Journal of the International Neuropsychological Society (2024), 1–10
doi:10.1017/S1355617724000638

Research Article

Marital status, brain health, and cognitive reserve among diverse older adults

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Abstract

Objective: Being married may protect late-life cognition. Less is known about living arrangement among unmarried adults and mechanisms such as brain health (BH) and cognitive reserve (CR) across race and ethnicity or sex/gender. The current study examines (1) associations between marital status, BH, and CR among diverse older adults and (2) whether one's living arrangement is linked to BH and CR among unmarried adults. **Method:** Cross-sectional data come from the Washington Heights-Inwood Columbia Aging Project ($N = 778$, 41% Hispanic, 33% non-Hispanic Black, 25% non-Hispanic White; 64% women). Magnetic resonance imaging (MRI) markers of BH included cortical thickness in Alzheimer's disease signature regions and hippocampal, gray matter, and white matter hyperintensity volumes. CR was residual variance in an episodic memory composite after partialing out MRI markers. Exploratory analyses stratified by race and ethnicity and sex/gender and included potential mediators. **Results:** Marital status was associated with CR, but not BH. Compared to married individuals, those who were previously married (i.e., divorced, widowed, and separated) had lower CR than their married counterparts in the full sample, among White and Hispanic subgroups, and among women. Never married women also had lower CR than married women. These findings were independent of age, education, physical health, and household income. Among never married individuals, living with others was negatively linked to BH. **Conclusions:** Marriage may protect late-life cognition via CR. Findings also highlight differential effects across race and ethnicity and sex/gender. Marital status could be considered when assessing the risk of cognitive impairment during routine screenings.

Keywords: Marriage; divorce; widowhood; cognition; MRI; neuroimaging

(Received 24 June 2024; final revision 21 October 2024; accepted 23 October 2024)

Introduction

Marital status is an important but often overlooked socio-demographic factor that could shape cognitive health in later adulthood. As one of the closest persons in one's social network, spouses are uniquely positioned to provide immediate social support, social engagement opportunities, and other resources in the daily lives of older adults. Indeed, married individuals are generally healthier than their unmarried counterparts (Carr & Springer, 2010; Lillard & Waite, 1995), including having a lower risk of cognitive impairment and dementia (Sommerlad et al., 2018). Existing theories of how marital status can protect or harm one's health could be applied to cognition. The marital resource model suggests that marriage provides health advantages through the availability of social, psychological, and financial resources (Rendall et al., 2011; Waite & Gallagher, 2000). On the other hand, the stress model posits that the experience of marital dissolution (e.g., divorce or bereavement) can cause emotional distress and require readjustment in the household, financial, and social aspects of life (Hughes & Waite, 2009; Lin et al., 2017), which can compromise cognitive functioning (Brown et al., 2021; Liu et al., 2020). While a growing body of literature documents dementia risk related to marital status, less is understood about the mechanisms through which marriage can influence late-life cognition. In this study, we sought to extend the literature on marital contexts of cognitive health by examining two potential mechanisms underlying links between marital status and cognitive functioning in later life: brain health and cognitive reserve. In addition, we examined whether living with other people can provide cognitive protection for older adults without spouses and whether the mechanisms operate similarly across race and ethnicity and sex/gender.

Marital status and the risk of cognitive impairment

Prospective population-level studies have generally found an elevated risk of dementia among unmarried individuals, compared

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Cite this article: Lee J.H., Scambray K.A., Morris E.P., Sol K., Palms J.D., Zaheed A.B., Martinez M.N., Schupf N., Manly J.J., Brickman A.M., & Zahodne L.B. Marital status, brain health, and cognitive reserve among diverse older adults. *Journal of the International Neuropsychological Society*, 1–10, https://doi.org/10.1017/S1355617724000638

to those who are married. For example, a meta-analysis found a higher risk of dementia for widowed or lifelong single persons (20 and 42% higher, respectively) compared to married individuals (Sommerlad et al., 2018). Older adults who experienced marital dissolution were more likely to experience cognitive impairment (Brown et al., 2021; Hakansson et al., 2009; Liu et al., 2019; Nakahori et al., 2021; Skirbekk et al., 2022; Sundström et al., 2016; Zhang et al., 2021). In most studies, the heightened risk of dementia among unmarried individuals was not fully explained by lower education levels (Sommerlad et al., 2018), lower income (Liu et al., 2019; Zhang et al., 2021), or worse health conditions (Nakahori et al., 2021; Zhang et al., 2021).

In a similar vein, other studies showed that being married is protective for maintaining cognitive functioning, including memory and language abilities. For example, married individuals showed better episodic memory than those who were never married, and a slower decline in memory than never married and widowed persons (Mousavi-Nasab et al., 2012). Being married/partnered was associated with a slower decline in episodic memory even when accounting for other social network characteristics (Zahodne et al., 2019). Others found that widowed individuals exhibit worse language levels compared to their married counterparts but experience slower declines in visuospatial functioning (Ying et al., 2020), revealing heterogeneous association between marital status and different cognitive domains. These findings suggest that there are protective effects of being married, but marital status may be linked to cognitive health in more nuanced ways.

An important limitation of most previous studies is that marital status was not examined in conjunction with one's living arrangement. Many older adults who were previously married re-enter into another marital/partnership union (Brown et al., 2018) or move in with their adult children (Seltzer & Friedman, 2014). Such living arrangement could provide social resources similar to those purported to underlie the protective effects of marriage (Lee & Kim, 2022). Older adults who live alone may face elevated risk of dementia, possibly due to lower economic resources (Desai et al., 2020). Thus, examining both marital status and living arrangement together could help to isolate the "active ingredients" of these factors that are closely linked to cognitive health in late life and reveal practical intervention opportunities, as living arrangement may be more modifiable than marital status.

Brain health and cognitive reserve

Previous studies primarily focused on documenting the association between marital status and dementia risk, but very little is known about brain mechanisms underlying these associations. Marriage may provide protection against cognitive impairment through two potential pathways: brain health and cognitive reserve. One of the ways to measure *brain health (BH)* is via neuroimaging data on structural integrity of the brain obtained by MRI. At any point in time, structural biomarkers of the brain can represent a confluence of genetic factors, developmental factors, and avoidance of neuropathology (e.g., brain maintenance; (Nyberg et al., 2012). On the other hand, *cognitive reserve (CR)* is an active model in that it refers to the adaptability (e.g., capacity, efficiency, compensation) of functional neural networks in the face of aging and disease (Barulli & Stern, 2013; Stern, 2012; Stern et al., 2020). CR can be shaped by lifetime exposure to various experiences, such as education, occupation, or social and leisure activities (Stern, 2012).

So far, very few empirical studies have examined marital status in the context of BH or CR. One recent study (Sharifian et al., 2021) showed that being married/partnered was not associated with cortical thickness in Alzheimer's disease (AD) signature regions (i.e., brain health), nor did it moderate the link between cortical thickness and global cognition (i.e., test of cognitive reserve). However, this study did not disaggregate the various non-married statuses (e.g., never married versus divorced), consider living arrangement, or examine multiple indicators of brain health (e.g., hippocampal volume, white matter hyperintensities). Thus, examining associations between marital status, living arrangement, multiple structural MRI indicators, and cognitive reserve could shed light on potential mechanisms for protecting cognitive health.

Differential associations across race and ethnicity and sex/gender

Despite strong evidence for race and ethnicity differences in both marital status (Bloome & Ang, 2020) and cognitive health (Chen & Zissimopoulos, 2018), very few studies explored racial and ethnic differences in links between marital status and cognition. One study found that divorce and widowhood were linked to a higher risk of dementia for both older Black and White adults, but the negative effect of marital dissolution on dementia risk was stronger for Black adults than White adults (Zhang et al., 2021). This finding supports the possibility that race and ethnicity may be another critical moderator of the effect of marital status on BH and/or CR.

Further, recent studies examined sex/gender variation in the association between marital status and cognition. For example, Chen et al. (2022) found that never being married was linked to higher risk of dementia similarly for both men (Odds ratio [OR] = 2.2) and women (OR = 2.1). However, divorce and widowhood in midlife was associated with 2.8 times higher risk of dementia only among men (Chen et al., 2022). Marital dissolution in midlife was associated with 2.75 times higher risk of dementia for men only. Similarly, being divorced or never married had a stronger negative effect on cognition for men compared to women (Kim, 2021; Xu et al., 2021). In contrast, other studies found that lifelong marital histories were associated with better episodic memory only among women (Zaheed et al., 2021). These mixed findings may suggest that resources and stressors related to marital status operate differently across men and women to influence brain and cognitive health.

The current study

The present study examined (1) which marital statuses are associated with BH and/or CR among diverse older adults, and (2) whether one's living arrangement is associated with BH and/or CR among those who are not currently married. Within these two aims, we further explored whether marital status, living arrangement, or their associations with cognition differ across race and ethnicity and sex/gender. We hypothesize that, compared to currently married older adults, previously married and never married older adults will show lower BH (i.e., lower cortical thickness, lower total gray matter volume, lower hippocampal volume, and more white matter hyperintensities) and/or lower CR (i.e., lower memory reserve). We also hypothesize that, among non-married older adults (e.g., previously married and never married), those who are living with others will have higher BH and CR compared to those living alone.

https://doi.org/10.1017/S1355617724000638 Published online by Cambridge University Press

Method

Participants and procedure

Cross-sectional data were drawn from the Washington Heights-Inwood Columbia Aging Project (WHICAP;(Manly et al., 2005; Tang et al., 2001). WHICAP is an ongoing, longitudinal study of a community-based sample of older adults residing in northern Manhattan, New York. To establish the WHICAP cohort, Medicare-eligible individuals aged 65 and older who were fluent in English and/or Spanish were recruited starting in 1992. Participants were evaluated at baseline and followed up every 18 to 24 months with medical, neurological, and neuropsychological tests in their preferred language (English or Spanish). Beginning in 2011, a random subset of participants was invited to join in a longitudinal 3T magnetic resonance imaging (MRI) study. This study complied with the ethical rules for human experimentation stated in the Declaration of Helsinki. The study procedures were approved by the Institutional Review Board at the Columbia University Medical Center, and all participants gave written informed consent.

To create an analytic dataset for the study, independent variables, cognitive performance, and covariates were drawn from the WHICAP wave closest to the MRI scan date. The analytic sample was limited to those without a research diagnosis of dementia and had valid data on MRI variables and independent variables of interest. Descriptive characteristics of the final sample of 778 participants are shown in Table 1.

Table 1. Sample characteristics ($N = 778$)

Variable [Range]	M (SD) or N (%)
Age [62–94]	74.55 (6.02)
Years of education [0–20]	12.37 (4.70)
Women	496 (63.8%)
Race and ethnicity	
Non-Hispanic White	196 (25.2%)
Non-Hispanic Black	260 (33.4%)
Hispanic	322 (41.4%)
Disease burden [0–15]	2.44 (1.61)
Functional impairment [0–6]	1.17 (0.63)
Income [1–12]	7.93 (3.07)
Marital status	
Married/partnered	274 (35.2%)
Previously married	386 (49.6%)
Never married	118 (15.2%)
Living arrangement	
Live alone	333 (42.8%)
Live with spouse and others	265 (34.1%)
Live only with others	180 (23.1%)
Brain health	
Cortical thickness (mm)	2.61 (0.12)
Total gray matter volume (mm^3)[a]	545967.83 (53,490.98)
Hippocampal volume (mm^3)[a]	7134.82 (856.58)
White matter hyperintensities (WMH, mm^3)	4577.69 (5611.41)
Cognitive reserve	
Selective Reminding Test	43.01 (10.29)

Note: [a]Unstandardized residual score after regressing out total intracranial volume (TICV).

Measures

Independent variables

Marital status and living arrangement were the independent variables. In WHICAP interviews, participant's current marital status was asked in a single question with response options including married, widowed, divorced, separated, and never married. We categorized those who were widowed, divorced, or separated as previously married. Dummy variables were created to compare across three marital status groups (i.e., married, previously married, and never married).

Next, the living arrangement was assessed by asking the participant to specify everyone who they live with. Two groups were identified within the unmarried subsample: living alone and living with others (i.e., children, parent, family, or friend).

Brain health outcomes

Structural MRI indicators of brain health included cortical thickness in Alzheimer's disease (AD) signature regions (Dickerson et al., 2009), hippocampal volume, total gray matter volume, and total white matter hyperintensity (WMH) volume. Images were obtained on a Philips Achieva 3.0 T MRI scanner at Columbia University Medical Center. Specifications are described elsewhere (Turney et al., 2023).

Regional cortical thickness, left and right hippocampal volumes, total gray matter volume, and total intracranial volume (TICV) were quantified using FreeSurfer version 6.0 (http://surfer.nmr.mgh.harvard.edu) with T1-weighted scans. A cortical thickness composite score was calculated by averaging the cortical thickness across hemispheres in nine regions that typically evidence AD-related neurodegeneration (Dickerson et al., 2009). The regions of interest include rostral medial temporal lobe, inferior parietal lobe, inferior frontal lobe, inferior temporal lobe, temporal pole, precuneus, supramarginal gyrus, superior parietal lobe, and superior frontal lobe. Next, hippocampal volumes (summed across left and right hemispheres) and total gray matter volumes (divided by 100) were corrected for TICV such that the unstandardized residual scores were used after regressing against TICV (Pa et al., 2022). Lastly, total WMH volumes were quantified from T2-weighted FLAIR images (Brickman et al., 2009; Brickman et al., 2011). In brief, images were skull stripped and voxel intensity was fit with a Gaussian curve. Voxel intensities greater than 2.1 SDs above the imaging study sample mean were labeled as WMH. The total WMH volume was log-transformed to normalize their distribution for the analysis (Pa et al., 2022).

Cognitive reserve outcomes

Memory reserve was used as a primary indicator of domain-specific cognitive reserve (Reed et al., 2010; Zahodne et al., 2013). In each core visit, WHICAP participants underwent a neuropsychological battery that assessed four domains of cognition, including episodic memory (Siedlecki et al., 2010; Stern, 1992). Previous factor analysis confirmed measurement invariance between those who took the test in English and Spanish (Siedlecki et al., 2010). Episodic memory was assessed with immediate recall, delayed recall, and delayed recognition trials from the Selective Reminding Test (Buschke & Fuld, 1974). A composite score was derived by computing z-scores of these tasks using the means and standard deviation of the baseline WHICAP sample and averaging them across tasks (Zahodne et al., 2015). Finally, memory reserve was quantified as the residual variance of the memory composite score after regressing out the four BH indicators (i.e., cortical thickness in AD signature regions, TICV-adjusted hippocampal volume, TICV-adjusted total gray matter volume, and WMH). The resulting residual value represents the discrepancy between one's memory performance compared to what is predicted from the degree of brain atrophy or injury (Reed et al., 2010; Zahodne et al., 2015; Zahodne et al., 2013). Higher residual values indicate a larger reserve.

https://doi.org/10.1017/S1355617724000638 Published online by Cambridge University Press

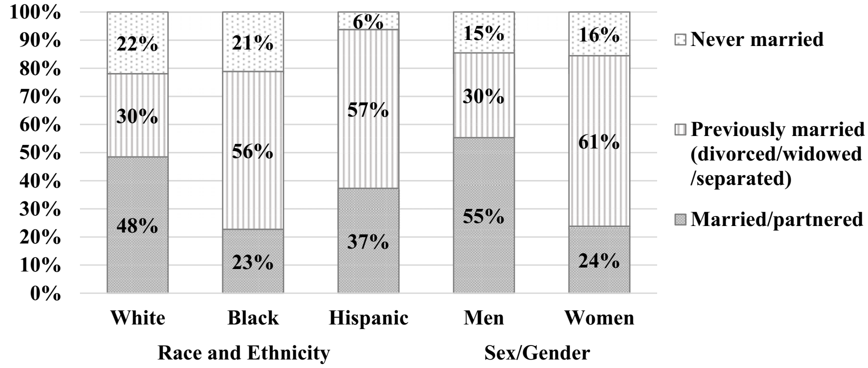

Figure 1. Marital status by race and ethnicity and sex/gender.

Covariates

Demographic covariates include age (in years, at neuropsychological evaluation), education level (in years, self-reported), sex/gender (1= female, 0 = male, self-reported), and race and ethnicity. Respondent's self-identification of race and ethnicity was coded into three mutually exclusive categories (i.e., non-Hispanic White, non-Hispanic Black, and Hispanic) which were dummy coded with non-Hispanic White as the reference group. Physical health (i.e., disease burden and functional impairment) and an additional indicator of socioeconomic status (i.e., income) were used as covariates in sensitivity analyses. Disease burden was computed as the sum of medical problems endorsed by the participant across 15 chronic conditions (i.e., hypertension, diabetes, heart disease, stroke, arthritis, COPD, thyroid, liver, renal, ulcer, peripheral vascular disease, cancer, Parkinson's disease, essential tremor, and multiple sclerosis). Functional impairment was measured with six items asking if the participant can perform activities of daily living (ADLs); a sum score was used with higher score indicating greater impairment (Manly et al., 2008). Self-rated monthly household income was operationalized as a 12-category variable (1 = \$450 or less to 12 = more than \$4,000) which was used as a continuous variable in the model.

Analytic strategy

Descriptive statistics were examined, and unadjusted race and ethnicity and sex/gender differences of study variables were analyzed using independent-sample T-tests and chi-square tests. A series of linear regression analyses were conducted to examine the associations between marital status and (1) BH or (2) CR. Models controlled for demographic covariates (i.e., age, sex/gender, education, race and ethnicity). Using dummy variables, the reference group was rotated to compare all three marital status categories. For example, two dummy variables were created for previously married (1) and never married (1) where the married (0) is the reference group. In the following model, similar dummy variables were utilized where the previously married group was the reference group. Separate race and ethnicity-stratified and sex/gender-stratified analyses were conducted. To answer the second aim, the sample was restricted to previously and never married participants. Two linear regression models examined the association between living arrangement and (1) BH or (2) CR, controlling for demographic covariates and marital status. Stratified models explored race and ethnicity and sex/gender differences.

Sensitivity analyses examined whether associations between marital status and BH or CR remained significant after accounting for living arrangement, disease burden, functional impairment, and household income. All analyses were conducted in SPSS Version 28. Two-sided p-values were statistically significant at .05.

Results

Descriptive statistics are presented in Table 1. About half of the sample was previously married (49.6%), followed by currently married/partnered (35.2%), and never married (15.2%).

As shown in Figure 1 and summarized in Supplementary Table 1, there were differences in marital status across race and ethnicity (χ^2 (4, 778) = 72.01, p = <.001) and sex/gender (χ^2 (2, 778) = 84.67, p = <.001). For non-Hispanic White (hereafter White) participants, the most common marital status was married (48%), with similar proportions previously and never married (30 and 22%, respectively). In contrast, the most common marital status for non-Hispanic Black (hereafter Black) and Hispanic participants was previously married (56 and 57%, respectively). One-fifth of Black participants were never married (21%), while very few Hispanic participants were never married (6%). In terms of sex/gender, more than half of men (55%) were currently married compared to only 24% of women. More than half (61%) of women were previously married.

In terms of demographic and health covariates, Hispanic participants were older (eta-squared = .02, hereafter η^2) and had higher functional impairment (η^2 = .04) than White or Black participants, who were similar to each other. White participants had the highest education (η^2 = .43), and income (η^2 = .33), followed by Black participants, then Hispanic participants. White participants had lower disease burden (η^2 = .04) than Black or Hispanic participants, who were similar to each other. Across sex/gender, women had less education (Cohen's d = .17, hereafter d), had more disease burden (d = .28), and had less income (d = .18) than men.

In terms of BH/CR outcomes, White participants had the highest cortical thickness (η^2 = .02) and greater gray matter volume (η^2 = .05) compared to Black or Hispanic participants, who were similar. Hippocampal volume did not differ across race and ethnic groups. Black participants had greater WMH volume (η^2 = .01) than White or Hispanic participants, who were similar. White participants had greater CR, followed by Black, then Hispanic participants (η^2 = .11). Across sex/gender, women had greater cortical thickness (d = .20), lower gray matter volume (d = .41), lower hippocampal volume (d = .24), and greater CR (d = .25) than men. Men and women did not differ in WMH volume.

Marital status

The associations between marital status and each BH and CR outcomes in the full sample are presented in Table 2. Marital status was not associated with any BH indicator. However, marital status

Table 2. Associations between marital status and brain health or cognitive reserve

	Previously married (Reference = Married)		Never married (Ref = Married)		Never married (Ref = Previously Married)	
	b [95% CI]	*β*	*b* [95% CI]	*β*	*b* [95% CI]	*β*
Brain health						
Cortical thickness	0.00 [−0.02, 0.02]	0	0.02 [−0.01, 0.04]	0.05	0.02 [0.00, 0.04]	0.05
Total gray matter volume	−41.02 [−97.74, 15.70]	−0.05	−10.16 [−85.49, 65.17]	−0.01	30.86 [41.02, 102.74]	0.03
Hippocampal volume	−85.46 [−206.78, 35.86]	−0.05	−27.70 [−188.82, 133.42]	−0.01	57.76 [−95.99, 211.51]	0.03
White matter hyperintensities	0.04 [−0.05, 0.12]	0.04	−0.03 [−0.15, 0.08]	−0.02	−0.07 [−0.18, 0.04]	−0.05
Cognitive reserve						
Memory residual	−0.11 [−0.22, −0.01]	−0.08*	−0.07 [−0.21, 0.07]	−0.04	0.04 [−0.09, 0.18]	0.02

Note: Estimates represent b = unstandardized coefficient [Lower Bound, Upper Bound 95% confidence interval], β = standardized coefficient, * $p < .05$. The models controlled for age, sex/gender, education, and race and ethnicity. [a]Unstandardized residual score after regressing out total intracranial volume (TICV). [b]Unstandardized residual episodic memory composite score after regressing out cortical thickness in AD signature regions, TICV-adjusted hippocampal volume, TICV-adjusted total gray matter volume, and WMH.

Table 3. Race and ethnicity-stratified models of associations between marital status and brain health and cognitive reserve

	Previously married (Reference = Married)		Never married (Ref = Married)		Never married (Ref = Previously Married)	
	b [95% CI]	*β*	*b* [95% CI]	*β*	b [95% CI]	*β*
Non-Hispanic White (*n* = 196)						
Brain health						
Cortical thickness	−0.02 [−0.05, 0.02]	−0.06	0.03 [−0.02, 0.07]	0.09	0.04 [0.00, 0.09]	0.14
Total gray matter volume	−33.96 [−144.41, 76.48]	−0.04	−68.33 [−187.56, 50.90]	−0.07	−34.37 [−165.48, 96.75]	−0.04
Hippocampal volume	21.01 [−218.78, 260.81]	0.01	−126.98 [−385.85, 131.88]	−0.07	−148 [−432.67, 136.67]	−0.08
White matter hyperintensities	0.08 [−0.11, 0.27]	0.06	0.00 [−0.20, 0.20]	0	−0.08 [−0.30, 0.14]	−0.06
Cognitive reserve						
Memory residual	−0.29 [−0.49, −0.08]	−0.21*	−0.11 [−0.33, 0.11]	−0.07	0.18 [−0.06, 0.42]	0.12
Non-Hispanic Black (n = 260)						
Brain health						
Cortical thickness	−0.02 [−0.05, 0.02]	−0.07	−0.01 [−0.05, 0.03]	−0.03	0.01 [−0.03, 0.04]	0.02
Total gray matter volume	−26.71 [−138.80, 85.38]	−0.03	60.36 [−72.49, 193.22]	0.06	87.07 [−24.76, 198.91]	0.09
Hippocampal volume	−83.48 [−331.70, 164.74]	−0.05	86.98 [−207.24, 381.20]	0.04	170.46 [−77.20, 418.12]	0.08
White matter hyperintensities	0.11 [−0.06, 0.28]	0.1	0.03 [−0.16, 0.23]	0.02	−0.08 [−0.24, 0.09]	−0.06
Cognitive reserve						
Memory residual	0.10 [−0.11, 0.32]	0.07	0.13 [−0.12, 0.39]	0.08	0.03 [−0.18, 0.25]	0.02
Hispanic (n = 322)						
Brain health						
Cortical thickness	0.02 [−0.01, 0.05]	0.09	0.04 [−0.01, 0.09]	0.08	0.02 [−0.03, 0.07]	0.04
Total gray matter volume	−27.19 [−109.63, 55.26]	−0.04	−87.27 [−244.89, 70.34]	−0.06	−60.09 [−210.71, 90.54]	−0.04
Hippocampal volume	−99.43 [−272.54, 73.69]	−0.06	−91.73 [−422.69, 239.24]	−0.03	7.70 [−308.59, 323.99]	0
White matter hyperintensities	−0.03 [−0.14, 0.09]	−0.03	−0.07 [−0.29, 0.15]	−0.04	−0.04 [−0.25, 0.16]	−0.02
Cognitive reserve						
Memory residual	−0.11 [−0.22, −0.01]	−0.08*	−0.07 [−0.21, 0.07]	0.04	0.04 [−0.09, 0.18]	0.02

Note: Estimates represent b = unstandardized coefficient [Lower Bound, Upper Bound 95% confidence interval], β = standardized coefficient, * $p < .05$. The models controlled for age, sex/gender, and education.

was linked to CR such that previously married participants had lower CR than their married counterparts ($\beta = -0.08$, $p = .036$). Never married participants did not differ in CR compared to their married counterparts ($\beta = -0.04$, $p = .329$) nor previously married counterparts ($\beta = 0.02$, $p = .524$).

These patterns were not consistent across race and ethnicity or sex/gender. In race and ethnicity-stratified models (Table 3), previously married participants had lower CR than married counterparts among White ($\beta = -0.21$, $p = .006$) and Hispanic ($\beta = -0.08$, $p = .032$) participants, but not among Black participants ($\beta = 0.07$, $p = .352$). When stratified by sex/gender (Table 4), both previously married women ($\beta = -0.12$, $p = .012$) and never married women ($\beta = -0.12$, $p = .016$) had lower CR compared to married women. There were no associations between marital status and CR among men.

A series of sensitivity analyses performed. In a model that categorized marital status into four groups (i.e., divorced/separated and widowed were distinguished), among White and Hispanic participants, the lower CR effects of previously married groups were driven by the divorced group. Among women, both divorced and widowed participants showed lower CR than married counterparts (Supplementary Table 2). Additionally, associations described in the main model remained significant after controlling for living arrangement, disease burden, functional impairment, and household income (Supplementary Table 3).

https://doi.org/10.1017/S1355617724000638 Published online by Cambridge University Press

Table 4. Sex/gender-stratified models of associations between marital status and brain health and cognitive reserve

	Previously married (Reference = Married)		Never married (Ref = Married)		Never married (Ref = Previously Married)	
	b [95% CI]	*β*	*b* [95% CI]	*β*	*b* [95% CI]	*β*
Men ($n = 282$)						
Brain health						
Cortical thickness	−0.02 [−0.05, 0.01]	−0.07	0.01 [−0.03, 0.05]	0.03	0.03 [−0.01, 0.07]	0.09
Total gray matter volume	−86.16 [−186.24, 13.92]	−0.09	31.75 [−100.16, 163.65]	0.03	117.91 [−23.18, 258.99]	0.1
Hippocampal volume	−138.07 [−361.80, 85.66]	−0.07	113.81 [−181.04, 408.67]	0.04	251.88 [−63.50, 567.27]	0.1
White matter hyperintensities	0.05 [−0.09, 0.20]	0.05	0.05 [−0.14, 0.24]	0.03	−0.01 [−0.21, 0.20]	−0.003
Cognitive reserve						
Memory residual	−0.05 [−0.23, 0.13]	−0.03	0.16 [−0.08, 0.40]	0.08	0.21 [−0.05, 0.47]	0.11
Women ($n = 496$)						
Brain health						
Cortical thickness	0.01 [−0.01, 0.03]	0.04	0.03 [−0.01, 0.06]	0.08	0.02 [−0.01, 0.04]	0.05
Total gray matter volume	−20.34 [−90.12, 49.44]	−0.03	−26.29 [−118.79, 66.21]	−0.03	−5.95 [−87.96, 76.06]	−0.01
Hippocampal volume	−73.16 [−217.58, 71.26]	−0.05	−103.06 [−294.51, 88.39]	−0.05	−29.90 [−199.64, 139.84]	−0.01
White matter hyperintensities	0.01 [−0.09, 0.12]	0.01	−0.08 [−0.22, 0.06]	−0.06	−0.10 [−0.22, 0.02]	−0.07
Cognitive reserve						
Memory residual	−0.17 [−0.30, −0.04]	−0.12*	−0.21 [−0.38, −0.04]	−0.12*	−0.04 [−0.20, 0.11]	−0.02

Note: Estimates represent b = unstandardized coefficient [Lower Bound, Upper Bound 95% confidence interval], β = standardized coefficient, * $p < .05$. The models controlled for age, race and ethnicity, and education.

Role of living arrangement among non-married older adults

Among those who were previously married ($n = 386$), their current living arrangement was not associated with their BH or CR (Table 5). Among those who were never married ($n = 118$), participants living with others had lower cortical thickness than those living alone ($\beta = -0.19$ $p = .030$) but were similar in other indicators of BH and in CR. Stratified models of never married subsample (Supplementary Table 4) revealed that lower cortical thickness of those living with others was only found among Hispanic participants ($\beta = -0.56$, $p = .029$). Additionally, living with others was only associated with smaller total gray matter volume ($\beta = -0.27$, $p = .046$) and hippocampal volume ($\beta = -0.40$, $p = .004$) among never married White participants.

Discussion

The present study of older adults examined whether marital status is associated with indicators of BH and CR, as well as the association between living arrangement and these outcomes among currently unmarried individuals. Marital status was associated with CR, but not BH, in this sample. Compared to being married, being previously married (i.e., divorced, widowed, and separated) was associated with lower CR in the full sample, among White and Hispanic participants and among women, but not among Black participants or men. Only among women, never being married was also linked to lower CR compared to being currently married. These associations persisted even after controlling for living arrangement, disease burden, functional impairment, and household income. Currently living with others was associated with worse BH among never married individuals, but not among previously married individuals. Overall, these results show that marital status is a salient sociodemographic factor associated with cognitive health, especially in the cognitive reserve of older adults.

Marital status and cognitive reserve

We found that previously married older adults had lower CR than their married counterparts in general. This finding complements many of the previous studies that examined marital loss and dementia risk among older adults (Brown et al., 2021; Liu et al., 2019, 2020; Liu et al., 2021; Sommerlad et al., 2018; Zhang et al., 2021). There are several reasons why marital status may be associated with CR. In line with the marital resource model, the dissolution of marriage via divorce, widowhood, or separation would be linked to considerable disruption in socioeconomic resources that were accessible during marriage. It is notable that the negative effect of experiencing marital dissolution on cognitive reserve persisted even after controlling for income, which is also consistent with the existing studies (Liu et al., 2020; Zhang et al., 2021). This finding suggest that the benefit of being married is not fully explained by access to financial resources. Although, we note that we only examined current household income. Given that our sample is older adults, it is possible that wealth and assets may be more influential indicators of financial resources and may also better capture lifelong access to shared financial resources via marriage. It is also possible that benefits of marriage come from non-financial aspects such as interpersonal processes. Having a spouse can provide cognitive stimulation and social resource sharing that can build and maintain CR. Living with a spouse or partner often involves cognitively demanding conversations rooted in shared experiences as well as perspective taking. For example, collaborative social interactions that involve social cognition (e.g., empathy, mentalizing, symbolic interaction) engage executive functions (Ybarra et al., 2008; Ybarra et al., 2011). These frequent spousal interactions could be an important source of social and cognitive stimulation (Fratiglioni et al., 2004), which is a key mechanism in building and maintaining CR (Barulli & Stern, 2013). In addition, the benefits of individual-level resources such as education can be shared in couples. It is

Table 5. Associations between living arrangement (living with others compared to living alone) and brain health and cognitive reserve among unmarried adults

IV: living with others (ref: living alone)	Previously married ($n = 370$)		Never married ($n = 112$)	
DV	*b* [95% CI]	*β*	*b* [95% CI]	*β*
Brain health				
Cortical thickness	−0.01 [−0.03, 0.02]	−0.03	−0.05 [−0.10, −0.01]	−0.19*
Total gray matter volume	3.45 [−68.09, 75.00]	0.004	−99.86 [−248.61, 48.89]	−0.10
Hippocampal volume	−0.51 [−147.83, 146.80]	0.00	−130.68 [−421.48, 160.13]	−0.08
White matter hyperintensities	−0.02 [−0.12, 0.09]	−0.02	−0.03 [−0.26, 0.20]	−0.03
Cognitive reserve				
Memory residual	0.00 [−0.14, 0.14]	0.00	0.02 [−0.29, 0.32]	0.01

Note: Models controlled for age, sex/gender, education, race and ethnicity. * $p < .05$.

shown that one's spouse's education level is associated with a higher level of and slower decline in cognitive functioning independent of their own education (Xu, 2019). Education is a primary source of CR that attenuates the association of brain pathology and cognition (Bennett et al., 2003); marriage could promote CR by extending the benefits of education to both partners.

The stress model may further help to explain the negative association between marital dissolution and CR. Often deemed as one of the most stressful life events (Miller & Rahe, 1997), death of the spouse involves grief that can greatly affect mental health, especially in the acute phase (Lin & Brown, 2020). In divorce and separation, lower CR may not be stemming from the end of marriage itself but from the extended exposure to negative marital quality that would have proceeded it (Liu et al., 2021). Practical stressors such as a decrease in income or managing responsibilities alone could lead to chronic stress that could also hinder maintenance of CR. In the reversed case, marriage may be protective of CR because intimacy and emotional support provided by one's spouse can buffer the effects of external stressors. To shed light on the processes underlying associations between marital dissolution and CR, future studies could investigate the role of mediators such as loneliness or loss of social network, which are linked to worse cognitive functioning (Harrington et al., 2023).

Regarding sex/gender differences, detrimental effects of marital dissolution and never entering marriage on CR were only found among women. Some studies have reported similar findings, such that one's marital history was impactful on memory trajectory only for women (Zaheed et al., 2021). However, the literature presents mixed findings, with some studies indicating that men may be more susceptible to cognitive decline associated with marital disruption (Feng et al., 2014; Zhang et al., 2021; van Gelder et al., 2006). Again, the resource model may help to explain the salience of marital status for women's CR. Women face substantial disruption in household income and assets after divorce or widowhood (Angel et al., 2007). It is possible that older women have more limited access to resources outside of marriage than men due to structural socioeconomic inequities experienced over their lifetime (Angel et al., 2007).

We found that marital status was not associated with CR among Black older adults. This finding is in contrast to a previous study that found stronger negative effects of divorce and widowhood on dementia risk for Black older adults compared to White older adults (Zhang et al., 2021). However, the discrepancy of findings may stem from differences in outcome (i.e., risk of being classified as having dementia vs. a memory residual reflecting cognitive reserve) and marital categories (i.e., we combined divorced and widowed). It is possible that higher involvement with extended families and religious congregations (Taylor et al., 2013) protect Black older adults from the negative effects of marital dissolution or never entering marriage. Future studies could explore other mediators such as social network engagement and participation to detangle the mechanisms of marital effects and its racial/ethnic differences.

Marital status and brain health

Contrary to our hypothesis, marital status was not associated with any indicators of BH in the full sample or among socio-demographic subgroups. This is consistent with Sharifian et al., (2022)'s null finding on cortical thickness. The fact that we did not find an effect of marital status on BH outcomes but only in CR suggests that the commonly reported marital status effects on cognition are more likely to be a functional process rather than a reflection of structural changes and neuropathology. Future studies with larger sample and a more direct indicator of neuropathology (e.g., amyloid) could be useful to corroborate our null findings.

The role of living arrangement

Contrary to our hypotheses, current living arrangement (i.e., living alone vs. living with others) were not associated with CR or BH for previously married older adults. Living with others was linked to *lower* cortical thickness compared to living alone among those who were never married. Because it is a cross-sectional study, we cannot rule out the possibility of reverse causation where declining cognition could have prompted older adults to live with others rather than remain living alone. Additionally, these results are based on a very small subsample and may not be reliable. Furthermore, living alone, particularly as a never married person, may not be an adequate indicator of social isolation or a lack of social stimulation because many older adults prefer to live *near*, rather than *with*, their families (Raymo et al., 2019). Future longitudinal studies should consider these decision processes to better capture the nuanced relationship between living arrangement and cognitive health for unmarried older adults.

Limitations and future directions

There are limitations to this study. First, the study used an assessment of marital status at a single time point, which does not capture the lifetime marital history. Growing evidence shows that many factors contribute to the complexity in links between marital status and cognitive impairment; duration of being unmarried (Zaheed et al., 2021), timing of divorce and widowhood (Zhang et al., 2022), and relationship quality within marriage (Liu et al., 2021) have been shown to have cognitive implications. Second, the

https://doi.org/10.1017/S1355617724000638 Published online by Cambridge University Press

residual method of quantifying CR may capture unmeasured aspects of brain health. However, we addressed this limitation by including structural MRI indicators beyond those included in foundational studies (Reed et al., 2010; Zahodne et al., 2013). Third, living arrangement of the WHICAP sample in Northern Manhattan may not adequately represent older adults living in suburban/rural regions. Additional research is needed to determine whether these results would generalize beyond this specific urban context. However, there are many strengths of the study which include the examination of multiple MRI based BH biomarkers, examination of BH and CR within the same sample, analysis of heterogeneity across racial/ethnic and sex/gender groups of similar sizes, disaggregation of unmarried individuals into those who are previously versus never married, consideration of living arrangement in addition to marital status, and the use of a community-based sample.

Conclusions

The current study showed that marital dissolution and never being married may be harmful to cognitive health by hindering the development or maintenance of CR for many groups of older adults. Lack of evidence for BH suggests that CR may be a more prominent pathway linking marital status to cognition. Different patterns of association across race/ethnicity and sex/gender point to differential impact of life experiences on cognitive health. Our findings can lead future research seeking to identify modifiable social resources relevant to dementia risk, help practitioners to recognize high-risk individuals based on marital status, and inform the development of targeted interventions.

Supplementary material. The supplementary material for this article can be found at https://doi.org/10.1017/S1355617724000638.

Acknowledgements. Data collection and sharing for this project was supported by the Washington Heights-Inwood Columbia Aging Project (R01AG054520, R01AG072474, P01AG07232, R01AG037212, RF1AG054023, R56AG034189, R01AG034189) funded by the National Institute on Aging (NIA). This manuscript has been reviewed by WHICAP investigators for scientific content and consistency of data interpretation with previous WHICAP publications. We acknowledge the WHICAP study participants and the WHICAP research and support staff for their contributions to this study. Ji Hyun Lee was supported by Alzheimer's Association [AARFD-22-970207]; Emily P. Morris was supported by NIA [F31AG077758]; Afsara Zaheed was supported by NIA [F31AG067717]; Ketlyne Sol was supported by NIA [P30AG059300; K01AG073588, R01AG082307], National Center for Advancing Translational Sciences [KL2TR002241; UL1TR002240], and the Antonia Lemstra Fund at the Michigan Alzheimer's Disease Resource Center.

Competing interests. The authors report no conflicts of interest.

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