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Mother's education and late-life disparities in memory and dementia risk among US military veterans and non-veterans

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Abstract

Background: Adverse childhood socioeconomic status (cSES) predicts higher late-life risk of memory loss and dementia. Veterans of U.S. wars are eligible for educational and economic benefits which may offset cSES disadvantage. We test whether cSES disparities in late-life memory and dementia are smaller among veterans than non-veterans.

Methods: Data came from U.S.-born men in the 1995–2014 biennial surveys of the Health and Retirement Study (N=7,916 born 1928–1956, contributing N=38,381 cognitive assessments). Childhood SES was represented by maternal education. Memory and dementia risk were assessed with brief neuropsychological assessments and proxy reports. Military service (non-veteran/veteran) was evaluated as a modifier of the effect of maternal education on memory and dementia risk. We employed linear or logistic regression models to test whether military service modified

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the effect of maternal education on memory or dementia risk, adjusting for age, race, birthplace, and childhood health.

Results: Low maternal education was associated with worse memory than high maternal education (β=−0.07SD,95%CI:−0.08,−0.05), while veterans had better memory than non-veterans (β=0.03SD,95%CI:0.02,0.04). In interaction analyses, maternal education disparities in memory were smaller among veterans than non-veterans (difference in disparities=0.04SD,95%CI: (0.01,0.08),p=0.006). Patterns were similar for dementia risk.

Conclusions: Disparities in memory by maternal education were smaller among veterans than non-veterans, suggesting military service and benefits partially offset the deleterious effects of low maternal education on late-life cognitive outcomes.

Introduction

A growing literature links childhood socioeconomic status (cSES) with cognitive function in late life[1–5]. Childhood SES may influence cognitive reserve, i.e., a high level of cognitive function, which delays manifestation of the consequences of accumulating neurodegenerative or cerebrovascular disease as the individual ages, and thereby delays dementia diagnosis. The development of cognitive reserve likely begins in early childhood, but may also be augmented throughout the lifecourse[6]. In this way, higher SES may increase cognitive reserve at any age, potentially resulting in slower declines in cognitive function in late life, reducing dementia risk.

Evidence increasingly suggests that improvements in SES throughout the lifecourse may offset the adverse effects of childhood socioeconomic adversity on late-life cognitive function[2]. Analyses leveraging natural experiments indicate that educational attainment predicts better memory[7,8] and lower dementia risk[9] among older adults. Numerous social policies, including benefits for military veterans[10,11] improve adult SES. In particular, U.S. military service since the World War II era (U.S. involvement: 1941 – 1945) has conveyed social and economic benefits to veterans, including college education subsidies; these benefits have been shown to increase SES in multiple dimensions[11–13] and improve health[14,15]. Furthermore, evidence suggests that groups that experience socioeconomic disadvantage in childhood may disproportionately benefit from military service and benefits in terms of economic[12] and health outcomes; Korean War GI Bill eligibility predicts smaller socioeconomic disparities in markers for mental health[14] and lung function[15] among veterans compared to non-veterans. To date, we have no evidence on whether such policies reduced socioeconomic disparities in late-life cognitive function.

In this study, we test the hypothesis that military service in the Korean (U.S. involvement: 1950 – 1953) or Vietnam Wars (U.S. involvement: 1964 – 1975) offset the effects of low maternal education (a marker of cSES[16]) on late life memory or dementia risk among US men, i.e., we hypothesize that disparities in late-life memory by maternal education are smaller among veterans compared to non-veterans. Evaluating the long-term impact of educational benefits conferred by military service is particularly salient now as the policies providing these benefits became substantially less generous after the Vietnam War[17].

Methods

Sample

Data come from the U.S. Health and Retirement Study (HRS), a national, observational, longitudinal sample of non-institutionalized adults 50 years and older and their spouses. Respondents have been interviewed biennially since 1992[18]. Every 6 years a new cohort of individuals aged 50 – 55 years is added to maintain a "steady state" sample[19,20]. We used outcome data from 1995–2014 in these analyses.

To ensure non-veterans were age-eligible for Korean War and Vietnam War era military service, analyses were restricted to U.S.-born men in the 1928 to 1956 birth cohorts. These birth cohorts were selected to exclude men age-eligible to serve in World War II (WWII ended in 1945, meaning men born in 1927 would have been 18 at the time the war ended), and to exclude men who were too young to serve in the Vietnam War (the Vietnam War ended in 1975, meaning men born in 1957 would have been 18 at the time the war ended). The total eligible sample was 9,743 men. We excluded 1,453 men with missing outcome data, and 374 men with missing covariate data, yielding an analytic sample size of N = 7,916 (81%) men contributing 38,381 cognitive assessments. WWII veterans were excluded because over 75%[21] of the age-eligible population served in WWII, suggesting the remaining non-veterans were markedly different, and therefore unlikely to be a credible control population.

Outcome

Outcome measures were imputed memory score and dementia probability from 1995 – 2014. Memory score and dementia probability were composite measures that combined proxy and direct assessments for those too impaired to participate themselves (usually spouses), developed previously[22]. The direct assessment of memory used immediate and delayed word recall and the validated Informant Questionnaire for Cognitive Decline (IQCODE)[23], while the proxy assessment asked respondents to rate participants memory on a 5-item Likert scale, and complete a short-form 16-item IQCODE; memory was standardized to the 1995 standard devation[24]. The dementia probability algorithm was developed to use immediate and delayed word list recall, Telephone Interview for Cognitive Status, and the IQCODE to identify who would meet the DSM III-R or DSM IV dementia definition[22].

Exposures

Mother's educational attainment (a marker of childhood SES[16]) and military service are the primary exposures in our analyses. We considered several operationalizations of cSES, including mother's education, father's education, childhood financial instability, childhood average financial resources, and a validated cSES index[16]. We used mothers' education because it was a stronger predictor of both outcomes and the hypothesized mediator (educational attainment) than alternative operationalizations (see Appendix Table 1 for details). We included alternative operationalizations of cSES in sensitivity analyses to check robustness (Appendix Tables 2a and 3a).

We separated mothers' education into low (<8years/missing data, N=1,258), middle (8≤years schooling<12, N=2,643), and high maternal education groups (≥12 years, N=4,015). In order to take advantage of all information available on mother's education, we used continuous data on mother's education (0–17+ years) imputed by previously[16]. We recoded individuals with missing information on mother's education as "low maternal education" as prior work indicates the missingness is informative; excluding those with missing cSES data disproportionately excludes more socially vulnerable individuals, potentially biasing estiamtes[16].

HRS respondents were asked if they had served in the military and if so, their years of service, which we used to categorize veteran status. For both the Korean and Vietnam Wars, the period of GI Bill eligibility extended beyond the end date of the war; we used the dates of GI Bill eligibility to operationalize the exposure: Korean War era military service / GI Bill eligibility (service: 1950–1954)[25,26] and Vietnam War era military service / GI Bill eligibility (service: 1955–1976)[27,28]. An estimated 43% of Korean War veterans and 76% of Vietnam War veterans used the education subsidy provided by the respective GI Bills[29]. In primary results, we combined veterans from both wars because estimates were substantively similar for both outcomes (Appendix Table 4). HRS did not collect data on use of GI Bill benefits, so these analyses focus on GI Bill eligibility; it is appropriate to focus on eligibility (rather than receipt of benefits) to understand the effect of a policy. Additionally, as those who were eligible and used these benefits likely differ substantially, and in ways we cannot measure, from those who were eligible but did not use the benefits, focusing on eligibility allows us to avoid substantial confounding.

Covariates

Other covariates included age and age-squared, race (non-Hispanic White, non-Hispanic Black, Hispanic, Other race), birth in a Southern state[30], and self-reported childhood health (excellent=ref, very good, good, fair, poor). We also included indicators for whether this was the respondents' first cognitive assessment (to account for practice effects with repeated cognitive assessments[31]) and interview wave year (fixed effect). In supplemental analyses, we additionally adjusted for common reasons for rejection for military service[32] (in the subsample with more detailed childhood health data), as well as additional measures of cSES (continuous father's education with a missing indicator, and height as an additional marker of childhood social and nutritional circumstances), and for the respondent's educational attainment (spline with a knot at 12 years, a discontinuity at 16 years, and an indicator for a GED[33]; Appendix Tables 2b and 3b). We considered a childhood health by veteran interaction term and found no evidence of an interaction in predicting memory or dementia (results available upon request).

The respondent's educational attainment and other markers of adult SES or adult health are downstream consequences of military service and therefore potential mediators of the relationship between military service and cognition (rather than confounders). Adjusting for mediators of the relationship of interest can result in incorrect inferences[34].

Analysis

We used generalized estimating equations with an identity link (linear models for memory), or logit link (for dementia probability) with an exchangeable correlation structure to examine the relationships between maternal education and later life cognition using outcome data from 1995–2014 while accounting for repeated measures. Model 1 examined the main effects of maternal education and military service, adjusting for: age, race, Southern birth, self-reported childhood health, practice effect, and interview wave. Model 2 additionally included an interaction term between maternal education and military service. Analyses were conducted using Stata 15 and SAS version 9.3. These analyses were determined not human subjects research by the Stanford University IRB.

Results

Sample Characteristics

There were 1,258 (15.9%) men from low maternal education backgrounds, 2,643 (33.4%) men from middle maternal education backgrounds, and 4,015 (50.2%) men from high maternal education backgrounds in this analysis. Men from lower maternal education backgrounds were older (average year of birth 1940 vs. 1944), more likely to be minorities (59% non-Hispanic White vs. 86%), more likely to be born in the South (65% vs. 30%), and less likely to report excellent health in childhood than men from high maternal education backgrounds (49% vs. 58%, Table 1).

Main Analysis

Low maternal education predicted poorer late life memory (low vs. high maternal education disparity in memory β=−0.07 SD, 95%CI:(−0.08,−0.05)), while veteran status predicted better late life memory (β=0.03 SD, 95%CI:(0.02,0.04); Table 2, Model 1). In interaction models, low maternal education predicted poorer memory among non-veterans (low vs. high maternal education disparity among non-veterans β=−0.09 SD, 95%CI:(−0.11,−0.07)), while the maternal education disparity among veterans was smaller (difference in low vs. high maternal education disparity among veterans β=0.04 SD, 95%CI:(0.01,0.08); Table 2, Model 2). For comparison, the estimated effect of one year of age on memory in these models was −0.04, equivalent to the difference in disparities for veterans compared to non-veterans. There was no differential effect of veteran status on memory for middle maternal education veterans (Table 2, Model 2).

Low maternal education also predicted higher odds of dementia (OR=1.72, 95%CI: (1.36,2.18)), while veteran status predicted lower odds of dementia (OR=0.72, 95%CI: (0.61,0.86); Table 3, Model 1). In interaction analyses, low maternal education predicted higher odds of dementia among non-veterans (low vs. high disparity among non-veterans OR=2.09, 95%CI:(1.53,2.84)), while the difference in maternal education disparities among veterans was smaller (difference in low vs. high maternal education disparity among veterans OR=0.64, 95%CI:(0.41,1.01)). For comparison, the estimated effect of one year of age on dementia risk in these models was log odds ratio=0.16, while the difference in low vs. high maternal education disparity was log odds ratio=0.44 indicating that the difference in disparities among veterans was equivalent to aging 2.8 years. There was no differential

effect of veteran status on dementia risk for middle maternal education veterans (Table 3, Model 2).

Sensitivity Analyses and Robustness Checks

Findings were substantively similar in several sensitivity analyses, including models that adjusted for additional measures of childhood SES and common reasons for rejection for military service; used alternative operationalizations of childhood SES (Appendix Tables 2 and 3); or examined Korean War and Vietnam War veterans with separate indicator variables (Appendix Table 4). The relationship between maternal education and both cognitive outcomes was substantially attenuated after adjusting for the respondent's educational attainment, consistent with our hypothesis that benefits of veteran status on late life cognition may be mediated by increases in educational attainment (Appendix Tables 2b and 3b, Model 7)[34].

Discussion

We found evidence of childhood socioeconomic disparities in memory score and dementia risk, and found veteran status predicted better memory and lower dementia probability. Military service and benefits predicted smaller socioeconomic disparities in memory score (difference in disparities equivalent to aging 1 year). Dementia results were in the same direction, although the confidence interval just included the null; the difference in disparities for dementia was equivalent to aging 2.8 years. Overall, these results suggest military service and benefits may partially offset the adverse consequences of early-life socioeconomic disadvantage on late life memory and dementia risk.

On an individual level, these results can seem small (difference in disparities equivalent to aging 1–3 years on average). However, on a population level, the effect of military service and benefits on delaying memory decline and dementia among a high-risk population may be substantial; an estimated 2.4 million veterans from the Korean War and 8.2 million veterans from the Vietnam War[29] used the GI Bill, our primary hypothesized mechanism, making the GI Bill a massive social exposure. Our findings that low maternal education veterans disproportionately benefited from this population-level exposure, suggests military service and benefits may have shifted the distribution of memory score and dementia risk towards a lower-risk distribution for a high-risk population, similar to the "Population Strategy" proposed by Rose[35]. As the United States population continues to age, more cases of dementia are expected; prior work has noted that if interventions could be identified that delay the onset of Alzheimer's disease, a common form of dementia, by 2 years, there would be nearly 2 million fewer cases than currently projected over 50 years[36], a major public health impact. Our results suggest that military service and benefits are an intervention that delays dementia onset by more than 2 years. Given that a year of caregiving and medical expenses for dementia costs an estimated $56,290 (in 2010 dollars)[37], the cost savings for delaying the onset of dementia by 2.8 years, just among the 468 low maternal education veterans in this dataset, is more than $72 million.

The hypothesized pathway from military service to cognitive function is through increased educational attainment (Figure 1), and the development of increased cognitive reserve[6].

There are several ways by which military service may increase educational attainment. First, veterans from the Korean and Vietnam Wars were eligible for generous college education subsides, reducing college costs for Korean War veterans by an estimated 39 – 71%[38]. The VA estimates that 76% of Vietnam veterans and 43% of Korean War veterans used these educational benefits[29]; in these data, we found low maternal education veterans had an additional 1.6 years of education compared to low maternal education non-veterans. Second, military veterans may be more desirable to educational institutions (or employers)[39]. Third, military service may serve as a bridging environment, teaching socially vulnerable men how to navigate bureaucracies[40], and other soft skills that are beneficial in higher education and in the labor markets. Fourth, the physical and mental demands of military service may build confidence to overcome obstacles, such as the work load and cognitive demands of going to college, that that previously felt overwhelming[41]. Finally, military service provides time away from formal education for individuals to grow and mature, potentially improving educational outcomes upon return.

These analyses add to the nascent literature that interventions and policies that increase educational attainment may improve cognitive health in older adulthood. By leveraging exogenous variation in compulsory schooling laws in the United States and England, prior work has suggested there is a causal effect of education on memory and dementia risk[7–9]. Our results are broadly supportive of these prior findings. However, our analyses also add that those from low maternal education backgrounds may particularly benefit from this type of social exposure, resulting in smaller socioeconomic disparities. Similar findings of smaller socioeconomic disparities among GI Bill-eligible veterans compared to non-veterans for mental[14] and physical[15] health outcomes makes us more confident in these results.

There are several limitations to these analyses. First, healthy individuals may be more likely to serve in the military, meaning the findings of smaller disparities among veterans may be at least partially due to pre-service differences in cognitive abilities. In supplemental analyses, adjusting for common reasons for rejection for military service[32] did not change our conclusions. It also seems plausible that individuals were rejected for military service based on physical health rather than cognitive health, suggesting these outcomes may be less subject to unmeasured confounding than physical health markers. Military service influences numerous exposures that may be relevant to late life cognition, including trauma, physical injury, as well as the socioeconomic benefits provided by the GI Bill. We are unable to disentangle these mechanisms with the existing data. Second, there is the possibility of selective survival, such that individuals with lower IQ were more likely to die in combat[42], and those with better cognitive health are more likely to survive to the age of our study initiation, and therefore be included in these analyses. However, similar findings among veterans from two different time periods and age groups increases our confidence in these results. Finally, these analyses were restricted to men, and it is unclear if these relationships will hold among women.

We found that maternal education disparities in memory were smaller among veterans compared to non-veterans; results for dementia risk were in the same direction. While not conclusive, these findings suggest that military service and benefits may partially offset the adverse consequences of low maternal education by improving cognitive reserve, possibly

through increased educational attainment. However, these findings may not generalize to current service members as today's GI Bill is substantially less generous than the GI Bills we studied in these analyses[17], and because today's veterans are targeted by low-quality, for-profit colleges[43]; such colleges may not help in the development of cognitive reserve. If the current GI Bill was strengthened to provide more generous college education benefits to veterans attending high-quality institutions, our results suggest this investment may pay large dividends in the long-term to health insurance providers, and the VA in particular, by delaying the onset of costly conditions such as dementia. Our results suggest similar population-level social policies may reduce socioeconomic disparities in cognitive function and improve population health.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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What is already known on this subject?

Socioeconomic adversity in childhood predicts poorer memory and higher dementia risk among older adults, while higher educational attainment predicts better memory and lower dementia risk. Evidence from natural experiments suggests the relationship from education to memory and dementia is causal. However, we do not know if those who experience socioeconomic adversity in childhood benefit more than others from social policies that promote education, resulting in smaller socioeconomic disparities among those exposed to the policy compared to those unexposed to the policy.

What this study adds?

We compare memory and dementia disparities by maternal education (a marker of childhood SES) among veterans, who were eligible for generous college education subsidies through the GI Bills, to non-veterans. We find that maternal education disparities in memory were smaller among veterans compared to non-veterans. These results suggest that military service and benefits may partially offset the deleterious effects of low maternal education on late-life cognitive outcomes, resulting in smaller disparities.

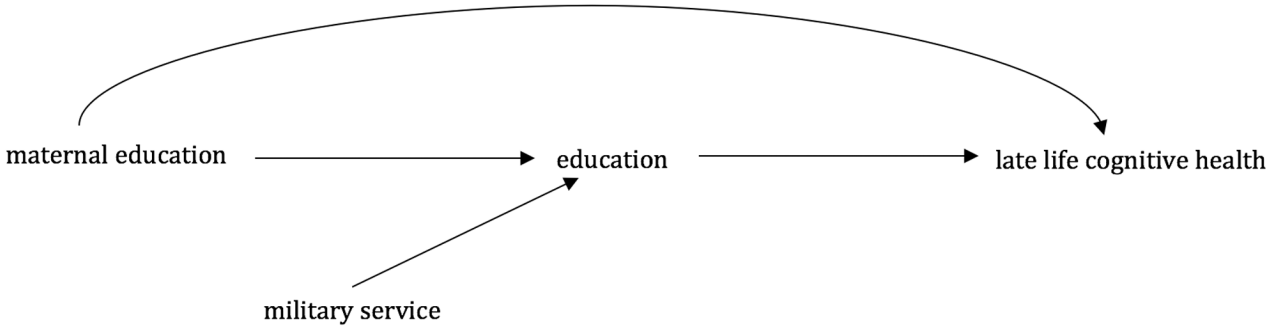

Figure 1. Military service as a hypothesized effect modifier of the relationship between cSES and late life cognitive health

We hypothesized that maternal education predicts late life cognitive health, and that military service modified the relationship between maternal education and late life cognitive health. We hypothesized that the increase in educational attainment associated with military service and benefits benefited those from low maternal education backgrounds disproportionately, resulting in smaller socioeconomic disparities in cognitive function.

Table 1.

Distribution of confounding and outcome variables by cSES (N = 7,916)

	Low maternal education (N = 1,258, 15.9%)		Middle maternal education (N = 2,643, 33.4%)		High maternal education (N = 4,015, 50.2%)		p-value for difference across maternal education categories[1]
	N / mean	% / sd	N /mean	% / sd	N /mean	% / sd	
Birth year (mean, sd)	1939.8	8.5	1939.6	7.9	1944.0	8.5	< 0.0005
Veteran status							< 0.0005
Non-veteran	789	62.8	1,553	58.8	2,590	64.5	
Korean War veteran	210	16.7	456	17.3	392	9.8	
Vietnam War veteran	259	20.6	634	24.0	1,033	25.7	
Race							< 0.0005
Non-Hispanic White	740	58.8	2,075	78.5	3,448	85.9	
Non-Hispanic Black	457	36.3	519	19.6	500	12.5	
Hispanic	10	0.8	3	0.1	5	0.1	
Other Race	51	4.1	46	1.7	62	1.5	
Height (meters; mean, sd)[2]	1.8	0.1	1.8	0.1	1.8	0.1	< 0.0005
Southern birth	815	64.8	1,096	41.5	1,190	29.6	< 0.0005
Childhood health (<16 years)							< 0.0005
Excellent	612	48.7	1,363	51.6	2,343	58.4	
Very good	301	23.9	688	26.0	1,006	25.1	
Good	256	20.4	438	16.6	489	12.2	
Fair	62	4.9	118	4.5	146	3.6	
Poor	27	2.2	36	1.4	31	0.8	
Outcomes							
First available memory score (sd units; mean, sd)[3]	1.01	0.41	1.13	0.33	1.23	0.27	< 0.0005
First available dementia probability (mean, sd)	0.02	0.09	0.01	0.05	0.00	0.04	< 0.0005

1. p-values come from chi-squared tests for categorical variables and one-way anovas for continuous variables

2. Using 2-sample ttests, we found the height of the high cSES group (1.792) is different than the low cSES (1.769) and middle cSES (1.773) groups (both p < 0.0005); height for low and middle cSES groups are not different (p = 0.29)

[3]Memory score was standardized to the 1995 standard deviation

Memory score is coded so higher values reflect better functioning; dementia probability is coded so higher values reflect poorer functioning.

Low maternal education is mother's education < 8 years / missing data on mother's education; middle maternal education is 8 years ≤ mother's education < 12 years; high maternal education is mother's education ≥ 12 years

Table 2.

Childhood SES, veteran status, and memory

	Model 1: Main Effects Model			Model 2: Interaction Model		
	Beta	**95% CI**	**p-value**	**Beta**	**95% CI**	**p-value**
Intercept (high cSES non-veteran)	0.94	(0.82, 1.06)	< 0.0005	0.94	(0.82, 1.06)	< 0.0005
Maternal education (high = ref)						
Low	−0.07	(−0.08, −0.05)	< 0.0005	−0.09	(−0.11, −0.07)	< 0.0005
Middle	−0.04	(−0.05, −0.03)	< 0.0005	−0.04	(−0.05, −0.02)	< 0.0005
Veteran	0.03	(0.02, 0.04)	< 0.0005	0.03	(0.01, 0.04)	< 0.0005
Interaction terms						
Low cSES * veteran				0.04	(0.01, 0.08)	0.006
Middle cSES * veteran				0.00	(−0.02, 0.03)	0.913

Model 1: includes age (linear and quadratic terms), year of outcome assessment, a practice effect, race, and childhood self-reported health

Model 2: adds interaction term between maternal education and veteran status

Table 3.

Childhood SES, veteran status, and dementia

	Model 1: Main Effects Model			Model 2: Interaction Model		
	OR	**95% CI**	**p-value**	**OR**	**95% CI**	**p-value**
Odds in the reference category (high cSES non-veteran)	0.01	(0.00, 0.82)	0.040	0.01	(0.00, 0.72)	0.035
Maternal education (high = ref)						
Low	1.72	(1.36, 2.18)	< 0.0005	2.09	(1.53, 2.83)	< 0.0005
Middle	1.41	(1.15, 1.72)	0.001	1.60	(1.22, 2.09)	0.001
Veteran	0.72	(0.61, 0.86)	< 0.0005	0.91	(0.67, 1.23)	0.524
Interaction terms						
Low cSES * veteran				0.64	(0.41, 1.01)	0.057
Middle cSES * veteran				0.76	(0.51, 1.14)	0.183

Model 1: includes age (linear and quadratic terms), year of outcome assessment, a practice effect, race, and childhood self-reported health

Model 2: adds interaction terms for maternal education * veteran status