Child neglect and maltreatment and child-to-adulthood cognition and mental health in a

prospective birth cohort

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Abstract

Objective: Life-long adverse effects of childhood maltreatment on mental health are well-established, but effects on child-to-adulthood cognition and related educational attainment have yet to be examined in the general population. We aimed to establish whether different forms of child maltreatment are associated with poorer cognition and educational qualifications in childhood/adolescence and whether associations persist to mid-life, parallel to associations for mental health.

Methods: Cognitive abilities at ages 7, 11 and 16y (math, reading and general intellectual ability) and 50y (immediate/delayed memory, verbal fluency, processing speed) were assessed using standardized tests and qualifications by 42y was self-reported. Information on childhood maltreatment (neglect and abuse: sexual, physical, psychological, witnessed), cognition and mental health was available for 8,928 participants in the 1958 British Birth Cohort.

Results: We found a strong association of child neglect with cognitive deficits from child-to-adulthood. To illustrate, the most neglected 6% of the population (score ≥4) had a 0.60(95% CI: 0.56,0.68)SD lower cognitive score at 16y and 0.28(0.20,0.36)SD deficit at 50y relative to the non-neglected (score=0) after adjustment for confounding factors and mental health, and they also had increased risk of poor qualifications (i.e. none/low versus degree-level). Childhood neglect and all forms of abuse were associated with poorer child-to-adulthood mental health, but abuse was mostly unrelated to cognitive abilities.

Conclusion: The study provides novel data that child neglect is associated with cognitive deficits in childhood/adolescence and decades later in adulthood, independently from mental health, and highlights the life-long burden of child neglect on cognitive abilities and mental health.

Introduction

Childhood maltreatment (abuse and neglect) has been associated with health consequences, often lasting into adulthood.[1,2] For mental health, the association with maltreatment is well established and seen for several disorders across the life-course, including childhood behavioural disorders, adult mood/anxiety disorders and suicidality.[1-3] The influence of maltreatment on mental health has been observed for all types of abuse and neglect and is not confined to particular disorders.[2,3] In parallel with mental health, there are reports of maltreated individuals having impaired cognition and academic achievement in childhood/adolescence.[4,5] Compelling findings for effects on childhood/adolescence cognition come from studies of severely neglected children raised in orphanages before adoption by well-off families.[5,6] Such findings raise concerns that maltreatment could compromise educational attainment and adult cognition, as suggested by findings for mental health. However, understanding of long-term effects of maltreatment on cognition and educational qualifications is rudimentary because few studies measure cognition in adulthood.[5] Findings to date are heterogeneous: some suggest that child maltreatment predicts cognitive deficits and poorer education by adulthood,[7-9] one study found no relationship with educational qualifications by 25y[10] and another showed no detrimental association of childhood abuse with late-life cognition.[11] Most research examining maltreatment and cognition/education over the long-term is based on small selected samples,[7,9,12] often limited to sexual and/or physical abuse[8,13] and usually disregards the potential influence of maltreatment on mental health, which is associated with cognition.[4] To our knowledge, no previous study examines childhood maltreatment associations with adult cognition in a general population. Furthermore, it is unclear whether all or specific maltreatments are associated with cognition and related educational qualifications as there is some suggestion that neglect is especially detrimental.[4] Education level is of interest as a potential outcome partly because it may be influenced via development of cognitive abilities but also via mental health or by other factors, such as interest in school or motivation to study. Our main aim was to establish whether associations of maltreatment with cognition/educational qualifications are evident in childhood/adolescence and then persist to mid-life, and whether associations are independent of mental health. To

establish whether associations vary for different maltreatments, we examined neglect and abuse separately. The main focus of our study is on child-to-adulthood associations with cognition and educational qualifications but to gain greater insight into long-term sequelea and the specificity of associations, we also examined mental health outcomes.

Methods

Sample

Data are from the 1958 British birth cohort all born in one week, 1958 in England, Scotland and Wales (n=17,638) and immigrants with the same birth week recruited to age 16y (n=920).[14] The cohort primarily represents white Caucasians (98%) but covers the full range of social class in Britain. Information was collected throughout childhood (birth, 7,11,16y) and adulthood (23,33,42,45,50y). At 45y, 9,377 (78%) participated from a target of 11,971 invited; 9,315 participants completed a childhood maltreatment questionnaire. Ethical approval was given (South East Multi-centre Research Ethics Committee ref. 01/01/44) and informed consent obtained from all participants.

Measures

Childhood maltreatment: Neglect was identified from information collected prospectively in childhood (7, 11y) and retrospectively in adulthood (45y). In childhood information was obtained from parental interviews (usually the mother) and the child's teacher, using structured questionnaires. A neglect scale was derived for ages 7 and 11y separately by summing five items on the child's physical appearance and parental involvement with the child (Tables 1 and 2). If ≤2 items were missing they were imputed ('statistical analysis'); if >2 items were missing the score was treated as missing. Also, neglect to 16y was recalled at 45y using three items, summed to create a retrospective scale (Tables 1 and 2). Prospective and retrospective neglect scales were summed to give a cumulative scale (Table 2). Childhood abuse to 16y was reported in adulthood (45y) using a confidential direct computer data entry questionnaire (including the three neglect questions); derived from the Personality and Total Health Through Life Project,[15] originating from the Parental Bonding Instrument,[16] British National Survey of Health and

5

Development,[17] and US National Comorbidity Survey[18] (Table 1). We created four binary variables: physical, psychological, sexual or witnessing abuse.

Cognition: was assessed via age-appropriate standardized tests at 7,11,16 and 50y. At 7y, participants took tests of reading (word recognition Southgate test)[19] and arithmetic, consisting of 10 problems of graded difficulty. At 11y, three tests were used for reading (selection of appropriate words to complete 35 sentences, parallel to the Watts Vernon Comprehension test), mathematics (constructed by the National Foundation for Educational Research in England and Wales) and general ability (approximating IQ, with verbal/non-verbal scales).[20] At 16y, reading (as for 11y) and mathematics tests were administered. At 50y, participants undertook tests of immediate and delayed word-lists, animal naming, and letter cancellation. Immediate and delayed word tests examined participant recall from a list of 10 common words (e.g. book, tree) immediately after the word list was read, and also after a 5min delay. For the animal naming task, a measure of verbal fluency based on ability to access mental vocabulary rapidly, participants named as many different animals as possible in 1min. For the letter cancellation test participants were instructed to cross out target letters within 1min from a page containing 780 letters. The total number of letters searched (range 84–780), i.e. the sum of all items processed whether correctly or incorrectly, assessed processing speed.

Educational qualifications: Highest qualification level by 42y was self-reported and categorized as no qualification (8.5%), <O-level (14.2%), O-level (or equivalent; 28.4%), A-level (or equivalent; 16.5%), or degree-level (32.5%).

Mental health: was assessed using age-appropriate measures at 7,11,16 and 50y. At 7y and 11y, teachers completed the 146-item Bristol Social Adjustment Guide (BSAG)[21] of behavioural problems e.g. miserable, resentful/aggressive. At 16y, teachers completed the 26-item Rutter Scale[22] e.g. miserable/unhappy, disobedient. At 50y, participants completed the Mental Health Inventory (MHI-5), a validated and widely-used measure of current depressive symptoms (e.g. nervousness, low-mood).[23] Childhood and adult mental health measures capture similar domains and are strongly related.[24] At all ages, scores were standardised so that high scores indicate severe problems/symptoms; to facilitate comparison we generated internally standardised Z-scores (mean=0, SD=1) at each age.

Confounding factors: occurring prior to maltreatment were identified as having known associations with cognition[25]: prospectively reported maternal age, maternal smoking ≥1cigarette/day in pregnancy, birth-weight, birth order, father's social class in 1958 (using the 1951 Registrar General's Classification), parental education (completion of minimal schooling) and household amenities (bathroom, indoor lavatory, hot water when child was 7y).

Statistical analysis

At each age cognitive tests had been conducted over several months. Thus, we centered test scores at ages 7,11,16 and 50y for all individuals using predictions from linear regression models that assumed a linear age trend over short periods (age-standardized). Also, as the multiple tests had different ranges, we converted all scores to a 0-100 scale. Tests at each age were correlated (r=0.49 (7y), 0.61-0.79 (11y), 0.64 (16y), 0.08-0.64 (50y) (p<0.001 for all)). To examine associations of maltreatment with cognition, we derived a global cognitive measure, i.e. an average score of all tests at each age. Each of the four global cognitive scores (i.e. at 7,11,16,50y) was converted to an internally standardized z-score (mean=0, SD=1) to facilitate comparison across ages. Within individuals standardized scores at different ages were correlated (r=0.31-0.84).

To assess childhood maltreatment associations with child-to-adult cognitive ability, we applied multivariate response models to global cognitive z-scores at all ages (7,11,16,50y) simultaneously, using the STATA mvreg command. For each type of maltreatment, there was no evidence of moderation by gender (interaction term maltreatment*gender); hence results are presented for genders combined. Next, we adjusted associations for potential confounding factors. In separate analyses, we examined associations between maltreatment and mental health at all ages simultaneously. These parallel analyses for mental health were conducted as a comparison for child-to-adult maltreatment-cognition associations e.g. to inform on the specificity of associations. We then assessed whether any significant maltreatment–cognition associations were independent of mental health by performing additional analyses with further

adjustments for mental health at 16y (for child cognition) and at both 16 and 50y (for adult cognition).

Relationships between maltreatments and educational qualifications were examined using multinomial logistic regression, comparing the relative risk (RR) of each qualification level to the reference (degree-level). Adjustments were undertaken for: (i) gender only; (ii) gender and confounding factors; (iii) additionally for 16y cognition (to establish whether associations of maltreatment with qualifications were independent of any association with prior cognition); and (iv) additionally, for 16y mental health.

In sensitivity analyses, we examined associations separately for prospective and retrospective neglect with cognition at all ages simultaneously, as described above and, likewise for educational qualifications. Of 9,315 participants with child maltreatment data at 45y, we excluded those identified with intellectual impairment at 7y (n=99). Inclusion in this study required participants to have ≥3 of 5 neglect items at 7y or 11y, at least one measure of cognition and mental health at any age and at least one measure of child maltreatment at 45y (n=8,928). Missing data ranged from 0% (qualifications) to 25% (16y mental health). To minimize data loss, missing data were imputed using multiple imputation chained equations; models included all model variables, which included key predictors of missingness.[26] Regression analyses were run across 10 imputed datasets. Imputed results were broadly similar to those using observed values; the former are presented. Finally, we checked whether restriction to the sample with at least one 45y report of child maltreatment affected results by repeating analyses using the larger sample available for childhood neglect (n=15,678). Main findings were unaltered; we present findings for child abuse and neglect based on the same sample (n=8,928).

Results

Table 2 shows that 6.1% of the population had a score of ≥4 for childhood cumulative neglect, whilst for abuse, sexual abuse was the least (<2%) and psychological abuse the most (~10%) common.

Associations with a) cognition and b) mental health.

Table 3 and S1 (S1 is available online) shows a negative association between childhood neglect and cognitive z-score at each age in childhood/adolescence that persisted into adulthood; e.g., per unit higher on the cumulative scale, cognitive z-score was lower by 0.31(95% CI: 0.29,0.32) at 16y and by 0.15(0.13,0.16)SD at 50y. Associations remained although attenuated after adjusting for confounding factors; e.g. deficits in cognitive scores at 16y and 50y attenuated to 0.20(0.18,0.22) and 0.09(0.07,0.11)SD respectively. Parallel analyses for mental health showed a positive association of higher symptom scores in child and adulthood per unit higher on the cumulative neglect scale (Table 3). Thus, the association of neglect with cognition reduced slightly with further adjustment for mental health: at 16y the cognition deficit reduced to 0.15(0.14,0.17)SD (adjusted for 16y behavioural problems) and at 50y to 0.07(0.05,0.09)SD (adjusted for 16y behavioural problems and 50y current depressive symptoms; data not shown). These estimates yield cognitive deficits of 0.60(0.56,0.68) at 16y and 0.28(0.20,0.36)SD at 50y for a neglect score ≥4 vs 0. Separate analyses of the three measures of neglect (prospective at 7y, 11y and retrospective report) showed cognitive deficits with increasing score for all except retrospective neglect and 50y cognition (see Table S2, available online).

Childhood physical, psychological, sexual and witnessed abuse were associated with lower cognitive score in childhood/adolescence (except for psychological abuse and 7y cognition), but only sexual and witnessed abuse were associated with 50y cognitive score (Table 3). Several associations were abolished after adjustment for confounding factors, but associations for sexual abuse and childhood/adolescence cognition remained, with deficits in childhood of approximately one-fifth of a SD. Childhood abuse was associated with poorer mental health

child-to-adulthood (Table 3) and when the sexual abuse-16y cognition association was further adjusted for 16y mental health the estimate reduced from -0.27(-0.42,-0.12) to -0.08(-0.22,0.06)SD in cognition (data not shown).

Associations with educational qualifications

Table 4 presents RRRs of each qualification level (vs degree-level) for childhood maltreatments. For neglect, there was an elevated risk of lower qualifications which decreased from the lowest to the highest qualification level, e.g. $RRR_{unadjusted}$ of no qualifications was 2.64(2.47,2.83) for each unit higher cumulative neglect score, for qualifications <O-level, $RRR_{unadjusted}$ was 1.91(1.80,2.02). After adjustment for confounding factors associations persisted although attenuated. With further adjustment for 16y cognition there was still a higher risk of none or <O-level vs degree-level and associations were not abolished after additional adjustment for 16y mental health (i.e. behavioural problems) (Table 4). Similar patterns were found in separate analyses of prospective 7 and 11y neglect, but not for retrospective report (Table S3, available online).

For childhood abuse, there was no trend of increasing risk of lower qualifications but for each type of abuse there was a higher risk of no qualifications, and additionally for sexual and witnessing abuse, a higher risk of <O-level qualifications (Table 4). In adjusted analyses, the higher risk of no qualifications remained for physical and sexual abuse but was abolished after further adjustment for 16y cognitive score. There was a lower risk of O-level qualifications for psychological abuse (RRR=0.75(0.62,0.91)) that persisted with additional adjustments. In fully adjusted models there was also a lower risk of O-level qualifications for those witnessing abuse and of <O-level qualifications for psychological abuse.

Discussion

Main findings from our large population cohort include, first, the strong association of child neglect with cognitive deficits throughout life. To illustrate, for 6% of the population with a

neglect score ≥4 (vs 0) cognition was 0.60SDs lower at 16y and 0.28 lower at 50y after allowance for confounding factors and mental health. Child neglect was associated also with an elevated risk of poor qualifications, interestingly even after allowing for 16y cognition and mental health. Second, abuse was mostly unrelated to cognitive function child-to-adulthood. Sexual abuse was an exception, with lower cognitive abilities (7 to 16y) and qualifications, although associations were not independent of mental health. Third, in comparison with the specific associations of childhood neglect and sexual abuse with cognitive abilities, all child maltreatments were associated with increased mental health symptoms, child-to-adulthood.

Study strengths include repeated measures of cognition child-to-adulthood and prospective and retrospective measures of maltreatments in a large study population. Availability of longitudinal data on mental health, as a secondary outcome, provided an important contrast for cognition associations as well as allowing an assessment of the latter's independence. Information on several covariates was available to minimise effects of confounding, e.g., family socio-economic status was controlled for via inclusion of parental education, social class and household amenities. Study limitations include the observational design, hence the possibility of residual confounding cannot be excluded. Ascertainment of childhood maltreatment is not straightforward with limitations noted for all methods.[1] Our neglect measures have the advantage of prospective ascertainment of some (i.e. failure to meet a child's basic physical, emotional or educational needs) but not all aspects (e.g. inadequate nutrition or shelter) of the conventional definition.[1] However, construct validity of our neglect measures is suggested by other studies showing shorter child-to-adult stature in this cohort.[27] Potentially, those with lower pre-morbid cognitive abilities may have been more likely to be neglected by parents, i.e. neglect was an outcome rather than precursor to cognitive deficit. Abuse by a parent to 16y was reported in adulthood and thus exclusion of abuse by others may lead to an under-estimate of prevalence. Such reports may be affected by recollection or mental health and information is lacking on timing and duration. Nonetheless, retrospective report is commonly used due to the lack of reliable alternative data ascertainment methods.[1] Inevitably, age-appropriate assessments of cognitive ability and mental health were used and the differences for child and

adulthood may hinder comparisons of the magnitude of associations. Cohort attrition has occurred over time and participants in mid-adulthood are generally representative of the surviving cohort, but with some underrepresentation of those with poor childhood cognitive abilities.[26] To reduce bias and loss of data, we applied multiple imputation. Sensitivity analysis using the larger sample of those with information for childhood neglect and imputed 50y cognition (n=15,678) suggests that results are robust.

In our study, neglect but not abuse predicted cognitive deficits throughout life independently of confounding factors and mental health. The specific association of neglect with child-to-adulthood cognition contrasts with mental health, for which detrimental associations were seen consistently for all maltreatments. Our findings for mental health are consistent with previous research,[2,3,28] and underscore the importance of taking mental health into consideration whilst investigating cognitive outcomes, although few studies do so.[9,12] Specificity of maltreatment associations for cognition is not readily discerned from the literature, as many studies combine different maltreatments[29,30] or examine only sexual and/or physical abuse.[8,10] The limited existing literature on associations for child neglect versus abuse and cognition is largely consistent with our finding of a pre-eminent association for neglect[7,9,31,32] although one study based on child protection records found similar reading and abstract reasoning deficits at 14y.[33] Elsewhere, main associations for neglect are documented, e.g., for academic difficulties in children[4] and for cognitive ability in young adulthood.[7] The latter study highlights long-term associations, as we do, although in court-substantiated cases which are most likely to be severe/chronic.[7,9] We obtained comparable results with a cruder neglect measure encompassing a broad range of severity and chronicity. This finding is important. Only a small proportion of cases are reported to agencies and then substantiated. Our results suggest that the spectrum of child neglect within a population is related to cognitive deficits that are life-lasting. As in other studies, we were unable to account for heritability, e.g. if lower IQ parents were more neglectful, an association with offspring cognition could be due to heredity. However, post-institutional and animal studies which are less affected by hereditary factors are consistent with our findings.[5,6] Interestingly, the cognition association was life-lasting for

prospective neglect measures, but confined to childhood for retrospective report. Explanations for differing associations include inaccuracies of recall or aspects of neglect that are captured, i.e. prospective measures emphasise lack of stimulation whilst retrospective reports emphasise emotional neglect.

In regard to our main study focus on cognition, the plausibility of long-term detrimental associations is supported by literature on neglect associated childhood cognitive deficits[31,32] to which our study adds and evidence suggesting high stability of IQ differences from childhood (11y) to later life (70-87y).[34] It is unlikely that adult lifestyle factors such as smoking or alcohol/drug consumption are major mediators of the association between childhood neglect and 50y cognition, given that an association of neglect with cognition was evident by ages 7/11y in childhood and then appeared to persist to ages 16 and 50y. The differences observed (adjusted) are equivalent to a 15% lower cognitive ability at 16y and 3.4% lower at 50y for the population with a neglect score ≥4 (vs 0). Thus, a parsimonious explanation of our findings is that deficits at 50y originate in those established in childhood. We cannot establish whether maltreatment associations with cognition changed with age, although an apparent weakening at 50y is consistent with the argument that neglect associated deficits could attenuate in adulthood. Indeed, while there is stability of cognition, there is also malleability[35] as other compensatory factors are experienced.[5,6] Similar arguments could apply to child-to-adulthood associations seen here for mental health.

Several possible explanations exist for the association of neglect with cognition and education. First, there may be biological alterations with long-lasting effects. Animals exposed to enriched stimulating environments have greater hippocampal cell proliferation and neurogenesis than those reared in relative deprivation.[36] In humans, neglected children have deficits in prefrontal cortex white matter[37] and corpus callosum[38] which link to cognition and their reduced head circumference may indicate poor brain maturation.[32] Also of relevance is the reported association of stunting with poor cognitive development[39] given that neglect but not abuse was associated with shorter child-to-adult stature in our cohort.[27] Such growth deficits point to the

likely early timing of insult; neglect may occur earlier in development than abuse and although plasticity of brain development is not confined to early life, detrimental effects may endure in the absence of compensating influences. Also, early timing of neglect may be accompanied by chronicity. Second, the caregiver's lack of involvement and encouragement of the child's education may affect the child's internalization of the value of education,[4] e.g., affecting school attendance. Continued lack of parental support and/or the individual's own value of education may explain the additional contribution of neglect to poorer qualifications even after allowing for 16y cognition. In turn, poorer education links to factors such as smoking that associate with mid-life cognitive decline,[40] possibly reinforcing early cognitive deficits.

Contrasting with child neglect, we found no detrimental associations for non-sexual abuse with cognition and educational qualifications after allowing for confounding factors. This finding is consistent with other studies in childhood/adolescence[29,32] and adulthood[7,9-11] although not all: e.g., domestic violence (representing witnessing abuse) was associated with lower IQ at 5y.[41] For sexual abuse we observed associations with lower cognition (7-16y) and qualifications after allowing for confounding factors, but not independent of mental health and no association was seen for 50y cognition. Comparison of parallel analyses for mental health, where poorer outcome is observed from child to adulthood, suggests that our findings are unlikely to be due to differences in measurement of child neglect and abuse; i.e. if a lack of association between child abuse and cognitive outcomes is due to shortcomings of measurement we would expect to see a lack of association also for mental health, but this was not the case. Our results strengthen the evidence base suggesting that after allowing for contextual factors or mental health, sexual abuse is unrelated to education,[10] mid-adult executive function and non-verbal reasoning[9] and other cognitive measures,[12] although some studies report detrimental associations.[8] Whether discrepancies between studies are due to measurement differences or other relevant factors is unknown.

Our finding of child neglect associations with cognition in childhood and decades later in adulthood has implications for policy, practice and future research. Primary prevention of child

neglect is paramount to avoid a life-long cognitive burden and poorer educational qualifications. Likewise, prevention of all maltreatments is important for child-to-adult mental health. Both cognition/education and mental health are closely connected to social and lifestyle factors that affect physical health.[42] Our study adds to the evidence-base on long-term outcomes of maltreatment. Understanding the breadth of long-term outcomes provides clues on possible opportunities for remedial action; e.g., our finding that sexual abuse associations with cognition/education were not independent of mental health suggests the need for future research on whether alleviation of mental health consequences could improve cognitive functioning. Future prospective studies are needed to confirm the specificity of our maltreatment associations with child-to-adulthood cognition and related educational qualifications. In sum, we highlight the need for primary prevention and remediation of long-term effects of child neglect.

Clinical guidance

- o All forms of child maltreatment (abuse and neglect) are known to influence mental health with effects lasting over decades of the life-course. Yet, understanding of the long-term consequences of child maltreatment for cognitive abilities remains rudimentary.
- o Our findings reveal that, in parallel with mental health, child neglect was associated with cognitive deficits equivalent to a 15% lower cognitive ability at 16y and longer-term into mid-adulthood (3.4% lower at 50y), with a corresponding increased risk of poor educational qualifications.
- o Conversely, sexual, physical, psychological and witnessing abuse were associated with poorer child-to-adulthood mental health, but not with cognition.
- o Findings highlight the need to remediate long-term effects of child neglect.

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Table 1: Childhood maltreatment items

Neglect indicators reported during childhood (7, 11y)
- Child looks undernourished, scruffy or dirty (item from the Bristol Social Adjustment Guide) (teacher report at 7 and 11y)
- Mother hardly ever takes the child out e.g. walks, outings, picnics, visits, shopping (parent report at 7 and 11y)
- Father hardly ever takes the child out e.g. walks, outings, picnics, visits, shopping (parent report at 7 and 11y)
- Mother has little interest in the child staying on at secondary school after minimum school leaving age (parent report at 7 and 11y)
- Father has little interest in the child staying on at secondary school after minimum school leaving age (parent report at 7 and 11y)

Neglect before age 16y, self-reported during adulthood (45y)
- I was neglected
- Mother not at all affectionate towards me
- Father not at all affectionate towards me

Abuse before age 16y, self-reported during adulthood (45y)
- Psychological abuse by a parent (verbally abused or humiliated, ridiculed, bullied/mental cruelty)
- Physical abuse by a parent (punched, kicked or hit or beaten with an object, or needed medical treatment)
- Sexual abuse by a parent
- Witnessed physical or sexual abuse of others in family

Table 2: Prevalence of childhood maltreatment, 1958 Birth Cohort (N=8,928)

		%(n)
Neglect[a]		
Cumulative score		
	0	60.8(3673)
	1	15.8(952)
	2	12.3(745)
	3	5.0(300)
	≥ 4	6.1(370)
7y Prospective score		
	0	79.8(6267)
	1	9.6(750)
	2	8.5(666)
	3	1.7(135)
	≥ 4	0.5(38)
11y Prospective score		
	0	76.2(5158)
	1	11.1(752)
	2	9.8(660)
	3	1.9(126)
	≥ 4	1.0(70)
Retrospective score		
	0	87.5(7813)
	1	10.1(897)
	≥2	2.4(218)
Abuse[a]		
Physical abuse by a parent		5.9(524)
Psychological abuse by a parent		9.8(878)
Sexual abuse by a parent		1.6(140)
Witnessed physical or sexual abuse of others in family		6.0(538)

N varies due to missing data

[a]Items in Table 1; cumulative neglect score includes prospective (7y and 11y) and retrospective (45y-recalled) items; abuse was recalled at 45y.

Table 3: Mean difference (95% confidence interval) in child (7,11,16y) and adult (50y) cognitive and mental health z-scores for childhood maltreatment.

	Cumulative neglect[a]	Physical abuse	Psychological abuse	Sexual abuse	Witnessed abuse
Cognitive z-score at age[b]					
7y					
adjusted for gender	-0.23 (-0.25,-0.22)*	-0.11 (-0.20,-0.03)*	-0.03 (-0.10,0.04)	-0.36 (-0.53,-0.20)*	-0.15 (-0.24,-0.07)*
adjusted for covariates[c]	-0.18 (-0.20,-0.16)*	-0.02 (-0.10,0.06)	0.01 (-0.06,0.07)	-0.21 (-0.37,-0.05)*	-0.04 (-0.12,0.04)
11y					
adjusted for gender	-0.30 (-0.31,-0.28)*	-0.17 (-0.26,-0.09)*	-0.10 (-0.17,-0.03)*	-0.44 (-0.60,-0.27)*	-0.23 (-0.31,-0.14)*
adjusted for covariates[c]	-0.20 (-0.22,-0.19)*	-0.04 (-0.12,0.04)	-0.04 (-0.11,0.02)	-0.21 (-0.36,-0.06)*	-0.05 (-0.13,0.04)
16y					
adjusted for gender	-0.31 (-0.32,-0.29)*	-0.18 (-0.27,-0.09)*	-0.08 (-0.15,-0.01)*	-0.52 (-0.68,-0.35)*	-0.24 (-0.33,-0.15)*
adjusted for covariates[c]	-0.20 (-0.22,-0.18)*	-0.03 (-0.11,0.05)	-0.02 (-0.08,0.05)	-0.27 (-0.42,-0.12)*	-0.04 (-0.12,0.04)
50y					
adjusted for gender	-0.15 (-0.16,-0.13)*	-0.04 (-0.13,0.05)	-0.07 (-0.14,0.01)	-0.23 (-0.43,-0.03)*	-0.13 (-0.22,-0.04)*
adjusted for covariates[c]	-0.09 (-0.11,-0.07)*	0.03 (-0.06,0.13)	-0.03 (-0.11,0.04)	-0.11 (-0.30,0.08)	-0.03 (-0.12,0.06)
Mental health z-score[d]					
7y					
adjusted for gender	0.21 (0.19,0.22)*	0.22 (0.14,0.30)*	0.17 (0.10,0.24)*	0.30 (0.14,0.47)*	0.20 (0.11,0.28)*
adjusted for covariates[c]	0.19 (0.17,0.21)*	0.17 (0.09,0.26)*	0.15 (0.08,0.22)*	0.22 (0.06,0.39)*	0.14 (0.05,0.22)*
11y					
adjusted for gender	0.22 (0.21,0.24)*	0.39 (0.30,0.47)*	0.28 (0.21,0.34)*	0.39 (0.22,0.56)*	0.33 (0.24,0.41)*
adjusted for covariates[c]	0.20 (0.18,0.22)*	0.33 (0.24,0.41)*	0.25 (0.18,0.31)*	0.29 (0.12,0.46)*	0.25 (0.17,0.33)*
16y					

adjusted for gender	0.22 (0.20,0.24)*	0.41 (0.31,0.50)*	0.30 (0.23,0.37)*	0.72 (0.54,0.89)*	0.45 (0.35,0.54)*
adjusted for covariates[c]	0.17 (0.15,0.19)*	0.33 (0.23,0.42)*	0.26 (0.19,0.33)*	0.59 (0.42,0.76)*	0.33 (0.23,0.42)*
50y					
adjusted for gender	0.09 (0.08,0.11)*	0.29 (0.19,0.38)*	0.37 (0.29,0.45)*	0.49 (0.32,0.66)*	0.32 (0.22,0.43)*
adjusted for covariates[c]	0.09 (0.06,0.11)*	0.27 (0.18,0.36)*	0.37 (0.29,0.44)*	0.46 (0.29,0.63)*	0.30 (0.19,0.40)*

Mean differences obtained from multivariate response models; *p<0.05.

[a]mean difference per unit higher neglect score, range 0-≥4 (Tables 1 and 2).

[b]scores are based on math, reading (7,16y), math, reading, general ability (11y), immediate/delayed word lists, animal naming, letter cancellation (50y); score=greater ability.

[c]gender, birth-weight, maternal smoking during pregnancy, birth order, maternal age, father's class at birth (four categories: professional/managerial; ski manual; skilled manual; semiskilled/unskilled manual), mother's/father's education, household amenities.

[d]scores based on behavioural problems (7,11,16y) or depressive symptoms (50y); higher score=greater level of problems.

Table 4: Relative Risk Ratio (95% confidence interval) for highest qualification level by 42y for childhood maltreatment groups.

Qualification level	Cumulative neglect[a]	Physical abuse	Psychological abuse	Sexual abuse	Witnessed abuse
None					
adjusted for gender	2.64 (2.47,2.83)*	2.05 (1.54,2.73)*	1.39 (1.09,1.77)*	4.34 (2.68,7.04)*	2.10 (1.57,2.81)*
adjusted for covariates[b]	1.98 (1.84,2.13)*	1.40 (1.01,1.92)*	1.14 (0.87,1.49)	2.53 (1.47,4.35)*	1.18 (0.85,1.63)
+ 16y cognition	1.39 (1.27,1.51)*	1.45 (0.98,2.16)	1.13 (0.81,1.57)	1.60 (0.80,3.20)	1.18 (0.80,1.75)
+16y mental health[c]	1.29 (1.18,1.41)*	1.04 (0.69,1.58)	0.81 (0.58,1.15)	1.07 (0.51,2.24)	0.86 (0.57,1.30)
< O-level					
adjusted for gender	1.91 (1.80,2.02)*	1.23 (0.93,1.62)	0.99 (0.79,1.23)	1.78 (1.06,2.99)*	1.60 (1.23,2.09)*
adjusted for covariates[b]	1.52 (1.43,1.62)*	0.90 (0.67,1.22)	0.85 (0.67,1.08)	1.13 (0.65,1.97)	1.06 (0.80,1.42)
+ 16y cognition	1.17 (1.09,1.26)*	0.90 (0.64,1.27)	0.85 (0.65,1.10)	0.84 (0.44,1.60)	1.01 (0.73,1.40)
+16y mental health[c]	1.13 (1.05,1.21)*	0.78 (0.55,1.10)	0.74 (0.56,0.98)*	0.72 (0.37,1.39)	0.88 (0.63,1.22)
O-level					
adjusted for gender	1.42 (1.34,1.50)*	0.99 (0.78,1.26)	0.83 (0.69,0.999)*	0.96 (0.58,1.57)	1.05 (0.83,1.33)
adjusted for covariates[b]	1.21 (1.14,1.28)*	0.81 (0.63,1.04)	0.75 (0.62,0.91)*	0.70 (0.42,1.17)	0.80 (0.62,1.03)
+ 16y cognition	1.03 (0.97,1.10)	0.79 (0.61,1.04)	0.74 (0.60,0.91)*	0.60 (0.34,1.04)	0.78 (0.59,1.02)
+16y mental health[c]	1.02 (0.96,1.09)	0.77 (0.58,1.01)	0.72 (0.59,0.89)*	0.58 (0.33,1.02)	0.75 (0.57,0.98)*
A-level					
adjusted for gender	1.23 (1.16,1.32)*	1.07 (0.81,1.41)	0.96 (0.77,1.20)	1.07 (0.56,2.06)	1.11 (0.83,1.48)
adjusted for covariates[b]	1.12 (1.04,1.20)*	0.96 (0.72,1.28)	0.92 (0.73,1.14)	0.90 (0.46,1.74)	0.96 (0.71,1.29)
+ 16y cognition	1.00 (0.93,1.08)	0.95 (0.71,1.26)	0.89 (0.71,1.12)	0.81 (0.41,1.60)	0.91 (0.68,1.24)
+16y mental health[c]	1.00 (0.93,1.07)	0.94 (0.70,1.25)	0.88 (0.70,1.11)	0.79 (0.40,1.56)	0.90 (0.66,1.22)

RRR from multinomial logistic regression; degree-level (reference category) *p<0.05.

[a] RRR per unit higher neglect score (see Tables 1 and 2 for details).

[b] gender, birth-weight, maternal smoking during pregnancy, birth order, maternal age, father's class at birth (four categories: professional/managerial; skilled non-manual; skilled manual; semi-skilled/unskilled manual), mother's/father's education, household amenities.

[c] behaviour problems.

Table S1: Mean standardized cognition scores at 7y, 11y, 16y and 50y according to childhood neglect and abuse

	Mean cognition z-score at age:			
Neglect[a]	7y	11y	16y	50y
Cumulative score				
0	0.25	0.32	0.34	0.16
1	-0.03	-0.04	-0.05	-0.002
2	-0.26	-0.34	-0.34	-0.19
3	-0.46	-0.58	-0.60	-0.28
≥ 4	-0.74	-0.91	-0.94	-0.45
Abuse[b]				
Physical abuse				
No	0.01	0.02	0.02	0.01
Yes	-0.18	-0.25	-0.27	-0.09
Psychological abuse				
No	0.01	0.02	0.02	0.01
Yes	-0.06	-0.14	-0.14	-0.06
Sexual abuse				
No	0.01	0.01	0.01	0.004
Yes	-0.43	-0.54	-0.67	-0.20
Witnessed abuse				
No	0.02	0.02	0.02	0.01
Yes	-0.20	-0.28	-0.33	-0.13

[a]Items listed in Table 1; cumulative neglect score includes both prospective (7y and 11y) and retrospective (45y recalled) items; [b]abuse was recalled at 45y.

Means averaged over 10 imputed datasets.

Note: means are not directly comparable to mean differences presented in main tables as these are unadjusted means.

Table S2: Mean difference (95% confidence intervals) in child (7,11,16y) and adulthood (50y) cognitive and mental health z-score for childhood neglect measures.

	7y Prospective neglect[a]	11y Prospective neglect[a]	Retrospective neglect[a]
Cognitive z-score[b]			
At age 7y			
adjusted for gender	-0.36 (-0.39,-0.34)*	-0.26 (-0.29,-0.24)*	-0.10 (-0.14,-0.05)*
adjusted for covariates[c]	-0.28 (-0.31,-0.26)*	-0.18 (-0.21,-0.16)*	-0.05 (-0.09,-0.001)*
At age 11y			
adjusted for gender	-0.40 (-0.43,-0.38)*	-0.37 (-0.40,-0.35)*	-0.16 (-0.21,-0.12)*
adjusted for covariates[c]	-0.26 (-0.29,-0.24)*	-0.25 (-0.27,-0.22)*	-0.08 (-0.12,-0.04)*
At age 16y			
adjusted for gender	-0.41 (-0.44,-0.38)*	-0.38 (-0.41,-0.36)*	-0.18 (-0.23,-0.13)*
adjusted for covariates[c]	-0.25 (-0.28,-0.23)*	-0.24 (-0.27,-0.22)*	-0.09 (-0.14,-0.05)*
At age 50y			
adjusted for gender	-0.20 (-0.23,-0.17)*	-0.19 (-0.23,-0.16)*	-0.05 (-0.10,0.01)
adjusted for covariates[c]	-0.12 (-0.15,-0.09)*	-0.13 (-0.16,-0.09)*	-0.003 (-0.05,0.05)
Mental health z-score[d]			
At age 7y			
adjusted for gender	0.34 (0.32,0.37)*	0.20 (0.18,0.23)*	0.15 (0.11,0.20)*
adjusted for covariates[c]	0.32 (0.29,0.35)*	0.17 (0.14,0.19)*	0.12 (0.08,0.17)*
At age 11y			
adjusted for gender	0.25 (0.22,0.28)*	0.32 (0.30,0.34)*	0.18 (0.13,0.22)*
adjusted for covariates[c]	0.20 (0.17,0.23)*	0.29 (0.26,0.31)*	0.14 (0.10,0.19)*
At age 16y			
adjusted for gender	0.29 (0.26,0.32)*	0.28 (0.25,0.31)*	0.20 (0.15,0.26)*
adjusted for covariates[c]	0.20 (0.17,0.23)*	0.20 (0.17,0.23)*	0.15 (0.09,0.20)*
At age 50y			
adjusted for gender	0.09 (0.06,0.12)*	0.10 (0.07,0.13)*	0.24 (0.19,0.29)*
adjusted for covariates[c]	0.07 (0.03,0.10)*	0.08 (0.05,0.12)*	0.23 (0.18,0.28)*

Mean differences obtained from multivariate response models; *p<0.05.

[a] mean difference per unit higher score (see Tables 1 and 2 for details).

[b] scores are based on math, reading (7, 16y), math, reading, general ability (11y), immediate/delayed word lists, animal naming, letter cancellation (50y); higher score= greater ability.

[c] gender, birth-weight, maternal smoking during pregnancy, birth order, maternal age, father's social class at birth (four categories: professional/managerial; skilled non-manual; skilled manual; semiskilled/unskilled manual), mother's/father's education, household amenities.

[d] scores are based on behavioural problems (7, 11, 16y) or depressive symptoms (50y); higher score=greater level of problems.

Table S3: Relative Risk Ratio (95% confidence intervals) for highest qualification level by 42 years for childhood neglect measures.

Qualification level	7y Prospective neglect[a]	11y Prospective neglect[a]	Retrospective neglect[a]
None			
adjusted for gender	3.49 (3.13,3.89)*	3.35 (3.03,3.70)*	1.55 (1.32,1.82)*
adjusted for covariates[b]	2.27 (2.03,2.55)*	2.31 (2.07,2.57)*	1.24 (1.04,1.48)*
+ 16y cognition	1.44 (1.26,1.66)*	1.52 (1.34,1.72)*	1.05 (0.85,1.31)
+16y mental health[c]	1.35 (1.17,1.55)*	1.40 (1.23,1.60)*	0.93 (0.74,1.18)
< O-level			
adjusted for gender	2.39 (2.16,2.65)*	2.31 (2.10,2.54)*	1.45 (1.25,1.67)*
adjusted for covariates[b]	1.70 (1.53,1.90)*	1.72 (1.55,1.91)*	1.24 (1.06,1.44)*
+ 16y cognition	1.21 (1.07,1.36)*	1.23 (1.09,1.38)*	1.07 (0.90,1.28)
+16y mental health[c]	1.16 (1.03,1.32)*	1.18 (1.05,1.32)*	1.02 (0.85,1.22)
O-level			
adjusted for gender	1.63 (1.47,1.80)*	1.63 (1.48,1.78)*	1.16 (1.02,1.32)*
adjusted for covariates[b]	1.28 (1.15,1.41)*	1.32 (1.20,1.45)*	1.05 (0.91,1.20)
+ 16y cognition	1.04 (0.93,1.16)	1.07 (0.96,1.18)	0.96 (0.83,1.12)
+16y mental health[c]	1.03 (0.92,1.15)	1.06 (0.95,1.17)	0.95 (0.83,1.10)
A-level			
adjusted for gender	1.33 (1.18,1.50)*	1.39 (1.26,1.55)*	1.03 (0.87,1.21)
adjusted for covariates[b]	1.14 (1.01,1.29)*	1.23 (1.10,1.36)*	0.97 (0.82,1.14)
+ 16y cognition	0.99 (0.87,1.12)	1.06 (0.95,1.18)	0.91 (0.77,1.08)
+16y mental health[c]	0.98 (0.87,1.12)	1.05 (0.94,1.17)	0.91 (0.77,1.08)

RRR obtained from multinomial logistic regression; degree level (reference category) *p<0.05.

[a] RRR per unit higher neglect score (see Tables 1 and 2 for details).

[b] gender, birth-weight, maternal smoking during pregnancy, birth order, maternal age, father's social class at birth (four categories: professional/managerial; skilled non-manual; skilled manual; semiskilled/unskilled manual), mother's/father's education, household amenities.

[c] behaviour problems.