8	33·3	
26-50%	259	22·0	5	20·8	0·59
51-75%	221	18·8	7	29·2	
>75%	184	15·7	4	16·7	
Outcome					
GCF factor scores; mean (SD)	-0·04	(1·0)	-0·1	(1·6)	0·76

Note:
The baseline characteristics are obtained from the core interviews of the English Longitudinal Study of Ageing (ELSA) in 2012. The outcome of GCF factor scores is constructed based on the ELSA-HCAP in 2016. The participant characteristics in both samples are not imputed. All values are not sampling-weighted.

Supplemental Figure 2. Directed acyclic graph (DAG) that guided selection of plausible confounders



Note:

The green, blue, and pink nodes respectively represent the exposure measured from the baseline (T0) of the study periods to the follow-up time-point (T1), the outcome measured at the follow-up time, and the confounders of the sociodemographic, lifestyle-related, and health-related factors measured at the baseline. Sociodemographic factors are age, sex/gender, marital status, minority status, education level, parent's education level, and baseline wealth quintile. Lifestyle-related factors are smoking status and BMI. Health-related factors are self-reported diagnosed health conditions, self-reported general health, positive for depressive symptoms, and baseline memory score quartile. All the confounding pathways (pink lines) in the DAG can be closed by adjusting for the sociodemographic, lifestyle-related, and health-related factors.

Supplemental Table 5. Percent of missing data in covariates before imputation, by country

	% missingness before imputation by study			
Characteristic	**HRS N=3,292**	**ELSA N=1,184**	**MHAS N=1,193**	**CHARLS N=3,796**
Age	0·0	0·0	0·0	0·0
Gender	0·0	0·0	0·0	0·0
Marital status	0·0	0·1	0·0	0·0
Minority status	0·0	0·0	0·0	0·0
Household size	0·0	0·0	0·0	0·0
Education attainment	0·1	0·0	0·5	0·0
Father's education attainment	13·6	2·2	14·3	1·3
Mother's education attainment	8·0	1·0	12·1	0·9
Wealth quintiles	0·0	0·0	0·0	0·0
Smoking status	0·6	0·0	0·0	0·1
BMI category	0·9	11·4	9·3	11·3
Self-reported diagnosed health conditions	0·9	0·0	0·7	10·1
Self-reported general health	0·1	0·8	4·0	0·1
Positive for depressive symptoms	1·3	1·2	4·0	0·1
Memory score quartiles	1·3	0·8	4·0	3·1

Supplemental Table 6. Coefficients for negative wealth shocks and subsequent cognitive function, comparing the main study results vs additional adjustment for time-varying confounders using inverse probability of treatment (IPTW)

	Main study results [a]				Additional adjustment for time-varying confounders using IPTW [b]			
	Stratified analyses			P-value of cross-country interaction effect [c]	Stratified analyses			P-value of cross-country interaction effect [c]
Negative wealth shock	**B**	**95% CI**			**B**	**95% CI**		
Extreme wealth loss (vs not) [d]								
US	-0·16	-0·29	-0·04	(ref)	-0·14	-0·25	-0·03	(ref)
England	-0·01	-0·24	0·22	0·47	0·01	-0·24	0·25	0·49
Mexico	-0·11	-0·24	0·03	0·67	-0·10	-0·24	0·03	0·89
China	-0·14	-0·21	-0·07	0·70	-0·14	-0·20	-0·07	0·87
Wealth rank decline (-4 to 4)								
US	-0·07	-0·11	-0·03	(ref)	-0·06	-0·09	-0·02	(ref)
England	-0·05	-0·11	0·01	0·43	-0·04	-0·11	0·02	0·61
Mexico	-0·03	-0·07	0·01	0·02	-0·03	-0·07	0·01	0·09
China	-0·07	-0·09	-0·04	0·13	-0·06	-0·09	-0·04	0·35

Note: All estimates accounted for survey sampling weights and household clusters. The p-values from pooled analyses additionally accounted for country strata.

[a] All results were adjusted for age, age^2, sex/gender, marital status, minority status, education level, parent's education level, baseline wealth quintile, smoking status, BMI, self-reported diagnosed health conditions, self-reported general health, positive for depressive symptoms, and baseline memory score quartile.

[b] Inverse probability of treatment weighting (IPTW) was used to adjust for the time-varying confounding effect of marital status, self-reported diagnosed health conditions, self-reported general health, and positive for depressive symptoms. Survey weights were considered in the construction of both the IPTW and the final weights - the product of the IPW and sampling weights.

[c] The interaction effect of wealth changes and country using the HRS as the reference.

[d] An extreme wealth loss is a ≥75% decrease in wealth from the baseline amount.

Supplemental Table 7. Coefficients for negative wealth shocks and subsequent cognitive function, comparing the main study results vs results using house value as the exposure

	Main study results [a]				Exposure restricted to house value [b]			
	Stratified analyses			P-value of cross-country interaction effect [c]	Stratified analyses			P-value of cross-country interaction effect [c]
Negative wealth shock	**B**	**95% CI**			**B**	**95% CI**		
Extreme wealth loss (vs not) [d]								
US	-0·16	-0·29	-0·04	(ref)	-0·35	-0·48	-0·22	(ref)
England	-0·01	-0·24	0·22	0·47	0·00	-0·35	0·36	0·26
Mexico	-0·11	-0·24	0·03	0·67	-0·12	-0·25	0·00	0·02
China	-0·14	-0·21	-0·07	0·70	-0·15	-0·21	-0·08	0·01
Wealth rank decline (-4 to 4)								
US	-0·07	-0·11	-0·03	(ref)	-0·06	-0·10	-0·03	(ref)
England	-0·05	-0·11	0·01	0·43	-0·01	-0·07	0·04	0·25
Mexico	-0·03	-0·07	0·01	0·02	-0·03	-0·06	0·01	0·11
China	-0·07	-0·09	-0·04	0·13	-0·04	-0·06	-0·02	0·22

Note: All estimates accounted for survey sampling weights and household clusters. The p-values from pooled analyses additionally accounted for country strata.

[a] All results were adjusted for age, age^2, sex/gender, marital status, minority status, education level, parent's education level, baseline wealth quintile, smoking status, BMI, self-reported diagnosed health conditions, self-reported general health, positive for depressive symptoms, and baseline memory score quartile.

[b] House value is the gross value of primary residence.

[c] The interaction effect of wealth changes and country using the HRS as the reference.

[d] An extreme wealth loss is a ≥75% decrease in wealth from the baseline amount.

Supplemental Table 8. Coefficients for negative wealth shocks and subsequent cognitive function, comparing the main study results vs results using liquid assets as the exposure

	Main study results [a]				Exposure restricted to liquid assets [b]			
	Stratified analyses			P-value of cross-country interaction effect [c]	Stratified analyses			P-value of cross-country interaction effect [c]
Negative wealth shock	**B**	**95% CI**			**B**	**95% CI**		
Extreme wealth loss (vs not) [d]								
US	-0·16	-0·29	-0·04	(ref)	0·03	-0·04	0·09	(ref)
England	-0·01	-0·24	0·22	0·47	-0·07	-0·17	0·04	0·12
Mexico	-0·11	-0·24	0·03	0·67	0·05	-0·06	0·16	0·92
China	-0·14	-0·21	-0·07	0·70	-0·11	-0·17	-0·04	0·002
Wealth rank decline (-4 to 4)								
US	-0·07	-0·11	-0·03	(ref)	-0·01	-0·04	0·01	(ref)
England	-0·05	-0·11	0·01	0·43	-0·02	-0·06	0·02	0·81
Mexico	-0·03	-0·07	0·01	0·02	0·01	-0·01	0·03	0·26
China	-0·07	-0·09	-0·04	0·13	-0·04	-0·06	-0·02	0·19

Note: All estimates accounted for survey sampling weights and household clusters. The p-values from pooled analyses additionally accounted for country strata.

[a] All results were adjusted for age, age^2, sex/gender, marital status, minority status, education level, parent's education level, baseline wealth quintile, smoking status, BMI, self-reported diagnosed health conditions, self-reported general health, positive for depressive symptoms, and baseline memory score quartile.

[b] Liquid assets mean non-housing financial wealth, excluding the value of any real estate, vehicles, or businesses.

[c] The interaction effect of wealth changes and country using the HRS as the reference.

[d] An extreme wealth loss is a ≥75% decrease in wealth from the baseline amount.

Supplemental Table 9. Coefficients for negative wealth shocks and subsequent cognitive function, comparing the main study results vs results using wealth decile rank as the exposure

	Stratified analyses			P-value of cross-country interaction effect [a]
Negative wealth shock	**B**	**95% CI**		
Extreme wealth loss (vs not) [b]				
US	-0·16	-0·29	-0·04	(ref)
England	-0·01	-0·24	0·22	0·47
Mexico	-0·11	-0·24	0·03	0·67
China	-0·14	-0·21	-0·07	0·70
Wealth rank decline (-4 to 4)				
US	-0·07	-0·11	-0·03	(ref)
England	-0·05	-0·11	0·01	0·43
Mexico	-0·03	-0·07	0·01	0·02
China	-0·07	-0·09	-0·04	0·13
Wealth decile decline (-9 to 9)				
US	-0·04	-0·06	-0·01	(ref)
England	-0·02	-0·05	0·01	0·37
Mexico	-0·01	-0·03	0·01	0·02
China	-0·03	-0·04	-0·02	0·11

Note: All estimates accounted for survey sampling weights and household clusters. Also, they were adjusted for age, age^2, sex/gender, marital status, minority status, education level, parent's education level, baseline wealth quintile, smoking status, BMI, self-reported diagnosed health conditions, self-reported general health, and positive for depressive symptoms.

[a] The interaction effect of wealth changes and country using the HRS as the reference.

[b] An extreme wealth loss is a ≥75% decrease in wealth from the baseline amount.

Supplemental Table 10. Coefficients for negative wealth shocks and subsequent cognitive function, comparing the main study results vs results based on the subsample at retirement age at baseline

	Main study results [a]				The subsample of those at retirement age at baseline [b]			
	Stratified analyses			P-value of cross-country interaction effect [c]	Stratified analyses			P-value of cross-country interaction effect [c]
Negative wealth shock	B	95% CI			B	95% CI		
Extreme wealth loss (vs not) [d]								
US	-0·16	-0·29	-0·04	(ref)	-0·25	-0·38	-0·12	(ref)
England	-0·01	-0·24	0·22	0·47	-0·10	-0·31	0·11	0·73
Mexico	-0·11	-0·24	0·03	0·67	-0·11	-0·27	0·05	0·37
China	-0·14	-0·21	-0·07	0·70	-0·14	-0·21	-0·07	0·29
Wealth rank decline (-4 to 4)								
US	-0·07	-0·11	-0·03	(ref)	-0·10	-0·14	-0·05	(ref)
England	-0·05	-0·11	0·01	0·43	-0·06	-0·13	0·01	0·19
Mexico	-0·03	-0·07	0·01	0·02	-0·04	-0·08	0·01	0·01
China	-0·07	-0·09	-0·04	0·13	-0·07	-0·09	-0·04	0·03

Note: All estimates accounted for survey sampling weights and household clusters. The p-values from pooled analyses additionally accounted for country strata.

[a] All results were adjusted for age, age^2, sex/gender, marital status, minority status, education level, parent's education level, baseline wealth quintile, smoking status, BMI, self-reported diagnosed health conditions, self-reported general health, and positive for depressive symptoms.

[b] The older adults in the subsample are >= 66 years in the US, >= 65in England and Mexico, and >=60 in China; N=2,569 in the US, 985 in England, 930 in Mexico, and 3,796 in China.

[c] The interaction effect of wealth changes and country using the HRS as the reference.

[d] An extreme wealth loss is a ≥75% decrease in wealth from the baseline amount.

Supplemental Table 11. Coefficients for negative wealth shocks and subsequent cognitive function, comparing the main study results vs results using data without imputation for missing data in covariates

	Main study results [a]				Unimputed covariates			
	Stratified analyses			P-value of cross-country interaction effect [b]	Stratified analyses			P-value of cross-country interaction effect [b]
Negative wealth shock	**B**	**95% CI**			**B**	**95% CI**		
Extreme wealth loss (vs not) [c]								
US	-0·16	-0·29	-0·04	(ref)	-0·16	-0·30	-0·02	(ref)
England	-0·01	-0·24	0·22	0·47	0·07	-0·19	0·32	0·31
Mexico	-0·11	-0·24	0·03	0·67	-0·05	-0·20	0·09	0·37
China	-0·14	-0·21	-0·07	0·70	-0·13	-0·21	-0·06	0·71
Wealth rank decline (-4 to 4)								
US	-0·07	-0·11	-0·03	(ref)	-0·07	-0·11	-0·02	(ref)
England	-0·05	-0·11	0·01	0·43	-0·04	-0·11	0·03	0·39
Mexico	-0·03	-0·07	0·01	0·02	-0·03	-0·07	0·01	0·05
China	-0·07	-0·09	-0·04	0·13	-0·06	-0·08	-0·03	0·16

Note: All estimates accounted for survey sampling weights and household clusters. The p-values from pooled analyses additionally accounted for country strata.

[a] All results were adjusted for age, age^2, sex/gender, marital status, minority status, education level, parent's education level, baseline wealth quintile, smoking status, BMI, self-reported diagnosed health conditions, self-reported general health, and positive for depressive symptoms.

[b] The interaction effect of wealth changes and country using the HRS as the reference.

[c] An extreme wealth loss is a ≥75% decrease in wealth from the baseline amount.