Childhood maltreatment confers long-term risk for cognitive impairment: A prospective investigation

Stephanie Assuras [a], Kellie Courtney [b], Molly Maxfield [c], Shaina Shagalow [d], Sara Sherer [d], Jennifer J. Manly [e], Cathy Spatz Widom [b,f,*]

[a] Columbia University Medical Center, The Neurological Institute of New York, 710W. 168th St., New York City, NY 10032, USA
[b] Psychology Department, John Jay College, 524 West 59th Street, New York City, NY 10019, USA
[c] Center for Innovation in Healthy and Resilient Aging, Edson College of Nursing and Health Innovation, Arizona State University, 550N. 3rd St, Phoenix AZ 85004, USA
[d] Department of Neurology, Columbia University, 710W. 168th St., New York City, NY 10032, USA
[e] Gertrude H. Sergievsky Center and the Taub Institute for Research in Aging and Alzheimer's disease, Columbia University, 710W 168th St, NY, NY 10032, USA
[f] Graduate Center, City University of New York, New York City, NY, USA

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ABSTRACT

Importance: Childhood maltreatment has been associated with greater risk for Alzheimer's disease and related dementias. Better understanding of this association will have implications for prevention and intervention efforts.

Objective: To determine whether individuals with documented histories of childhood maltreatment and matched controls differ in cognitive functioning in late midlife and whether maltreatment leads to higher rates of cognitive impairment.

Design: Prospective cohort design

Setting: Metropolitan Midwestern county area

Participants: Children with documented maltreatment histories and demographically matched controls were followed up into late midlife ($N = 447$, Mage = 59.4). Control group children were matched to maltreated children on age, sex, race and ethnicity, and approximate family social class during the time the cases were processed.

Exposure: Children with documented cases of physical and sexual abuse and neglect during 1967 to 1971 in the county juvenile (family) or adult criminal courts. Cases were restricted to children ages 0–11 at the time of the maltreatment to ensure that the temporal direction of consequences was clear.

Main outcome and measures: Using a comprehensive neuropsychological assessment battery, multiple tests of cognitive functioning and the Functional Activities Questionnaire were administered. Participants were categorized as having cognitive impairment with no dementia (CIND) or dementia.

Results: Individuals with histories of childhood maltreatment performed worse on all 12 neuropsychological tests, compared to matched controls (Cohen's d 0.28 to 0.42) and had significantly higher risk for CIND [AOR = 1.86], amnestic CIND [AOR = 1.68] and non-amnestic [AOR = 1.48]. About 13 % of maltreated individuals met criteria for amnestic CIND. Few met criteria for dementia. Males, females, Blacks, Whites, older and younger individuals, and those physically or sexually abused or neglected showed the effects of maltreatment.

Conclusions and relevance: Cognitive repercussions of childhood maltreatment continue into late midlife. Findings reinforce the importance of early detection and preventive interventions that may decrease risks associated with childhood maltreatment in later adulthood. Because we use documented court cases from childhood, this design reduces potential biases associated with reliance on retrospective self-reports of childhood adversities. To our knowledge, this is the first study to examine long-term consequences of childhood neglect for cognitive impairment.

1. Introduction

Childhood maltreatment has been associated with greater risk for Alzheimer's disease and related dementias (ADRD) [1–4]. Each represents a significant public health issue at different points in the lifespan, with a childhood maltreatment incidence rate of 7.7 per 1000 US-based children (558,899 substantiated reports in 2022)[5] and an ADRD prevalence rate of one of every nine older adults (an incidence rate of 4.76 per 1000 older adults, with increasing risk with age) [6]. Each is costly for those directly affected and society at large.

A developing scientific consensus indicates that the "origins of adult disease are often found among developmental and biological disruptions occurring during the early years of life."[7] Scholars and public health officials interested in the determinants of health in later life have begun to adopt a life course perspective to better understand how childhood adversities and cognitive impairment and dementia are associated. However, knowledge about the relationship between childhood adversities and cognitive functioning, mild cognitive impairment (MCI), and Alzheimer's Disease (AD) in old age is limited.

There is increasing recognition of the importance and potential benefits of early identification of cognitive decline and developmental trajectories in individuals at risk for AD. Research has demonstrated that the neuropathological changes associated with ADRD begin decades before clear cognitive and functional decline [8,9]. Cognitive decline reaching the level of mild cognitive impairment (MCI) has also been shown to confer significant risk for progression to dementia [10–13]. Therefore, increased impairment and accelerated decline may manifest before ADRD in individuals exposed to childhood maltreatment. Better understanding of the extent to which childhood maltreatment increases risk for ADRD would have implications for targeted prevention and intervention efforts. Early detection and diagnosis of cognitive impairment may lead to improved efforts at intervention to reduce risk or delay/slow the progression of symptoms. However, aging studies of middle-aged adults are sparse, even though the preclinical phase begins 10–15 years before the onset of the disease.

Consistent with a life course perspective, researchers have hypothesized that long-term consequences of childhood maltreatment, including potential altered stress regulatory functions [14,15], poorer physical health [15–18], increased psychopathology [16,19–22], reduced socioeconomic status, and worse behavioral and social outcomes [23,24], may serve to explain the relationship between childhood adversities and cognitive functioning. Increasingly, research has focused on the impact of childhood maltreatment on neurological development, affecting neuronal integrity, including both brain structure and function, as well as neuropsychological functioning [4,25–28]. In children, the consequences of child maltreatment include deficits in IQ, language, basic and complex attention, and visuo-spatial/motor abilities relative to those without a history of child maltreatment [29,30]. However, the literature is not consistent [26,27,31,32].

This project is a continuation of a prospective longitudinal study of the long-term consequences of childhood abuse and neglect that involved a large group of children with documented histories of physical and sexual abuse and neglect and a demographically matched control group. Both groups have been followed and interviewed over multiple waves of the study. While the study was begun to examine the theory that there was a "cycle of violence" [33], the focus of the study has expanded over the past 35 years to include multiple domains of functioning. The original study was designed to overcome many of the methodological concerns of earlier research and represents a scientifically rigorous approach to understanding the consequences of childhood maltreatment. Focusing on cognitive impairment in late midlife provides an opportunity to determine early risk trajectories that may reveal different types of cognitive decline, susceptibilities to cognitive impairment, or manifestations of deficits in functioning.

Most studies that examine the role of childhood adversities in relation to aging, dementia, or Alzheimer's disease have been based on specialized samples [34], brief cognitive assessments [35], or utilize cross-sectional designs and rely on retrospective reports of childhood adversities and child maltreatment [36]. Cross-sectional studies cannot demonstrate that childhood adversities cause particular outcomes, only that reporting of childhood adversities is associated with certain outcomes. There is also an almost exclusive reliance on retrospective reports of child maltreatment. Baldwin et al [37] demonstrated that prospective and retrospective methods of capturing child maltreatment identified different people. Furthermore, Danese and Widom[38] have demonstrated that research based on retrospective measures of child maltreatment significantly underestimates the extent of deficits in those with versus without a maltreatment history. In addition, the onset of dementia may affect retrospective recall of childhood experiences [39]. Current psychopathology may increase the likelihood of recall of childhood adversities, leading to spurious associations with later outcomes [40]. Our study involves documented court cases from childhood, a design characteristic that reduces the problems and potential biases associated with reliance on retrospective self-reports.

Previous work with this sample examined risk for dementia with data collected when participants were mean age 41 [41]. That study found that 92.3 % of the participants had at least one risk factor for dementia, and 49.5 % had at least 3 risk factors. Individuals with documented histories of childhood maltreatment also had significantly more dementia risk factors compared to controls.

1.1. The current study

The current work describes the new results of a longer-term follow-up of the individuals in this study who are now, on average, 59 years old. The purpose is to determine whether individuals with documented histories of childhood maltreatment and demographically matched controls differ in terms of their cognitive functioning in late midlife and the extent to which they manifest cognitive impairment with no dementia (CIND) [42], or dementia. This study provides a unique contribution to the existing literature. While some longitudinal studies have looked at lifetime cognitive differences and rates of decline in those exposed versus those unexposed to childhood adversities or maltreatment, to our knowledge, few studies have examined CIND or dementia [25]. Importantly, most studies are cross-sectional and rely on retrospective reports of childhood maltreatment, making them susceptible to recall bias [4].

1.2. Research questions

We have three major research questions: (1) Compared to demographically matched controls, are individuals with documented histories of childhood maltreatment at increased risk for cognitive impairment [cognitive impairment with no dementia (CIND), amnestic CIND (aCIND), and non-amnestic CIND (naCIND), and dementia] in late midlife? (2) Does the type of childhood maltreatment (i.e., neglect, physical abuse, and sexual abuse) predict different risk patterns for cognitive impairment and dementia? and (3) Are maltreated individuals who differ in demographic characteristics of sex, race, age, and level of education at differential risk for cognitive impairment and dementia compared to controls?

2. Methods and measures

2.1. Design

The description of the methods for this study are similar to those published previously [43]. This prospective cohort design study of children with documented histories of childhood maltreatment and demographically matched controls who were followed into adulthood builds on existing research and has several advantages. The design includes an unambiguous operationalization of childhood maltreatment, a

comparison group of children matched closely on age, sex, race and approximate family social class background, and a diverse sample of male, female, Black, and White participants who have been followed for more than 30 years across multiple waves of the study.

The initial phase of the study was archival and compared the abused and/or neglected children to the matched comparison group on juvenile and adult criminal arrest records [33]. Subsequent phases of the study involved locating and interviewing the maltreated and comparison groups. In the current analyses, we use information from 1989–1995 (Interview 1: $N = 1196$; $M_{age} = 29.2$ years) and 2022–2023 (Interview 5: $N = 447$, $M_{age} = 59.4$ years).

2.2. Participants

The original sample of maltreated children ($N = 908$) represents substantiated cases of childhood physical abuse, sexual abuse, and neglect processed from 1967 to 1971 in the county juvenile (family) or adult criminal courts of a Midwestern metropolitan area. Cases of abuse and neglect were restricted to children ages 0–11 at the time of the maltreatment (age at petition) to minimize ambiguity and to maximize the likelihood that the temporal direction of consequences was clear. Since it was not possible to assign subjects randomly to groups, the assumption of equivalence for the groups is an approximation.

A critical element of the study design involved the selection of a control group of children without documented histories of child abuse or neglect ($N = 667$) matched with the abused and neglected children on the basis of age, sex, race and ethnicity, and approximate family social class during the time that the abuse and neglect records were processed. Matching for approximate family social class was important because it is theoretically plausible that any relationship between child abuse and neglect and subsequent outcomes may be confounded with or explained by social class differences [33,44,45]. The matching procedure used here is based on proxies for social class that include neighborhood schools that children attended and hospitals of birth. The use of schools and hospital controls to match on variables that are related to outcomes is recommended when random sampling is not possible [46]. The comparison group establishes the base rates of pathology we would expect in a sample of adults from comparable circumstances who did not come to court attention in childhood as victims of abuse or neglect.

Children who were under school age at the time of the abuse and/or neglect were matched with children of the same sex, race, date of birth (±1 week), and hospital of birth through the use of county birth record information. For children of school age, records of more than 100 elementary schools for the same time period were used to find matches with children of the same sex, race, date of birth (±6 months), and class in elementary school during the years 1967–1971. Overall, matches were found for 74 % of the abused and neglected children. Non-matches occurred for a number of reasons. For birth records, non-matches occurred in situations when the abused and neglected child was born outside the county or state or when date of birth information was missing. For school records, non-matches occurred because of the lack of adequate identifying information for the abused and neglected children or because the elementary school had closed and class registers were not available.

Table 1 shows the sample characteristics at all waves of the study. At the first interview, the sample was 48.7 % female and 62.9 % White, non-Hispanic. Participants were asked to identify their race and ethnicity using a list on show cards. For the present analysis, race was categorized as 1) White, non-Hispanic, 2), Black, non-Hispanic, 3) Hispanic, and 4) all others. However, when stratifying by race, we only report results for White, non-Hispanic and Black, non-Hispanic participants, and exclude the small group of individuals who identified as Hispanic, Native American, Pacific Islander, or other ($N = 13$).

As in most longitudinal studies, there was attrition associated with death, refusals, and our inability to locate participants over the various waves of the study. To address potential attrition-related bias, we

Table 1
Descriptive characteristics of participants across the study waves.

	Records	Interviews				
		1	2	3	4	5
DATES	1967-1971	1989-1995	2000-2002	2003-2005	2009-2010	2022-2023
N	1575	1196	896	807	649	447
Childhood maltreatment	57.7	56.5	55.9	56.7	55.2	56.8
Sex (% female)	50.7	48.7	51.0	52.7	53.9	56.7
White (%)	66.2	62.9	62.2	60.4	59.2	58.8
Black (%)	32.6	34.9	35.2	37.3	34.5	35.6
Hispanic (%)	0.3	3.8	4.0	4.0	3.7	3.1
Abuse/neglect (%)	57.7	56.5	55.8	56.8	55.2	56.8
Physical abuse (%)	10.2	9.2	8.8	9.7	8.3	9.2
Neglect (%)	44.3	45.4	45.3	45.9	44.1	45.4
Sexual abuse (%)	9.7	2	7.6	7.5	8.3	8.3
Mean age at interview (SD)		29.2 (3.8)	39.5 (3.5)	41.2 (3.5)	47.0 (3.5)	59.4 (3.6)
Education		11.5 (2.2)	12.2 (7.2)	12.2 (7.5)	12.0 (5.1)	11.7 (2.3)

Note: The numbers of cases of specific types of abuse and neglect do not add up to the total in the abused/neglect group because some individuals (11 %) experienced more than one type of abuse or neglect. Education represents the highest grade of school completed.

compared demographic characteristics and cognitive test scores for participants who completed Interview 5 and those who did not. There were no significant differences in terms of maltreatment status ($p = .92$) or percent White, non-Hispanic ($p = .17$). However, participants in Interview 5 were significantly more likely to be female, younger at Interviews 2 and 3, to report higher levels of education at Interview 1, and to perform better on cognitive tests at Interview 3, including Trail Making A, Trail Making B, and Matrix Reasoning [26]. Because of these findings, inverse probability weighting was applied in subsequent regression analyses.

2.3. Procedures

Field interviewers located and invited participants who had taken part in past waves of the study to take part in the most recent wave (Interview 5). Interviewers conducted a comprehensive cognitive assessment battery, an interview, a brief health exam including height, weight, blood pressure, pulse, and an airway resistance (peak airflow) test, and collected saliva and hair samples. Interviews were delayed because of the Covid epidemic, and when interviews began, personal protective gear was used for both participants and interviewers.

Participants were interviewed in person in their home or other quiet location of their choosing. Interviewers were unaware of the purpose of the study and the inclusion of an abuse/neglect group. Participants were also unaware of the purpose of the study so as to avoid potential demand characteristics stemming from awareness of selection based on a history of maltreatment. In the first wave of the study, participants were told that they had been selected to participate as part of a large group of individuals who grew up in that area during the late 1960s and early 1970s. Institutional Review Board (IRB) approval was obtained for each wave of the study, including the IRB of the City University of New York (Protocol #2015–0133), where the present analyses were completed. Participants provided written or verbal (for those with limited reading ability) informed consent.

Because of concerns with possible limitations in participants' cognitive capacity that might influence whether that participant would be capable of providing informed consent, procedures were in place to determine whether a legally authorized representative was needed to provide consent for the participant. Inspection of interviewer notes

shows that there were 9 individuals where the interviewer noted that "participant is dependent on others or needs assistance; lives in a home that provides help." There were also individuals who had to be read the consent form, either because they had problems seeing or couldn't read, including 14 participants who had trouble reading and/or writing, and 27 had difficulty seeing or hearing.

2.4. Measures

Childhood maltreatment. Childhood maltreatment was assessed through a review of official records processed during the years 1967 to 1971 when children were ages 0–11 years. Neglect cases reflected a judgment that the parents' deficiencies in childcare were beyond those found acceptable by community and professional standards at the time. These cases represented extreme failure to provide adequate food, clothing, shelter, and medical attention to children. Physical abuse cases included injuries such as bruises, welts, burns, abrasions, lacerations, wounds, cuts, bone and skull fractures, and other evidence of physical injury. Sexual abuse cases included fondling or touching, felony sexual assault, sodomy, incest, and rape. Eleven percent of the sample experienced more than one type of maltreatment.

2.4.1. Cognitive status

Multiple tests of cognitive functioning were included in the comprehensive neuropsychological assessment battery. The 12 tests were: *Benson Complex Figure Copy*; Consortium to Establish a Registry for Alzheimer's Disease (CERAD) neuropsychological battery tests[47]: *CERAD Category Fluency Test: Animals, CERAD Word List Learning and Recall (Immediate), and CERAD Word List Recall – Delayed; Verbal Fluency: Phonemic Letter Fluency (S); Multilingual Naming Test (MINT*[48]); *Number Span Test; Symbol-Digit Modalities Test (SDMT* Smith (1982); *Trail Making Test (A and B*[49]); *and Stroop Color and Word Test* [50].

2.4.2. Functional activities questionnaire (FAQ)

Participants were also administered the FAQ[51] and presented with 10 routine activities for daily living, including shopping alone, remembering appointments, traveling out of the neighborhood, etc. For each activity, participants were asked whether in the past 4 weeks they had experienced any difficulty or need for help with each activity. Response options ranged from normal, have difficulty but do by myself, require assistance, or dependent (codes ranged from 0 to 3).

2.5. Determination of cognitive status

To determine cognitive status, raw scores for each cognitive test were transformed into T scores based on population-based norms. Raw data was used for the CERAD Word List Learning Test, Letter Fluency (S), and WRAT because of the lack of appropriate norms. MOAANS and MOANS norms[52–55] were used for Trail Making, Symbol Digit Modalities Test,

and Stroop. Given the ability to stratify by age, sex, and race, data from the Offspring study[56] were used for norms for the Benson Complex Figure Copy Test, Number Span test, Category Fluency Test (animals) Letter Fluency (F) and MINT. In the case of the Offspring study, only the tests administered in English were used for the norms. Norms for the WAIS-III Matrix Reasoning Test were from the manual [57].

Kim et al.[58] have pointed out that one of the problems with the diagnosis of MCI is that there is no consistently applied diagnostic criteria and that the many different definitions sometimes compete with one another. Criteria need to balance the risk of false negatives with false positives. Saxton et al.[59] found that a neuropsychological test-based algorithm for MCI diagnosis was associated with less false positives and better predictions of progression compared to a structured clinical interview method (the Clinical Dementia Rating).

Participants were categorized as having cognitive impairment with no dementia (CIND) if a test normative score was at least 1.5 SD below the population mean (i.e., $T < 35$) and they did not meet the FAQ cut-point for functional dependence (FAQ <9). CIND was further divided into two subtypes: amnestic CIND (aCIND) and non-amnestic CIND (naCIND). Participants were categorized as aCIND if they met criteria for CIND and had scores that were 1.5 SD below the mean on at least one of the two verbal memory measures (CERAD Learning or CERAD Delayed Recall). Participants were categorized as naCIND if they met criteria for CIND and scores on both verbal memory measures (CERAD Learning and CERAD Delayed Recall) were within normal limits (i.e., $T = 36$ or greater). Participants were categorized as having dementia if they met the test normative score criteria for CIND, but had a FAQ cutpoint of 9 or higher (functionally dependent in 3 or more activities) [60].

2.6. Statistical analysis

Bivariate descriptive statistics for the performance of the maltreated and control groups on all cognitive assessment measures were calculated using *t*-tests. To determine effect size, we report Cohen's d. Logistic regressions were then used to determine whether individuals with histories of childhood maltreatment (overall and by types) and controls differed in risk for CIND, aCIND, naCIND, and dementia. Adjusted odds ratios (AORs) and 95 % confidence intervals are reported controlling for participant's sex, race, and age at the time of the interview. Analyses used inverse probability weighting to control for attrition bias. Analyses were repeated stratifying by sex, race, age, and education level. All analyses were conducted in R version 4.2.1, R-package *lavaan* version 0.6–13 [61].

3. RESULTS

3.1. Childhood maltreatment and cognitive tests at mean age 59

Table 2 shows bivariate descriptive statistics comparing individuals

Table 2
Bivariate descriptive statistics for maltreated and control individuals on all individual tests.

	Controls	Maltreated	T test	p	Cohen's d
Benson Complex Figure Copy (M, SD)	15.3 (1.3)	14.6 (2.3)	3.79	**<0.001**	0.35
Category Fluency Test: Animals (M, SD)	19.6 (5.5)	18.0 (5.4)	2.90	**0.004**	0.29
CERAD Word List Learning and Recall (Immediate) (M, SD)	21.9 (3.9)	20.4 (4.4)	3.54	**<0.001**	0.35
CERAD Word List Recall (delayed) (M, SD)	7.8 (1.7)	7.2 (2.0)	3.32	**<0.001**	0.32
Multilingual Naming Test (MINT) (M,SD)	28.7 (2.1)	27.9 (2.4)	3.68	**<0.001**	0.37
Number Span Forward (M, SD)	7.8 (2.4)	6.9 (2.4)	3.74	**<0.001**	0.37
Number Span Backward (M,SD)	6.2 (2.3)	5.3 (2.1)	4.21	**<0.001**	0.42
Symbol-Digit Modalities Test (M,SD)	41.8 (9.8)	38.8 (11.0)	2.82	**0.005**	0.28
Trail Making Test A (M,SD)	33.9 (17.2)	40.8 (24.0)	3.24	**0.001**	0.32
Trail Making Test B (M, SD)	105.5 (67.3)	134.3 (77.8)	3.88	**<0.001**	0.39
Stroop Word Test (M,SD)	84.7 (16.2)	77.7 (18.7)	3.88	**<0.001**	0.40
Stroop Color Test (M,SD)	64.1 (13.2)	59.1 (15.9)	3.44	**<0.001**	0.34

Note. Scores on all tests are raw scores. For Trail Making A & B, the higher the scores, the worse the performance.

with histories of childhood maltreatment with controls on all cognitive tests at average age 59. These results show significant differences on all tests, with maltreated individuals performing worse than controls. Effect sizes ranged from 0.28 to 0.42, indicating a medium effect of childhood maltreatment on cognitive functioning. Table 3 shows the percent of individuals in the maltreated and control groups who performed 1.5 SDs below the mean on each specific test. In all of the domains assessed, maltreated individuals were significantly more likely to perform at a lower level on at least one test than controls, and for some domains (e.g., executive functioning), all four test scores revealed significant differences in the likelihood of poor performance for the maltreated individuals.

3.2. Childhood maltreatment and cognitive impairment: CIND, amnestic CIND, non-amnestic CIND, and dementia

Table 4 shows that the study sample had high rates of CIND (61.9 % for the maltreated group compared to 49.4 % of the controls). In these analyses that controlled for sex, race, age at Interview 5, and education, individuals with any documented history of childhood maltreatment had significantly higher risk for CIND [AOR = 1.86 (95 % CI = 1.46–2.37]], aCIND [AOR = 1.68 (95 % CI = 1.15–2.49]], and naCIND [AOR = 1.48 (%% CI = 1.16–1.88]], compared to controls. Very few of the sample met the criteria for dementia (4.2 % overall); however, it is noteworthy that the only individuals who met the criteria for dementia at this age were those with histories of childhood maltreatment.

3.3. Specific types of childhood maltreatment and cognitive impairment

Table 4 also shows the extent of cognitive impairment in individuals with specific types of childhood maltreatment. Adults with documented histories of childhood neglect were at increased risk for all three types of cognitive impairment. Adults with documented histories of childhood sexual abuse were at increased risk for CIND and aCIND, but not naCIND. In contrast, individuals with histories of physical abuse were at decreased risk for naCIND, with 25 % of those physically abused meeting the criteria for naCIND compared to 40.6 % of controls (AOR = 0.54, 95 % CI = 0.33–0.86, p<.01).

3.4. Childhood maltreatment and cognitive impairment stratified by sex, race, age, and level of education

Table 5 shows the results of comparisons of maltreated and control individuals stratified by sex, race, age, and level of education. The first part of this table shows that both maltreated males and females were at increased risk for CIND and naCIND, compared to controls. In addition, maltreated females were at increased risk for aCIND, compared to controls. Five percent of the maltreated males met the criteria for dementia compared to none of the controls. Table 5 also shows that both Black and White maltreated participants were at increased risk for CIND compared to Black and White controls. However, Black maltreated participants were also at increased risk of aCIND and naCIND compared to Black controls.

Comparing participants who were older (above age 59 – the mean age of the sample overall) and younger (below age 59), Table 5 shows that maltreated individuals in both age groups were at increased risk for CIND [older (AOR = 2.08 (1.52–2.86) and younger (AOR = 1.63 (1.11–2.40)], compared to controls. However, the older maltreated individuals were at increased risk for naCIND [AOR = 1.80 (1.33–2.45)], whereas younger maltreated individuals were at increased risk for aCIND [AOR = 3.06 (1.57–6.38)], compared to controls.

Finally, Table 5 shows that maltreated individuals who completed high school were at increased risk for CIND, aCIND amnestic, and naCIND, compared to controls who completed high school. However, although the rates of CIND were higher than those who graduated from high school, among individuals who did not graduate from high school, there were no differences between the maltreated and control groups.

We also tested whether age, sex, race, or level of education moderated the relationship between childhood maltreatment and cognitive impairment. The results indicated that there were no significant interactions for age, sex, or race; however, there was a significant interaction for education. Fig. 1 shows the significant interaction of education with childhood maltreatment predicting CIND [AOR = 1.81 (1.09–3.01), p = .021], revealing the negative impact of childhood maltreatment on high school graduates (that is, individuals with higher levels of education). These results show that high school graduation was not protective for individuals who were maltreated in childhood, whose risk for cognitive impairment was similar to maltreated individuals who did not graduate from high school.

Table 3
Percent of individuals in the maltreated and control groups who performed 1.5 SDs below the mean on each specific test.

	Controls N (%)	Maltreated N (%)	AOR (95% CI)	p
ATTENTION				
Number span forward	2 (1.1 %)	12 (5.0 %)	**4.33 (2.00, 10.92)**	**<0.001**
Number span backward	4 (2.2 %)	6 (2.5 %)	0.93 (0.43, 2.04)	.856
LANGUAGE				
Category fluency test	3 (1.7 %)	14 (5.9 %)	**4.34 (2.12, 10.01)**	**<0.001**
Multilingual naming test (MINT)	5 (2.8 %)	11 (4.6 %)	1.60 (0.83, 3.18)	.171
VISUAL SPATIAL				
Benson Complex figure test	9 (5.0 %)	24 (10.0 %)	**2.81 (1.75, 4.68)**	**<0.001**
VERBAL MEMORY				
CERAD Word List Recall (Immediate)	18.0 (10.0 %)	41 (17.2 %)	**1.94 (1.37, 2.76)**	**<0.001**
CERAD Word List Recall (delayed)	3 (1.7 %)	14 (5.9 %)	**3.61 (1.85, 7.72)**	**<0.001**
EXECUTIVE FUNCTIONING				
Stroop Word Test	26 (14.4 %)	57 (23.8 %)	**2.03 (1.50, 2.78)**	**<0.001**
Stroop Color Test	26 (14.4 %)	56 (23.4 %)	**1.91 (1.40, 2.62)**	**<0.001**
Trail Making Test A	19 (10.6 %)	43 (18.0 %)	**1.94 (1.37, 2.78)**	**<0.001**
Trail Making B	62 (34.4 %)	111 (46.4 %)	**2.17 (1.68, 2.80)**	**<0.001**
PROCESSING SPEED				
Symbol-Digit Modalities Test	25 (13.9 %)	49 (20.5 %)	**1.72 (1.26, 2.38)**	**<0.001**

Note. AOR = adjusted odds ratio, controlling for participant's sex, race, and age at Interview 5. Analyses included inverse probability weighting to control for attrition bias.

Table 4

Prevalence of cognitive impairment and dementia for the overall sample and specific types of child maltreatment.

	Control	Any Maltreatment		Neglect		Sexual Abuse		Physical Abuse	
N	180	239		191		35		40	
	N (%)	N (%)	AOR (95 %CI)	N (%)	AOR (95 %CI)	N (%)	AOR (95 %CI)	N (%)	AOR (95 %CI)
CIND	89 (49.4 %)	148 (61.9 %)	**1.86 (1.46-2.37)*****	121 (63.4 %)	**2.05 (1.58-2.67)*****	24 (68.6 %)	**2.12 (1.28-3.57)****	16 (40.0 %)	0.76 (0.49-1.17)
CIND: Amnestic	15 (8.3 %)	30 (12.6 %)	**1.68 (1.15-2.49)****	25 (13.1 %)	**1.68 (1.14-2.51)****	4 (11.4 %)	**2.27 (1.00-5.05)***	6 (15.0 %)	1.81 (0.95-3.33)
CIND: Non-Amnestic	73 (40.6 %)	117 (49.0 %)	**1.48 (1.16-1.88)****	96 (50.3 %)	**1.63 (1.27-2.09)*****	20 (57.1 %)	1.60 (0.98-2.62)	10 (25.0 %)	0.54 (0.33-0.86)*****
Dementia	0 (0.0 %)	10 (4.2 %)	-	8 (4.2 %)	-	0 (0.0 %)	-	4 (10.0 %)	-

Notes: AOR = adjusted odds ratio; CIND = cognitive impairment, no dementia. 447 individuals participated in Interview 5, only 419 people had cognitive data. 28 did not have any or did not have enough cognitive data to make a determination about dementia or cognitive impairment. The total count for specific types of maltreatment exceeds the number of individuals in the maltreated group because some individuals experienced multiple types of maltreatment (n = 26). Analyses use inverse probability weighting and control for participant's sex, race, and age at Interview 5.

* p <.05,
** p <.01,
*** p <.001.

4. Discussion

This longitudinal study followed a large group of children with documented histories of abuse and neglect and a demographically matched control group into late midlife at average age 59. At that time, participants were administered a comprehensive neuropsychological battery of 12 cognitive tests to determine whether childhood maltreatment increased a person's risk for CIND, aCIND, naCIND, and dementia. These new results show that on all tests of cognitive functioning, the maltreated group performed significantly worse than the controls in late midlife, with a medium effect size of childhood maltreatment over the course of several decades. The impact of maltreatment was particularly evident in tasks of executive functioning.

We compared the extent of maltreated individuals who had aCIND and naCIND and found that maltreated individuals overall were at greater risk for both types (amnestic and non-amnestic CIND) compared to controls. A larger percent of participants with histories of childhood maltreatment showed non-memory problems (naCIND) compared to controls. It is possible that other risk factors for poor brain health (e.g., socio-economic status, lower levels of education, and poorer access to medical care) may explain these findings. Non-amnestic CIND potentially has multiple causes, many of which may be modifiable. For example, if the naCIND is associated with cardio-vascular disease (CVD), then treatment for CVD might reduce risk for or slow down the progression of impairment to dementia [62]. Further research is needed to determine whether modifiable risk factors explain the increase in risk for naCIND for these individuals.

About 13 % of the individuals with documented histories of childhood maltreatment also met the criteria for aCIND and were significantly more likely than the demographically matched controls to have aCIND. These findings suggest that there is a subset of individuals who have documented histories of childhood maltreatment who are at high risk of AD, compared to individuals who were demographically matched in childhood. Previous research has shown that progression to AD with amnestic CIND is more likely than progression with non-amnestic MCI [11–13].

Although previous studies have examined cognitive impairment using adversities or maltreatment as a single construct [63], a small number of studies have reported differences in risk for cognitive impairment by type of childhood adversity experienced [34]. Xie et al. [2] reported that emotional and physical abuse were associated with increased risk for all cause dementia in later life, whereas sexual abuse was not. Our results suggest that there may be differences in the impact of the type of childhood maltreatment experienced on cognitive functioning over time and, ultimately on risk for dementia. Individuals with histories of childhood neglect were at risk for all three types of cognitive

impairment (CIND, aCIND, and naCIND). For adults with histories of childhood neglect, this increase in risk for cognitive impairment may be explained by the heavy co-occurrence of poverty with neglect. It is possible that these long-term consequences for cognitive functioning for individuals with histories of childhood neglect reflect earlier deficiencies in the provision of food and medical care by childhood caretakers that then placed these children at risk for inadequate medical and health care as they grew into adulthood. To our knowledge, this is the first study that has examined these long-term consequences for CIND as a result of childhood neglect. With these new findings, we need to address efforts to determine the mechanisms that have placed these adults at increased risk and develop prevention strategies.

Although sparse, the existing literature is not consistent about the extent to which sexual abuse is associated with increased risk for cognitive impairment in later life. Nakayama and colleagues[34] found that adult female PTSD patients who reported sexual abuse scored more poorly on language tests and overall cognitive functioning, compared to healthy control women. In contrast, Xie et al.[2] did not find an association of sexual abuse with all cause dementia in late life. Our results show that individuals with histories of sexual abuse were at increased risk for CIND and aCIND. PTSD may play a critical role here (as suggested by the Nakayama et al.[34] findings), since individuals who have experienced childhood sexual abuse often have high rates of PTSD[64] and may have memory deficits associated with traumatic reactions to those experiences. On the other hand, in earlier work [26], childhood maltreatment overall and childhood neglect predicted poorer executive functioning and non-verbal reasoning at age 41, whereas physical and sexual abuse did not. Furthermore, a past history of PTSD did not mediate or moderate these relationships.

In contrast to expectations, individuals with histories of childhood physical abuse were not at increased risk for CIND. Instead, there was a significant decrease in risk for naCIND for individuals with histories of childhood physical abuse. Fewer (25 %) of those with histories of physical abuse met the criteria for naCIND, compared to 40.6 % of the controls. These are surprising findings as are other trends in relation to physical abuse and cognitive functioning. Although not significant, individuals with histories of physical abuse were at higher risk for aCIND (15 % versus 8 %) and were more likely to manifest dementia in late midlife (10 % versus none) compared to the controls. Although the sample size for the physical abuse group is small, given that the results for naCIND were significant, it is hard to argue that the findings about aCIND and dementia are solely due to smaller sample of physically abused group. But these provocative findings warrant further examination.

There is increasing recognition of the role of social determinants of health and increasing attention to the important influence of non-

Table 5

Comparisons of the extent of cognitive impairment in maltreated and control participants, stratified by sex, race, age, and education.

Cognitive Impairment

	Male				Female			
	Total (N = 181)	Control (N = 80)	Maltreated (N = 101)	AOR (95 % CI)	Total (N = 238)	Control (N = 100)	Maltreated (N = 138)	AOR (95 % CI)
Any CIND	112 (61.9 %)	41 (51.2 %)	66 (65.3 %)	2.05 (1.46-2.89)***	135 (56.7 %)	48 (48.0 %)	82 (59.4 %)	1.68 (1.18-2.39)**
Amnestic	31 (17.1 %)	10 (12.5 %)	17 (16.8 %)	1.56 (0.98-2.50)†	19 (8.0 %)	5 (5.0 %)	13 (9.4 %)	2.04 (1.05-4.21)*
Non-Amnestic	79 (43.6 %)	31 (38.8 %)	47 (46.5 %)	1.52 (1.09-2.13)*	116 (48.7 %)	42 (42.0 %)	70 (50.7 %)	1.42 (1.01-2.01)*
Dementia	5 (2.8 %)	0 (0.0 %)	5 (5.0 %)	-	5 (2.1 %)	0 (0.0 %)	5 (3.6 %)	-

	Black				White			
	Total (N = 154)	Control (N = 77)	Maltreated (N = 77)	AOR (95 % CI)	Total (N = 243)	Control (N = 98)	Maltreated (N = 145)	AOR (95 % CI)
Any CIND	102 (66.2 %)	44 (57.1 %)	56 (72.7 %)	2.15 (1.43-3.25)***	132 (54.3 %)	44 (44.9 %)	81 (55.9 %)	1.57 (1.15-2.15)**
Amnestic	20.0 (13.0 %)	7 (9.1 %)	12 (15.6 %)	2.04 (1.15-3.72)*	28 (11.5 %)	8 (8.2 %)	17 (11.7 %)	1.43 (0.87-2.40)
Non-Amnestic	81 (52.6 %)	36 (46.8 %)	44 (57.1 %)	1.47 (1.00-2.15)*	103 (42.45)	36 (36.7 %)	63 (43.4 %)	1.36 (0.99-1.87)†
Dementia	2 (1.3 %)	0 (0.0 %)	2 (2.6 %)	-	7 (2.9 %)	0 (0.0 %)	7 (4.8 %)	-

	Older (Above 59)				Younger (Below 59)			
	Total (N = 253)	Control (N = 106)	Maltreated (N = 147)	AOR (95 % CI)	Total (N = 166)	Control (N = 74)	Maltreated (N = 92)	AOR (95 % CI)
Any CIND	169 (66.8 %)	58 (54.7 %)	104 (70.7 %)	2.08 (1.52-2.86)***	78 (47.0 %)	31 (41.9 %)	44 (47.8 %)	1.63 (1.11-2.40)*
Amnestic	33 (13.0 %)	11 (10.4 %)	18 (12.2 %)	1.24 (0.78-1.99)	17 (10.2 %)	4 (5.4 %)	12 (13.0 %)	3.06 (1.57-6.38)**
Non-Amnestic	134 (53.0 %)	46 (43.4 %)	85 (57.8 %)	1.80 (1.33-2.45)***	61 (36.7 %)	27 (36.5 %)	32 (34.8 %)	1.08 (0.73-1.61)
Dementia	7 (2.8 %)	0 (0.0 %)	7 (4.8 %)	-	3 (1.8 %)	0 (0.0 %)	3 (3.3 %)	-

	Graduated High School				Did Not Graduate High School			
	Total (N = 254)	Control (N = 119)	Maltreated (N = 135)	AOR (95 % CI)	Total (N = 165)	Control (N = 61)	Maltreated (N = 104)	AOR (95 % CI)
Any CIND	136 (53.5 %)	51 (42.9 %)	80 (59.3 %)	2.04 (1.50-2.79)***	111 (67.3 %)	38 (62.3 %)	68 (65.4 %)	1.36 (0.89-2.09)
Amnestic	28 (11.0 %)	9 (7.6 %)	17 (12.6 %)	1.84 (1.11-3.0)*	22 (13.3 %)	6 (9.8 %)	13 (12.5 %)	1.48 (0.82-2.72)
Non-Amnestic	108 (42.5 %)	42 (35.3 %)	63 (46.7 %)	1.64 (1.21-2.25)**	87 (52.7 %)	31 (50.8 %)	54 (51.9 %)	1.08 (0.73-1.60)
Dementia	5 (2.0 %)	0 (0.0 %)	5 (3.7 %)	-	5 (3.0 %)	0 (0.0 %)	5 (4.8 %)	-

Notes: CIND = cognitive impairment, no dementia; AOR = adjusted odds ratio, controlling for age, sex, and race when not the object of the stratification. Analyses use inverse probability weighting.

† p <.10,
* p <.05,
** p <.01,
*** p <.001.

medical factors and conditions in which people live, work, and develop. In particular, studies have examined the role of education and income in relation to cognitive aging. Manly et al.[65] found that each additional year of education was associated with decreased risk of dementia. In our study, we used high school graduation as an indicator of level of education and found that high school graduation was protective overall, associated with better cognitive functioning scores and lower rates of CIND. However, a significant interaction showed that high school graduation was not protective for maltreated individuals. Individuals with histories of childhood maltreatment who graduated from high school (that is, maltreated individuals with higher levels of education) were at higher risk for CIND, aCIND, and naCIND compared to controls who graduated from high school.

These unexpected findings require comment, particularly since common theories would have predicted different results. For example, the cognitive reserve hypothesis[66–68] would have predicted that enriched experiences such as getting a high school degree would protect individuals with a history of childhood maltreatment from cognitive decline. Our results do not provide support for this hypothesis. Our results show that individuals with a history of child maltreatment and a high school degree suffer from similar risk of cognitive decline as those without high school degrees. Similarly, the compensatory stress model [69] suggests that educational attainment can act as a moderator of trauma responses. Our results suggest that in the case of these maltreated individuals, educational attainment is not strong enough to prevent higher levels of cognitive impairment in individuals with histories of maltreatment. Most likely the best interpretation of these new results is to acknowledge the "Long Arm of Childhood Model"[70,71] that reflects the phenomenon whereby childhood experiences impact adult health through extended and complex pathways that include education, health behaviors, and biological processes.

Both older and younger maltreated individuals in our study were at increased risk for any CIND, compared to demographically matched controls. However, our findings revealed differences in the types of
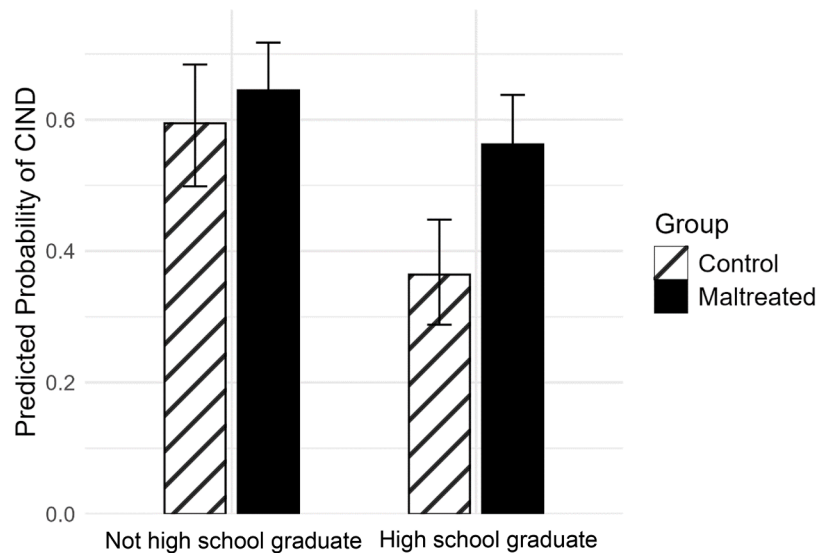
Fig. 1. Results of OLS regressions testing whether high school graduation moderates the relationship between childhood maltreatment and CIND.
Note. CIND = cognitive impairment, no dementia. Fig. 1 shows the interaction between childhood maltreatment and high school graduation in predicting CIND (adjusted odds ratio = 1.81, 95 % confidence interval = 1.09, 3.01, p= .021). Analyses use inverse probability weighting and control for age, sex, and race.

cognitive impairment manifest by the older and younger participants. Among older participants (individuals above age 59), more maltreated individuals met the criteria for naCIND compared to younger maltreated individuals, whereas for the younger participants, maltreated individuals were at significantly increased risk for aCIND. By age, the younger participants in the study should be at lower risk for CIND. Although the younger controls have low rates of aCIND, the younger maltreated participants have the highest rates of aCIND. These findings are similar to the counterintuitive findings for education and maltreatment. That is, the group with the lower risk in general (more educated and younger) shows the greatest effect of childhood maltreatment.

The literature on social determinants of health indicates a higher burden of dementia among Black, non-Hispanic individuals compared to White, non-Hispanic individuals [72]. In our study, we found that both Black and White maltreated children were at increased risk for CIND in late midlife, compared to Black and White controls, respectively. However, we also found that Black, non-Hispanic maltreated individuals were at increased risk for aCIND compared to Black, non-Hispanic controls (16 % versus 9 %), whereas we did not find the same effect for White, non-Hispanic maltreated individuals compared to White, non-Hispanic controls (12 % versus 8 %). These findings are consistent with the larger literature on the health burden for Black individuals and suggest that the Black, non-Hispanic maltreated individuals in our study are at higher risk of accelerated progression leading to dementia.

Finally, our findings also reveal that even at this relatively young age, there was evidence of dementia in the sample, but only among the maltreated individuals, not the controls. Though base rates of dementia in this age group are low, early onset is rare. It is possible that the increase in functional impairment is due to the impact of other medical or psychiatric variables rather than cognitive decline, but this is difficult to determine given the very small number of cases that met the criteria for dementia.

4.1. Limitations

Although these findings provide important information about the impact of childhood maltreatment on risk for cognitive impairment and dementia, some limitations should be noted. First, these findings are based on cases of childhood abuse and neglect drawn from official court records and most likely represent the most extreme cases processed in the system. Second, cases that came to the attention of the courts are

skewed toward the lower end of the socio-economic spectrum and, these results cannot be generalized to abused and neglected children who grew up in middle- or upper-class homes. Third, the cases included here represented those that occurred in the late 1960s and early 1970s in the Midwest part of the United States and might differ from cases currently being processed by child protection agencies. However, these cases are comparable in demographic characteristics to the kinds of cases being processed currently by child protection services across the country. Fourth, we used algorithms to determine cognitive impairment, rather than rater diagnoses since we lacked access to other medical history information that would have been needed to make a diagnostic adjudication. For example, we did not have information about whether low cognitive scores might have occurred for other reasons, such as injury or accidents. These rates of CIND in the overall sample are high relative to other studies of similar age adults and most likely reflect the large proportion of maltreated individuals with cognitive impairment and the skewness of the sample toward the lower end of the socio-economic spectrum. We were able to investigate the potential differential effects of neglect, physical abuse, and sexual abuse, adding significantly to a literature that often combines these abuse types when examining long-term consequences associated with adverse childhood experiences. However, the sample sizes of individuals with histories of physical abuse and sexual abuse are smaller than the neglect group. Therefore, it is possible that some of the differences (or lack of significant differences) among types may be due to differences in sample sizes. Finally, our measure of functional impairment (the FAQ) was based on self-report rather than informant report. It is possible that participants lacking insight into their impairments under-reported changes in independent functioning. If this is the case, the current results may underestimate dementia prevalence.

4.2. Conclusions

The present study advances our understanding of the long-term consequences of childhood maltreatment in relation to cognitive functioning in late midlife. Building on earlier findings documenting poorer executive functioning and nonverbal learning in midlife (age 41) [26], these new findings indicate that the cognitive repercussions of childhood maltreatment continue into late midlife (age 59). In earlier work, we found that midlife adults who experienced childhood maltreatment possessed, on average, more dementia risk factors (that is, greater risk

for low educational attainment, social isolation, smoking, and clinical depression) compared to midlife adults without a history of maltreatment [41]. These new results reveal that childhood maltreatment increases risk for cognitive impairment in late midlife. Future research should examine the extent to which poorer physical health, increased psychopathology, reduced socioeconomic status, and worse behavioral and social outcomes are some of the mechanisms by which childhood maltreatment increases risk for later impairments in cognitive functioning and point to modifiable risk factors. These findings reinforce the importance of early detection and interventions for maltreated children and adults with histories of maltreatment that may help offset some of the risks associated with childhood maltreatment in later adulthood.

CRediT authorship contribution statement

Stephanie Assuras: Writing – review & editing, Validation, Methodology, Investigation, Data curation. **Kellie Courtney:** Writing – review & editing, Writing – original draft, Validation, Methodology, Formal analysis. **Molly Maxfield:** Writing – review & editing, Methodology, Investigation, Funding acquisition, Conceptualization. **Shaina Shagalow:** Writing – original draft. **Sara Sherer:** Validation, Investigation, Data curation. **Jennifer J. Manly:** Writing – review & editing, Validation, Methodology, Investigation, Funding acquisition, Conceptualization. **Cathy Spatz Widom:** Writing – review & editing, Writing – original draft, Validation, Supervision, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests:

Cathy Spatz Widom reports financial support was provided by National Institute on Aging. Stephanie Assuras reports financial support from Columbia University that includes: employment. Molly Maxfield reports financial support from Arizona State University that includes: funding grants. If there are other authors, they declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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