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Supplementary appendix

This appendix formed part of the original submission and has been peer reviewed. We post it as supplied by the authors.

Supplement to: Kobayashi LC, Peterson RL, Yu X, et al. Life course financial mobility and later-life memory function and decline by gender, and race and ethnicity: an intersectional analysis of the US KHANDLE and STAR cohort studies. *Lancet Healthy Longev* 2024. https://doi.org/10.1016/S2666-7568(24)00129-6

Supplemental Materials

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Supplemental Methods

The null model specification was as follows:

$$y_{ijk} = \beta_0 + \beta_1 time_{ijk} + \beta_\alpha Covs'_{jk} + \mu^{(2)}_{1jk} + \mu^{(3)}_{1k} + (\mu^{(2)}_{2jk} + \mu^{(3)}_{2k}) time_{ij} + \epsilon_{ijk}$$

$$\begin{bmatrix} \mu^{(3)}_{1k} \\ \mu^{(3)}_{2k} \end{bmatrix} \sim N(0,\ \psi^{(3)}),\ \psi^{(3)} = \begin{bmatrix} Var(\mu^{(3)}_{1k}|Covs'_{jk}) & Cov(\mu^{(3)}_{1k}, \mu^{(3)}_{2k}|Covs'_{jk}) \\ Cov(\mu^{(3)}_{2k}, \mu^{(3)}_{1k}|Covs'_{jk} & Var(\mu^{(3)}_{2k}|Covs'_{jk}) \end{bmatrix}$$

$$\begin{bmatrix} \mu^{(2)}_{1jk} \\ \mu^{(2)}_{2jk} \end{bmatrix} \sim N(0,\ \psi^{(2)}),\ \psi^{(2)} = \begin{bmatrix} Var(\mu^{(2)}_{1jk}|Covs'_{jk}, \mu^{(3)}_{1k}) & Cov(\mu^{(2)}_{1jk}, \mu^{(2)}_{2jk}|Covs'_{jk}, \mu^{(3)}_{1k}) \\ Cov(\mu^{(2)}_{1jk}, \mu^{(2)}_{2jk}|Covs'_{jk}, \mu^{(3)}_{1k} & Var(\mu^{(2)}_{2jk}|Covs'_{jk}, \mu^{(3)}_{1k}) \end{bmatrix}$$

$$\epsilon_{ijk} \sim N(0, \sigma^2_\epsilon)$$

In the model, y_{ijk} is the standardized verbal episodic memory score at wave i for person j within intersectional strata k; β_0 is the grand mean verbal episodic memory score at baseline; $time_{ijk}$ is the time in years since study baseline; β_1 is the corresponding parameter value for time (the mean slope across all persons and strata) for persons in the reference categories of all covariates $Covs'_{jk}$; $Covs'_{jk}$ is a vector of fixed effects for the confounders (age at baseline, country of birth, maternal education, paternal education, and the interaction between age at baseline and time since baseline); β_α is a vector of parameter values associated with $Covs'_{jk}$. The random intercepts for persons at level 2 and intersectional strata at level 3 are denoted by $\mu^{(2)}_{1jk}$ and $\mu^{(3)}_{1k}$, respectively. The person-level random intercept indicates the difference in verbal episodic memory scores between the value predicted for person j in stratum k at baseline and the mean predicted value across all persons with the same values for the fixed effects. The stratum-level random intercept indicates the difference in verbal episodic memory scores between the mean predicted value for stratum k at baseline based on the fixed (β) parameters and the mean predicted value across all strata. The random slopes for persons at level 2 and intersectional strata at level 3 are denoted by $(\mu^{(2)}_{2jk} + \mu^{(3)}_{2k}) time_{ij}$. The person-level random slope indicates the difference in the slope between the value predicted for person j in stratum k and the grand mean slope β_1, holding the fixed effects constant. The stratum-level random slope indicates the difference in the mean slope for stratum k from the grand mean slope β_1, holding the fixed effects constant. The stratum-level random intercept and slope are assumed to have a mean of zero and variance $\psi^{(3)}$. The person-level random intercept and slope are assumed to have a mean of zero and variance $\psi^{(2)}$. The observation-level error term ϵ_{ijk} is assumed to have a mean of zero and variance σ. The error terms in the model are assumed to be uncorrelated across levels.

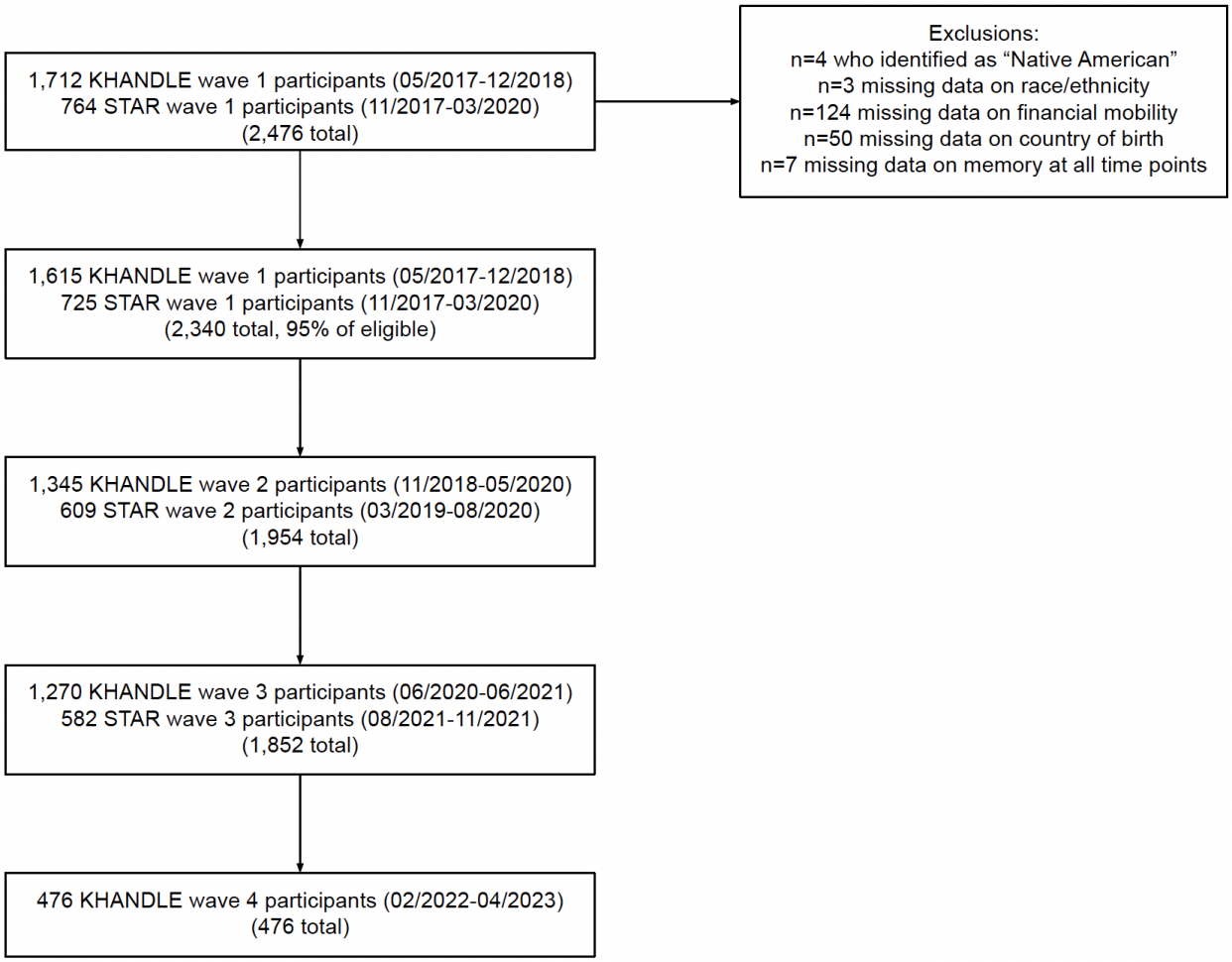
The intersectional model specification was like the null model specification, except with additional individual fixed effects parameters for the three components of the intersectional identity strata (sex/gender, race/ethnicity, and life course financial mobility trajectories):

$$\begin{aligned} y_{ijk} = \beta_0 + \beta_1 time_{ijk} + \beta_2 woman_i + \beta_3 black\_race\_eth_i + \beta_4 latinx\_race\_eth_i + \beta_5 white\_race\_eth_i \\ + \beta_6 upwardly\_mobile_i + \beta_7 downwardly\_mobile_i + \beta_8 consistently\_low_i + \beta_\alpha Covs'_{jk} \\ + \mu^{(2)}_{1jk} + \mu^{(3)}_{1k} + (\mu^{(2)}_{2jk} + \mu^{(3)}_{2k}) time_{ij} + \epsilon_{ijk} \end{aligned}$$

$$\begin{bmatrix} \mu^{(3)}_{1k} \\ \mu^{(3)}_{2k} \end{bmatrix} \sim N(0,\ \psi^{(3)}) \text{ and } \psi^{(3)} = \begin{bmatrix} Var(\mu^{(3)}_{1k}|Covs'_{jk}) & Cov(\mu^{(3)}_{1k}, \mu^{(3)}_{2k}|Covs'_{jk}) \\ Cov(\mu^{(3)}_{2k}, \mu^{(3)}_{1k}|Covs'_{jk} & Var(\mu^{(3)}_{2k}|Covs'_{jk}) \end{bmatrix}$$

$$\begin{bmatrix} \mu^{(2)}_{1jk} \\ \mu^{(2)}_{2jk} \end{bmatrix} \sim N(0,\ \psi^{(2)}) \text{ and } \psi^{(2)} = \begin{bmatrix} Var(\mu^{(2)}_{1jk}|Covs'_{jk}, \mu^{(3)}_{1k}) & Cov(\mu^{(2)}_{1jk}, \mu^{(2)}_{2jk}|Covs'_{jk}, \mu^{(3)}_{1k}) \\ Cov(\mu^{(2)}_{1jk}, \mu^{(2)}_{2jk}|Covs'_{jk}, \mu^{(3)}_{1k} & Var(\mu^{(2)}_{2jk}|C\square\square vs'_{jk}, \mu^{(3)}_{1k}) \end{bmatrix}$$

$$\epsilon_{ijk} \sim N(0, \sigma^2_\epsilon)$$



Supplemental Figure 1. Study flow diagram. The dates for each data collection wave are shown in (MM/YYYY) format. For each individual study participant, follow-ups occurred, on average, every 16-18 months since wave 1 (baseline) in KHANDLE and 13-14 months since wave 1 (baseline) in STAR. We used all available verbal episodic memory observations from all waves, which gave a total of 6,616 observations for the 2,340 included individuals. A total of 136 individuals were excluded for the reasons described in the figure, which were non-mutually exclusive.

Supplemental Table 1. Characteristics of individuals included (2,340/2,476) and excluded (136/2,476) from the analysis

Baseline characteristic	Included N (%)	Excluded N (%)	p-value
	2,340 (95%)	136 (5%)	
Age (mean, SD, range)	73·6 (8·1, 53-89)	76·1 (8·4, 55-89)	0.0004
Baseline memory score (mean, SD)	0.171 (0.87)	-0.073 (0.93)	0.0032
Gender			
Man	880 (38%)	57 (42%)	0.314
Woman	1,460 (62%)	79 (58%)	
Race/ethnicity			
Asian	388 (17%)	267(21%)	0.345
Black	1,136 (49%)	61 (47%)	
Latinx	334 (14%)	21 (16%)	
White	482 (21%)	20 (16%)	
Life course financial mobility			
Consistently high	1,094 (47%)	2 (17%)	0.218
Upwardly mobile	330 (14%)	5 (42%)	
Downwardly mobile	654 (28%)	3 (25%)	
Consistently low	262 (11%)	2 (17%)	
Mother's education			<0.0001
High school or less	1,465 (63%)	49 (36%)	
Some college or an Associate's degree	308 (13%)	13 (10%)	
Bachelor's degree or higher	240 (10%)	8 (6%)	
Missing or not applicable	327 (14%)	66 (49%)	
Father's education			<0.0001
High school or less	1,250 (53%)	38 (27%)	
Some college or an Associate's degree	236 (10%)	13 (10%)	
Bachelor's degree or higher	319 (14%)	12 (9%)	
Missing or not applicable	535 (23%)	73 (54%)	
Country of birth			0.09
United States	1,933 (83%)	65 (76%)	
Elsewhere	407 (17%)	21 (24%)	

Supplemental Table 2. Age distribution of the sample, by race/ethnicity, KHANDLE and STAR cohorts, Kaiser Permanente Northern California, 2017-2023, n=2,347

Baseline characteristic	Total N (%)	Asian	Latinx	Black	White
	2,340 (100%)	388 (16·6%)	334 (14·3%)	1,136 (48·6%)	482 (20·6%)
Age (mean, SD, range)	73·6 (8·1, 53-89)	75·6 (6·5, 65-89)	75·9 (6·3, 65-89)	70·9 (8·6, 53-89)	76·6 (7·0, 65-89)

Note: KHANDLE is the "Kaiser Healthy Aging and Diverse Life Experiences" cohort, and STAR is the "Study of Healthy Aging in African Americans" cohort. Both draw from the same sampling frame of community-dwelling, long-term members of Kaiser Permanente Northern California, an integrated healthcare delivery system, in Northern California. Eligibility for KHANDLE and STAR varied based on age and race/ethnicity, as seen in the demographic differences in this table.

Supplemental Table 3. Sample size (persons and verbal episodic memory observations) across intersectional identity strata, KHANDLE and STAR cohorts, Kaiser Permanente Northern California, 2017-2023, n=2,340

Intersectional identity strata (sex/gender, race/ethnicity, financial mobility)	N persons (Model level 2)	N memory observations (Model level 1)
Man; Asian; Consistently high	104	301
Man; Asian; Downwardly mobile	22	67
Man; Asian; Upwardly mobile	44	126
Man; Asian; Consistently low	13	34
Man; Black; Consistently high	175	465
Man; Black; Downwardly mobile	81	202
Man; Black; Upwardly mobile	62	164
Man; Black; Consistently low	38	90
Man; Latinx; Consistently high	54	164
Man; Latinx; Downwardly mobile	29	81
Man; Latinx; Upwardly mobile	28	87
Man; Latinx; Consistently low	26	66
Man; White; Consistently high	126	395
Man; White; Downwardly mobile	44	115
Man; White; Upwardly mobile	23	61
Man; White; Consistently low	11	33
Woman; Asian; Consistently high	113	343
Woman; Asian; Downwardly mobile	49	137
Woman; Asian; Upwardly mobile	32	101
Woman; Asian; Consistently low	12	33
Woman; Black; Consistently high	303	839
Woman; Black; Downwardly mobile	279	768
Woman; Black; Upwardly mobile	90	260
Woman; Black; Consistently low	108	287
Woman; Latinx; Consistently high	75	215
Woman; Latinx; Downwardly mobile	66	179
Woman; Latinx; Upwardly mobile	25	73
Woman; Latinx; Consistently low	31	81
Woman; White; Consistently high	144	453
Woman; White; Downwardly mobile	84	247
Woman; White; Upwardly mobile	27	81
Woman; White; Consistently low	23	68

Supplemental Table 4. Parameter estimates from multilevel models of verbal episodic memory, restricted to individuals born in the United States, KHANDLE and STAR cohorts, Kaiser Permanente Northern California, 2017-2023, n=1,933

Parameter	Null model Coef. (95% CI)	Main effects model Coef. (95% CI)
Fixed effects		
Intercept	0·019 (-0·101, 0·148)	-0·102 (-0·235, 0·030)
Baseline age (continuous, years)	-0·042 (-0·047, -0·037)	-0·042 (-0·047, -0·037)
Gender		
Man (reference)	-	-
Woman	-	0·616 (0·536, 0·697)
Race/ethnicity		
Asian (reference)	-	-
Black	-	-0·299 (-0·428, -0·171)
Latinx	-	-0·124 (-0·280, -0·033)
White	-	0·006 (-0·132, 0·145)
Life course financial mobility		
Consistently high (reference)	-	-
Upwardly mobile	-	-0·052 (-0·166, 0·061)
Downwardly mobile	-	-0·167 (-0·264, -0·070)
Consistently low	-	-0·184 (-0·315, -0·052)
Time since baseline (continuous, years)	-0·040 (-0·065, -0·014)	-0·042 (-0·068, -0·015)
Time*Baseline age	-0·002 (-0·004, -0·000)	-0·002 (-0·004, -0·000)
Random intercepts		
Intersectional strata-level	0·117 (0·065, 0·211)	0·003 (0·000, 0·090)
Person-level	0·451 (0·405, 0·503)	0·452 (0·406, 0·503)
Random slopes		
Intersectional strata-level	0·000 (0·000, 9·277)	0·000 (0·000, 0·009)
Person-level	0·014 (0·007, 0·025)	0·013 (0·007, 0·025)
Variance partition coefficient (VPC)		
VPC, intersectional strata-level (%)	13%	0·4%
VPC, person-level (%)	65%	60%

Note: The null and main effects models are additionally adjusted for age at baseline, mother's education, father's education, and mode of interview. The VPC indicates the proportion of baseline memory variance attributable to differences between intersectional identity strata and differences between persons.

Supplemental Table 5. Parameter estimates from multilevel models of verbal episodic memory, with additional adjustment for educational attainment, KHANDLE and STAR cohorts, Kaiser Permanente Northern California, 2017-2023, n=2,340

Parameter	Null model Coef. (95% CI)	Main effects model Coef. (95% CI)
Fixed effects		
Intercept	0·019 (-0·101, 0·148)	-0·781 (-1·055, -0·507)
Baseline age (continuous, years)	-0·043 (-0·068, -0·018)	-0·043 (-0·048, -0·039)
Gender		
Man (reference)	-	-
Woman	-	0·616 (0·536, 0·697)
Race/ethnicity		
Asian (reference)	-	-
Black	-	-0·292 (-0·399, -0·185)
Latinx	-	-0·070 (-0·188, 0·047)
White	-	-0·004 (-0·114, 0·106)
Life course financial mobility		
Consistently high (reference)	-	-
Upwardly mobile	-	-0·032 (-0·129, 0·065)
Downwardly mobile	-	-0·121 (-0·201, -0·041)
Consistently low	-	-0·065 (-0·177, -0·048)
Time since baseline (continuous, years)	-0·043 (-0·068, -0·018)	-0·044 (-0·069, -0·019)
Time*Baseline age	-0·003 (-0·005, -0·001)	-0·003 (-0·005, -0·001)
Random intercepts		
Intersectional strata-level	0·103 (0·058, 0·182)	0·002 (0·000, 0·047)
Person-level	0·430 (0·388, 0·477)	0·429 (0·387, 0·476)
Random slopes		
Intersectional strata-level	0·000 (0·000, 0·009)	0·000 (0·000, 0·006)
Person-level	0·015 (0·008, 0·026)	0·014 (0·008, 0·026)
Variance partition coefficient (VPC)		
VPC, intersectional strata-level (%)	12%	0·2%
VPC, person-level (%)	62%	57%

Note: The null and main effects models are additionally adjusted for age at baseline, mother's education, father's education, country of birth, mode of interview, and the participant's educational attainment. The VPC indicates the proportion of baseline memory variance attributable to differences between intersectional identity strata and differences between persons.

Supplemental Table 6. Distribution of education attainment according to life course financial mobility categories, KHANDLE and STAR cohorts, Kaiser Permanente Northern California, 2017-2023, n=2,340

Educational attainment	Life course financial mobility			
	Consistently low	Downwardly mobile	Upwardly mobile	Consistently high
	262 (11%)	654 (28%)	330 (14%)	1,094 (47%)
Grade school	23 (9%)	13 (2%)	4 (1%)	7 (<1%)
Some high school	22 (8%)	26 (4%)	14 (4%)	11 (1%)
Technical or trade school	23 (9%)	46 (7%)	7 (2%)	26 (2%)
Some college	94 (36%)	259 (40%)	112 (34%)	345 (32%)
College	37 (14%)	111 (17%)	82 (25%)	306 (28%)
Graduate school	20 (8%)	101 (15%)	75 (23%)	309 (28%)
High school or GED	43 (16%)	98 (15%)	36 (11%)	90 (8%)

Supplemental Table 7. Parameter estimates from multilevel models of verbal episodic memory without random effects for intersectional identity strata, stratified by cohort (KHANDLE and STAR, separately), Kaiser Permanente Northern California, 2017-2023, n=2,340

Parameter	Main effects model: KHANDLE cohort Coef. (95% CI)	Main effects model: STAR cohort Coef. (95% CI)
Fixed effects		
Intercept	-0·279 (-0·146, 0·090)	-0·403 (-0·532, -0·275)
Baseline age (continuous, years)	-0·051 (-0·057, -0·044)	-0·038 (-0·046, -0·031)
Gender		
Man (reference)	-	-
Woman	0·606 (0·526, 0·687)	0·561 (0·445, 0·677)
Race/ethnicity		
Asian (reference)	-	-
Black	-0·345 (-0·469, -0·221)	-
Latinx	-0·173 (-0·292, -0·054)	-
White	-0·054 (-0·166, 0·058)	-
Life course financial mobility		
Consistently high (reference)	-	-
Upwardly mobile	-0·046 (-0·163, 0·072)	-0·041 (-0·206, 0·125)
Downwardly mobile	-0·193 (-0·290, -0·096)	-0·132 (-0·255, -0·008)
Consistently low	-0·139 (-0·271, -0·006)	-0·234 (-0·429, -0·039)
Time since baseline (continuous, years)	-0·046 (-0·074, -0·018)	-0·046 (-0·074, -0·018)
Time*Baseline age	-0·004 (-0·007, -0·002)	-0·004 (-0·007, -0·002)
Random intercepts		
Person-level	0·466 (0·412, 0·527)	0·429 (0·362, 0·509)
Random slopes		
Person-level	0·010 (0·004, 0·025)	0·031 (0·017, 0·056)
Variance partition coefficient (VPC)		
VPC, person-level (%)	57%	61%

Note: The models are additionally adjusted for age at baseline, mother's education, father's education, country of birth, and mode of interview. The VPC indicates the proportion of baseline memory variance attributable to differences between persons. No variable for race/ethnicity was included in the model for the STAR cohort because this cohort is 99% Black.