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ARTICLE

# Obesity and Type 2 Diabetes Risk in Midadult Life: The Role of Childhood Adversity

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**What's Known on This Subject**

Socioeconomic disadvantage is associated with poorer health outcomes in adulthood, including obesity, type 2 diabetes, and cardiovascular disease. Little is known about the long-term influences of adverse childhood experiences, such as abuse and neglect, on adult health.

**What This Study Adds**

Some adverse childhood experiences increase the risk of obesity and thereby type 2 diabetes in midadulthood. The interrelationships among childhood adversity, socioeconomic factors in childhood and adulthood, adult lifestyle factors, and adult health suggest potential causal pathways for additional investigation.

## ABSTRACT

OBJECTIVE. Child abuse has been associated with poorer physical health in adulthood, but less is known about childhood adversity more broadly, including neglect and family problems, or the pathways from adversity to adult disease. We have examined how different stressful emotional or neglectful childhood adversities are related to adiposity and glucose control in midadulthood, taking into account childhood factors, and whether the relationships are mediated by adult health behaviors and socioeconomic position.

METHODS. This was a prospective longitudinal study of 9310 members of the 1958 British birth cohort who participated in a biomedical interview at 45 years of age. Primary outcomes consisted of continuous measures of BMI, waist circumference, and glycosylated hemoglobin at 45 years and categorical indicators: total obesity (BMI ≥ 30), central obesity (waist circumference: ≥102 cm for men and ≥88 cm for women), and glycosylated hemoglobin level of ≥6.

RESULTS. The risk of obesity increased by 20% to 50% for several adversities (physical abuse, verbal abuse, witnessed abuse, humiliation, neglect, strict upbringing, physical punishment, conflict or tension, low parental aspirations or interest in education, hardly takes outings with parents, and father hardly reads to child). Adversities with the strongest associations with adiposity (eg, physical abuse) tended to be associated with glycosylated hemoglobin levels of ≥6, but in most cases associations were explained by adjustment for adulthood mediators such as adiposity. Effects of other adversities reflecting less severe emotional neglect and family environment were largely explained by childhood socioeconomic factors.

CONCLUSIONS. Some childhood adversities increase the risk of obesity in adulthood and thereby increase the risk for type 2 diabetes. Research is needed to understand the interrelatedness of adversities, the social context of their occurrence, and trajectories from adversity to adult disease.

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**Key Words**
type 2 diabetes, HbA1c, obesity, child abuse, child neglect, lifestyle, socioeconomic factors, smoking, alcohol drinking, cohort studies

**Abbreviations**
SEP—socioeconomic position
WC—waist circumference
HbA1c—glycosylated hemoglobin
OR—odds ratio
CI—confidence interval

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IT IS WELL known that lower socioeconomic position (SEP) in childhood is linked to obesity[1] and cardiovascular disease in adulthood,[2] including insulin resistance[3] and type 2 diabetes.[4,5] Early life abusive and neglectful experiences may also have long-term effects on health, with recent studies showing increased risks of obesity, cardiovascular disease, diabetes, and liver disease,[6–11] as well as risks of associated health behaviors.[12–15] For example, adults exposed to abuse or who witnessed abuse of a family member,[16–18] experienced family conflict,[19] experienced parental separation,[16,19] or experienced parental substance or alcohol abuse as a child[16,19] have been found to be more likely to smoke. Similarly, those exposed to sexual abuse,[20] parental separation,[21] and parental substance or alcohol abuse were reported to have a later risk of alcoholism.[17] However, the mechanisms linking stressful emotional and neglectful childhood experiences (adversities) to adult health are unclear, with little research using large, population-based longitudinal studies and with little evidence as to whether effects of these childhood adversities might be because of other exposures in early life.

Obesity and type 2 diabetes are important public health concerns[22,23]; thus, the relationship for childhood adversity with obesity and diabetes suggested by the literature deserves fuller investigation. Using data from a British cohort

followed from their birth in 1958, we sought to establish (1) whether different stressful emotional or neglectful childhood adversities are related to adiposity and glucose metabolism in midadulthood; (2) whether associations for childhood adversities are because of other childhood factors, such as material disadvantage or cognition; and (3) whether childhood adversity is indirectly associated with adiposity and glucose metabolism through effects on adult health behaviors (smoking, alcohol consumption, diet, and physical activity) and socioeconomic destinations.

## METHODS

### Participants

The 1958 cohort consists of 17 638 participants originally enrolled in the Perinatal Mortality Survey all born during 1 week in March 1958 in England, Scotland, and Wales and subsequently interviewed in childhood (ages 7, 11, and 16 years) and adulthood (23, 33, 42, and 45 years).[24] An additional 920 immigrants with the same birth dates were recruited to the study up to age 16 years. By age 45 years, 1245 cohort members had died and 1300 had emigrated from Britain ($n$ = 16 013). At 45 years, contact was not attempted for 3004 members (for various reasons, such as members of armed forces), and 1038 gave a permanent refusal.[25] Therefore, a target of 11 971 cohort members who had not died or emigrated, were still in contact with the survey, and were able to provide informed consent were invited to a biomedical assessment at age 45 years: 9377 were interviewed (78%). The resulting sample was broadly similar to the original birth population with slight underrepresentation from unskilled manual backgrounds.[25] Individuals with type 1 diabetes (59 self-reported at 42 years and 8 prescribed insulin [British National Formulary code 060101] at 45 years) were excluded from analyses ($N$ = 9310). Ethical approval for the biomedical survey was given by the South East Multi-Centre Research Ethics Committee.

### Measures

*Outcomes*

Adiposity at 45 years was assessed by BMI, calculated as kilograms per meter squared, and waist circumference (WC) in centimeters. A nurse using a standardized protocol and equipment (scales and a stadiometer) measured height and weight without shoes and in light clothing. WC was measured by a nurse midway between the costal margin and iliac crest. World Health Organization recommendations for BMI (≥30 kg/m$^2$) and WC (≥102 cm for men and ≥88 cm for women) were used to indicate total and central obesity.[23] Glucose control at 45 years was assessed by glycosylated hemoglobin (HbA1c), reflecting average glucose levels over the last 2 to 3 months. HbA1c was measured from nonfasting venous blood samples using ion exchange high-performance liquid chromatography (Tosoh A1c2.2 Glycohemoglobin Analyser, HLC-723GHb [Tosoh Corp, Tokyo, Japan])[26] at the Department of Clinical Biochemistry, Newcastle-on-Tyne Hospitals National Health Service Trust. Results were standardized to the HbA1c assay used in the Diabetes Control and Complications Trial.[27,28] As in our previous work,[29] HbA1c was analyzed as binary variable using 6% (2 SDs above the mean[30,31]) as a cutoff. Type 2 diabetes cases (doctor's diagnosis reported at 42 years or oral antidiabetes treatment at 45 years) were included in the definition of HbA1c ≥6.

*Childhood Adversity*

Data were collected retrospectively (at 45 years) and prospectively at different ages in childhood. For retrospective reports, participants completed a confidential questionnaire, using a hand-held computer, about their childhood to age 16 years. The questions, used by the Path Through Life Project,[32] originated from the Parental Bonding Instrument, the British National Survey of Health and Development, and the US National Comorbidity Survey. The questions, listed ad verbatim in Table 1, have been grouped into 4 broad categories: emotional neglect, physical neglect, household dysfunction, and abuse, similar to groups used by the Adverse Childhood Experiences Study.[7] Data on parental separation or divorce were collected at 33 years and supplemented with prospective data from parent interviews at 11 and 16 years.

Prospective measures were obtained at 7, 11, and 16 years, when a Local Authority Health Visitor interviewed the parents (usually the mother) using a structured schedule. We used information on low parental involvement with the child to indicate emotional neglect. This consisted of little interest in child's education rated for each parent by teachers at 7, 11, and 16 years (compared with some, very, or overconcerned); hardly ever has outings with mother or father (compared with occasionally or most weeks) at 7 and 11 years; mother or father hardly ever reads to the child (compared with occasionally or every week) at 7 years; and low parental aspirations indicated by the parents wishes for the child to leave school at minimum age collected at 11 and 16 years (compared with staying on after age 16 years). Physical neglect was ascertained by "appearance of child" as scruffy or dirty in the Bristol Social Adjustment Guide, judged by teachers at 7 and 11 years.[33] Household dysfunction is indicated by domestic tension (7 years), whether the child had ever been in local or voluntary care by age 16 years, whether the participant got on well with his or her mother or father (16 years), and parental alcoholism (7 years). For prospective items measured at >1 age, we classified respondents as having experienced that adversity if it was reported at least once.

*Childhood Factors*

SEP at birth was based on the fathers occupation using the Registrar General's Social Class and grouped as 1 and 2, 3 nonmanual, 3 manual, and 4 and 5 (including single-mother households). Where data were missing, father's SEP when the child was 7 years old was used. We used 3 measures of material (dis)advantage: type of accommodation at 7, 11, and 16 years of age categorized

TABLE 1 **Description of the 1958 Cohort at 45 Years of Age ($N = 9310$)**

| Variable | *n* | Men | Women | *P* |
|---|---|---|---|---|
| Biomedical outcomes at 45 y | | | | |
| Mean BMI (95% CI)[a] | 9282 | 27.5 (27.4 to 27.6) | 26.5 (26.3 to 26.6) | <.001 |
| Mean WC (95% CI)[a] | 9225 | 97.8 (97.5 to 98.1) | 84.6 (84.3 to 85.0) | <.001 |
| Mean HbA1c (95% CI)[a] | 7862 | 5.26 (5.25 to 5.28) | 5.14 (5.13 to 5.16) | <.001 |
| Obesity (BMI ≥30 kg/m$^2$), % (*n*) | 9282 | 25.3 (1168) | 23.7 (1104) | .066 |
| High WC (≥102 cm men, ≥88 cm women), % (*n*) | 9225 | 32.6 (1497) | 36.8 (1706) | <.001 |
| Type 2 diabetes, % (*n*) | 9225 | 1.68 (77) | 1.16 (54) | .035 |
| HbA1c ≥6 (excluding type 2 diabetes), % (*n*) | 7751 | 3.20 (124) | 2.09 (81) | .002 |
| Childhood adversity, retrospective measures (45 y), % (*n*) | | | | |
| Abuse | | | | |
| I was verbally abused by a parent | 9243 | 6.65 (305) | 9.41 (438) | <.001 |
| I suffered humiliation, ridicule, bullying or mental cruelty from a parent | 9242 | 5.76 (264) | 8.87 (413) | <.001 |
| I was physically abused by a parent—punched, kicked or hit or beaten with an object, or needed medical treatment | 9242 | 5.91 (271) | 6.16 (287) | .611 |
| I was sexually abused by a parent | 9242 | 0.46 (21) | 2.71 (126) | <.001 |
| Physical neglect | | | | |
| I was neglected | 9242 | 1.79 (82) | 3.52 (164) | <.001 |
| Emotional neglect | | | | |
| How affectionate was your father towards you? (father not at all affectionate) | 9244 | 10.16 (466) | 8.13 (379) | .001 |
| How affectionate was your mother towards you? (mother not at all affectionate) | 9244 | 1.85 (85) | 5.13 (239) | <.001 |
| Household dysfunction | | | | |
| Did your father suffer from nervous or emotional trouble or depression? (had problems) | 9239 | 9.32 (427) | 10.87 (506) | .014 |
| Did your mother suffer from nervous or emotional trouble or depression? (had problems) | 9240 | 16.54 (758) | 22.53 (1049) | <.001 |
| Did your father have trouble with drinking or other drug use? (had problems) | 9239 | 9.60 (440) | 11.23 (523) | .010 |
| Did your mother have trouble with drinking or other drug use? (had problems) | 9240 | 3.38 (155) | 5.43 (253) | <.001 |
| How much conflict and tension was there in your household while you were growing up? (a lot) | 9243 | 11.04 (506) | 16.17 (753) | <.001 |
| I had a strict, authoritarian or regimented upbringing | 9241 | 24.72 (1133) | 27.91 (1300) | <.001 |
| I received too much physical punishment: hitting, smacking, etc | 9242 | 6.39 (293) | 8.85 (412) | <.001 |
| I witnessed physical or sexual abuse of others in my family | 9242 | 4.45 (204) | 7.58 (353) | <.001 |
| Separation or divorce of parents by age 16 y | 8263 | 9.93 (401) | 11.27 (476) | .049 |
| Childhood adversity, prospective measures, % (*n*) | | | | |
| Physical neglect | | | | |
| Neglected appearance (BSAG: 7 and 11 y) | 7805 | 3.98 (148) | 2.47 (101) | <.001 |
| Emotional neglect | | | | |
| Mother hardly ever reads to child (7 y) | 8092 | 15.58 (623) | 14.41 (590) | .142 |
| Father hardly ever reads to child (7 y) | 7857 | 27.65 (1079) | 27.49 (1087) | .878 |
| Hardly ever takes outings with mother (7 and 11 y) | 8868 | 6.59 (290) | 4.68 (209) | <.001 |
| Hardly ever takes outings with father (7 and 11 y) | 8676 | 10.38 (448) | 11.53 (503) | .086 |
| Mother has little interest in education (7, 11, or 16 y) | 8488 | 27.63 (1163) | 25.29 (1082) | .014 |
| Father has little interest in education (7, 11, or 16 y) | 8302 | 31.20 (1286) | 29.67 (1240) | .129 |
| Low parental aspirations: leave school at minimum age (11 or 16 y) | 8781 | 29.02 (1266) | 26.82 (1185) | .021 |
| Household dysfunction | | | | |
| Domestic tension (7 y) | 8154 | 4.32 (174) | 4.46 (184) | .751 |
| Alcoholism (7 y) | 8150 | 0.67 (27) | 0.75 (31) | .661 |
| Does not get on well with mother (16 y) | 7078 | 3.72 (130) | 5.66 (203) | <.001 |
| Does not get on well with father (16 y) | 6848 | 6.14 (208) | 8.99 (311) | <.001 |
| In care by age 16 y | 6895 | 2.87 (98) | 2.96 (103) | .840 |

*t* tests and $\chi^2$ tests were used to test gender differences for continuous and categorical variables, respectively. BSAG indicates British Social Adjustment Guide.

[a] Data are the geometric mean.

as owner occupied, rented from the council, or privately rented; number of persons per room at 7, 11, and 16 years (≤1.0, 1.0–1.5, 1.5–2.0, or >2.0) and whether any child in the home received free school meals at 11 and 16 years. Birth weight for gestational age was based on measured weights (converted from pounds [ounces] into grams) and age in weeks. Cognitive ability was based on a general test at 11 years.[34]

### *Adulthood Mediators*

Adulthood factors were regarded as potential mediators of the childhood adversity-adult outcome (obesity or HbA1c) association. SEP at 42 years (categorized as for childhood SEP) and qualifications attained by 33 years (none, less than O level, O level, A level, or higher) were used as indicators of adult social position. Smoking was reported at 42 years: 5 categories from never to current smoker of ≥20 cigarettes per day. Frequency of alcohol consumption was recorded at 45 years: 5 categories from not in the last 12 months to ≥4 times per week. Amount of alcohol was recorded as: 1 to 2, 3 to 4, 5 to 6, 7 to 9, or >9 drinks per day for those who consumed alcohol. Diet and physical activity were recorded at 33 and 42 years, as described previously.[35] Briefly, participants re-

ported chips, fried food, and fruit and vegetable consumption as never, <1, 1 to 2, or ≥3 days per week. Frequency of leisure activity at 33 and 42 years in 4 categories ranged from <2 to 3 times per month to 4 to 7 days per week. Watching television or using a computer (other than at work) was reported at 45 years, ranging from <1 hour per day to >4 hours per day (5 categories).

*Other Confounders*

Family history of type 2 diabetes (parent or sibling had diabetes) was ascertained from 2 data sources: at the 7-year follow-up, parents reported any history of diabetes in parents, brothers or sisters, and diabetes-related causes of death (original or underlying) of parents were available to the end of December 2003 and coded according to the International Classification of Diseases, 10th Revision, codes E10 to E14.[36]

### Statistical Analysis

Analyses were conducted on continuous (BMI, WC, and HbA1c) and binary (total obesity, central obesity, and HbA1c ≥ 6) outcomes using linear and logistic regression, respectively. Continuous outcomes were log transformed and regression results back transformed to obtain geometric mean differences. For HbA1c, robust SEs were used, because the homoscedasticity assumption could not be met through transformation of the dependent variable.[37]

Three models were fitted for each outcome. A basic model was fitted for each adversity variable separately, controlling for gender (plus family history of type 2 diabetes for HbA1c/HbA1c ≥ 6 and diabetes treatment for analyses of continuous HbA1c), and then adjusted for childhood confounding factors plus adulthood mediators. Linearity of continuous independent variables was assessed and quadratic terms were tested and included in models where necessary. The likelihood ratio statistic was used to test gender interactions by comparing the log likelihoods from models with and without the interaction term. Interactions with results at $P$ values $< .05$ are presented separately for men and women.

The analysis sample depended on completion of childhood adversity questions at 45 years and valid data for each outcome: 9219 individuals formed the sample for analysis of BMI, 9165 for WC, and 7784 for HbA1c. However, samples with complete data on confounding factors or mediators were smaller. The model of HbA1c regressed on "doesn't get on with father at 16 years" was most affected by missing data: although 74% of the sample had valid data for the adversity, 57% were missing data on ≥1 covariate. To reduce possible bias, we imputed for missing data using the multiple imputation by chained equations method described by van Buuren.[38] As recommended, 10 copies of the original data set imputed for missing data were created, and a regression analysis that combines results from each data set was undertaken.[39] Comparison of results from complete data and multiple imputation models found generally consistent results, except that effect sizes for complete case results were slightly higher, suggesting bias, and were less likely to be statistically significant because of the smaller sample. Results based on imputation are presented. Analyses were conducted by using Stata 9.2 (Stata Corp, College Station, TX).

## RESULTS

### Descriptive Information

Men had a higher mean BMI, WC, and HbA1c and prevalence of HbA1c ≥ 6 (4.88% vs 3.25%), but more women had central obesity as defined by World Health Organization cutoffs (Table 1). Most study participants had ≤1 childhood adversity, as identified retrospectively (25% with 1 and 45% with 0 adversities) or prospectively (21% with 1 and 35% with 0 adversities). The most common retrospectively identified adversities were strict upbringing and a mother with depression, whereas common prospective adversities were low parental aspirations and lack of parental interest in education (Table 1). For the participants with some prospectively identified common adversities (eg, low parental aspirations), the proportion also reporting multiple (≥3) retrospective adversities was similar to that observed for the whole population (14% in all men and women), whereas for participants with some less common adversities, such as alcoholism, there was a higher percentage (47%) with ≥3 adversities. Similarly, for retrospectively identified common adversities, such as strict upbringing, the proportion with ≥3 prospectively identified adversities was no greater than for the whole population (15% vs 19%, respectively); yet, among those with less common retrospectively identified adversities, such as neglect, there was a higher percentage (29%) with ≥3 prospectively identified adversities. Women were more likely to report exposure to childhood adversities on most retrospective questions except for lack of paternal affection, which was more prevalent in men, and physical abuse, which was reported by 6% of both sexes. Fewer gender differences were seen for prospective than for retrospective measures.

### Adverse Childhood Experiences, Obesity, and Glucose Metabolism

Regression results of the associations for adversities with BMI, central obesity, and HbA1c ≥ 6 are presented in the tables; results for total obesity, continuous WC, and HbA1c are referred to in the text where differences are relevant.

### Adversities Measured During Childhood

Several adversities (mother hardly reads to child, does not get on with either parent, scruffy or dirty appearance, domestic tension, parental alcoholism, in care) were unrelated to BMI, central obesity, or HbA1c ≥ 6 (Table 2). These adversities were also unrelated to total obesity, continuous WC, or HbA1c (data not shown). Some adversities (low parental aspirations and little paternal or maternal interest in education) were significantly associated with increased BMI, central obesity, and HbA1c ≥ 6 at 45 years of age (Table 2). "Hardly

**TABLE 2 Regression Models for BMI, Central Adiposity, and Raised HbA1c Levels at 45 Years With Exposure to Childhood Adversities Measured in Childhood**

| Variable | BMI (kg/m²) Coefficient (95% CI)[a] | | | Central Obesity OR (95% CI) | | | Type 2 Diabetes Mellitus or HbA1c ≥ 6 OR (95% CI) | | |
|---|---|---|---|---|---|---|---|---|---|
| | Model 1[b] | Model 2[c] | Model 3[d] | Model 1[b] | Model 2[c] | Model 3[d] | Model 1[b] | Model 2[c] | Model 3[d] |
| Physical neglect | | | | | | | | | |
| Scruffy or dirty appearance | 0.20 (−0.44 to 0.85) | −0.10 (−0.72 to 0.55) | −0.18 (−0.8 to 0.51) | 1.12 (0.89 to 1.40) | 1.01 (0.80 to 1.28) | 0.96 (0.75 to 1.23) | 1.27 (0.73 to 2.19) | 1.03 (0.58 to 1.80) | 0.99 (0.53 to 1.85) |
| Emotional neglect | | | | | | | | | |
| Mother hardly reads to child | 0.21 (−0.08 to 0.51) | 0.06 (−0.22 to 0.36) | 0.02 (−0.26 to 0.32) | 1.03 (0.91 to 1.17) | 0.97 (0.85 to 1.11) | 0.95 (0.83 to 1.09) | 1.06 (0.75 to 1.49) | 0.96 (0.68 to 1.36) | 0.93 (0.64 to 1.37) |
| Father hardly reads to child | 0.28 (0.04 to 0.52)[e] | 0.10 (−0.13 to 0.34) | 0.05 (−0.18 to 0.3) | 1.11 (1.00 to 1.23)[e] | 1.05 (0.94 to 1.16) | 1.01 (0.91 to 1.13) | 1.10 (0.83 to 1.46) | 1.00 (0.75 to 1.34) | 0.97 (0.70 to 1.34) |
| Hardly takes outings with mother | 0.73 (0.3 to 1.17)[f] | 0.44 (0.02 to 0.88)[e] | 0.33 (−0.09 to 0.79) | 1.09 (0.90 to 1.32) | 0.98 (0.80 to 1.19) | 0.94 (0.77 to 1.15) | 0.93 (0.55 to 1.57) | 0.77 (0.46 to 1.32) | 0.78 (0.43 to 1.42) |
| Hardly takes outings with father | 0.49 (0.18 to 0.81)[g] | 0.21 (−0.1 to 0.53) | 0.11 (−0.19 to 0.44) | 1.15 (1.00 to 1.33) | 1.05 (0.90 to 1.21) | 1.00 (0.86 to 1.17) | 1.17 (0.82 to 1.68) | 0.99 (0.68 to 1.43) | 1.00 (0.66 to 1.52) |
| Mother little interest in education | — | — | — | — | — | — | 1.74 (1.34 to 2.26)[f] | 1.39 (1.04 to 1.86)[e] | 1.36 (0.99 to 1.87) |
| Men | 0.46 (0.17 to 0.76)[g] | 0.11 (−0.20 to 0.44) | 0.11 (−0.21 to 0.47) | 1.07 (0.92 to 1.24) | 0.93 (0.79 to 1.10) | 0.89 (0.74 to 1.06) | — | — | — |
| Women | 1.18 (0.79 to 1.58)[f] | 0.71 (0.28 to 1.17)[f] | 0.48 (0.06 to 0.95)[e] | 1.35 (1.18 to 1.55)[f] | 1.14 (0.99 to 1.33) | 1.05 (0.90 to 1.23) | — | — | — |
| Father little interest in education | — | — | — | 1.17 (1.05 to 1.30)[g] | 1.00 (0.89 to 1.13) | 0.95 (0.84 to 1.07) | 1.50 (1.17 to 1.92)[f] | 1.17 (0.90 to 1.52) | 1.09 (0.81 to 1.46) |
| Men | 0.42 (0.13 to 0.73)[g] | 0.07 (−0.25 to 0.39) | 0.07 (−0.23 to 0.42) | — | — | — | — | — | — |
| Women | 0.94 (0.58 to 1.32)[f] | 0.46 (0.07 to 0.89)[a] | 0.27 (−0.13 to 0.72) | — | — | — | — | — | — |
| Low parental aspirations | 0.50 (0.28 to 0.73)[f] | 0.09 (−0.14 to 0.34) | −0.05 (−0.28 to 0.18) | 1.17 (1.06 to 1.29)[g] | 1.02 (0.92 to 1.13) | 0.95 (0.85 to 1.06) | 1.51 (1.16 to 1.96)[g] | 1.23 (0.92 to 1.64) | 1.19 (0.86 to 1.64) |
| Household dysfunction | | | | | | | | | |
| Domestic tension | 0.39 (−0.10 to 0.9) | 0.11 (−0.36 to 0.62) | 0.11 (−0.38 to 0.65) | 1.09 (0.85 to 1.39) | 0.99 (0.77 to 1.27) | 0.99 (0.77 to 1.28) | 0.99 (0.56 to 1.76) | 0.85 (0.47 to 1.53) | 0.83 (0.44 to 1.56) |
| Alcoholism | −0.24 (−1.43 to 1.01) | −0.60 (−1.73 to 0.62) | −0.64 (−1.78 to 0.64) | 0.92 (0.52 to 1.62) | 0.80 (0.45 to 1.41) | 0.75 (0.41 to 1.36) | 0.95 (0.23 to 3.84) | 0.79 (0.19 to 3.25) | 0.90 (0.20 to 4.02) |
| Does not get on with mother | −0.01 (−0.51 to 0.51) | −0.06 (−0.54 to 0.44) | −0.02 (−0.49 to 0.49) | 0.92 (0.72 to 1.17) | 0.91 (0.71 to 1.15) | 0.90 (0.70 to 1.16) | 0.75 (0.38 to 1.45) | 0.71 (0.37 to 1.39) | 0.70 (0.34 to 1.44) |
| Does not get on with father | 0.20 (−0.23 to 0.65) | 0.11 (−0.31 to 0.55) | 0.17 (−0.25 to 0.62) | 1.13 (0.94 to 1.37) | 1.11 (0.91 to 1.35) | 1.12 (0.91 to 1.37) | 1.07 (0.66 to 1.74) | 1.04 (0.64 to 1.71) | 0.99 (0.57 to 1.71) |
| In care by 16 y | −0.04 (−0.68 to 0.62) | −0.39 (−1.01 to 0.26) | −0.44 (−1.02 to 0.21) | 1.01 (0.75 to 1.36) | 0.90 (0.67 to 1.22) | 0.89 (0.66 to 1.20) | 1.14 (0.54 to 2.39) | 0.93 (0.44 to 1.98) | 0.93 (0.40 to 2.13) |

Sample sizes are based on valid data for outcome and completion of childhood adversity questionnaire at 45 years: $n = 9219$ for BMI, $n = 9165$ for WC, and $n = 7784$ for HbA1c.

[a] Data show the geometric mean difference.

[b] Model 1 was adjusted for gender (plus current diabetes treatment, family history of diabetes for type 2 diabetes mellitus, or HbA1c ≥6).

[c] Model 2 was model 1 adjusted for birth weight for gestational age, childhood SEP, general ability (11 years), free school meals (11 and 16 years), type of housing (7, 11, and 16 years), and number of persons per room (7, 11, and 16 years).

[d] Model 3 was model 2 adjusted for SEP at 42 years, qualifications at 33 years, smoking and alcohol intake at 42 years, and diet and physical activity at 33 and 42 years. HbA1c was additionally adjusted for BMI and WC.

[e] *P* value was <.05.

[f] *P* value was ≤.001.

[g] *P* value was ≤.01.

takes outings with father" was significantly associated with BMI and central obesity; the weak increased risk of HbA1c ≥ 6 associated with this adversity was nonsignificant (Table 2), but a significant increase in continuous HbA1c existed (odds ratio [OR]: 0.050% [95% confidence interval (CI): 0.001 to 0.090]). Adjustment for childhood factors reduced the associations for each outcome by >50%, usually with loss of statistical significance, but some associations remained significant, for example, those whose mothers had little interest in their education had higher BMI and increased likelihood of HbA1c ≥ 6, and women also had an increased likelihood of central obesity (Table 2). Additional adjustment for adult mediators reduced the associations with adiposity or HbA1c ≥ 6 by up to an additional 20% and fully attenuated the associations in most cases, and only BMI (Table 2) and continuous WC (coefficient: 1.01 cm [95% CI: 0.12 to 1.99]) remained significantly higher for women whose mothers had little interest in their education.

### Childhood Adversities Reported at 45 Years

Some adversities were unrelated and some were positively and others inversely associated with the adult outcomes (Table 3). A strict upbringing was significantly associated with increased BMI, central obesity, and HbA1c ≥ 6 at 45 years. Physical abuse was also associated with BMI and central obesity, but a borderline association existed for HbA1c ≥ 6 (Table 3); however, HbA1c increased significantly by 0.070% (range: 0.001–0.140). Adjustment for child or adulthood factors had little affect on the associations for BMI and central obesity. For HbA1c ≥ 6, adjustment for adult mediators also partially explained the association with childhood adversities, for example, the OR for a strict upbringing reduced by 17% with adjustment for childhood factors and a further 28% with adulthood factors, suggesting mediation by adulthood factors, such as adiposity.

Several adversities (verbal abuse, humiliation, neglect, witnessed abuse, conflict or tension, and physical punishment) were significantly associated with increases in adiposity but not HbA1c ≥ 6, although moderate effect sizes existed for the latter that were explained by childhood and adulthood factors (Table 3). Adjustment for childhood or adulthood factors had little impact on effect sizes for adiposity, although some attenuation was observed for witnessing abuse for BMI and central obesity (Table 3). "Father drink/drugs" was not associated with adiposity, but for men, risk of HbA1c ≥ 6 remained increased after adjustment for childhood and adulthood factors.

Maternal and paternal depression was associated with a lower BMI (Table 3). Paternal depression was also associated with a significantly lower HbA1c for men (coefficient: −0.05% [95% CI: −0.10% to −0.01%]), with little change after adjustment. Although not statistically significant, after full adjustment, associations of sexual abuse were suggestive of a smaller WC (coefficient: −1.09 cm [95% CI: −3.01 to 0.98]) analyzed as a continuous variable and a reduced risk of HbA1c ≥ 6 (Table 3).

## DISCUSSION

Some severe forms of childhood adversity, such as physical abuse or witnessing abuse of a family member, were associated with increased risk of total or central obesity by 20% to 40% and were not fully explained by confounding from other childhood influences or mediation by adult socioeconomic or lifestyle factors. Adversities with the strongest associations with adiposity in adulthood tended to also be associated with glucose metabolism, although in most cases associations were explained by adult mediators, including adiposity. Several markers of less severe stressful emotional environments showed moderate-to-weak effects and, for measures obtained prospectively, these appeared to be largely explained by other childhood factors. Given the limited evidence available to date, our study provides important insights on the extent to which effects of stressful emotional and neglectful childhood experiences persist to influence important markers of physical health >3 decades later.

The major strengths of the study include its longitudinal design, large sample, objective measures for glucose metabolism, BMI and WC, and rich data on childhood circumstances. Such data allow us to distinguish effects of neglectful and abusive experiences from adversities that are primarily socioeconomic. Our study has the additional strength of prospective measurement of childhood adversities, as well as information collected at 45 years of age using instruments developed elsewhere.[32] Retrospective data collection is subject to recall bias or influenced by current events or state of mind.[40] Two previous studies have found that retrospective, but not prospective, reports of child abuse were associated with pain and drug abuse, suggesting that associations may be affected by recall bias.[41,42] However, prospective identification of cases may underestimate the incidence of abuse and be unrepresentative, with undetected cases being possibly more severe over a prolonged period.[43] Therefore, retrospective report may be preferable for the more extreme adversities, such as physical and sexual abuse.[44] In general, the retrospective and prospective exposures examined in our study do not measure the same adversities (exceptions are family conflict and parental alcohol or drug abuse); hence, direct comparison between reporting methods is limited.

A main limitation of the study is the lack of glucose tolerance tests because of practical limitations. However, HbA1c provides an estimate of average glucose concentration over the previous 2 to 3 months and is a good predictor of microvascular and macrovascular outcomes when compared with the oral glucose tolerance test.[30,45] Given the large number of tests conducted as part of the current analyses, some may argue that correction for multiple testing would have been required. However, the use of multiple correction testing is not universally accepted, and corrections such as Bonferroni are known to artificially increase the risk of type 2 error.[46–48] As with all longitudinal studies, sample attrition had occurred over time, and although participation at 45 years showed only small biases by childhood class,[25] larger biases were apparent when complete data were examined for this study, and we, therefore, used multiple

**TABLE 3 Regression Models for BMI, Central Adiposity, and Raised HbA1c at 45 Years With Exposure to Childhood Adversities Reported at 45 Years**

| Variable | BMI (kg/m²) Coefficient (95% CI)[a] | | | Central Obesity OR (95% CI) | | | Type 2 Diabetes Mellitus or HbA1c ≥ 6 OR (95% CI) | | |
|---|---|---|---|---|---|---|---|---|---|
| | Model 1[b] | Model 2[c] | Model 3[d] | Model 1[b] | Model 2[c] | Model 3[d] | Model 1[b] | Model 2[c] | Model 3[d] |
| Abuse | | | | | | | | | |
| Verbal abuse | 0.47 (0.11 to 0.84)[e] | 0.37 (0.02 to 0.74)[e] | 0.47 (0.10 to 0.86)[e] | 1.18 (1.01 to 1.38)[e] | 1.16 (0.99 to 1.35) | 1.18 (1.00 to 1.39) | 1.23 (0.82 to 1.84) | 1.16 (0.77 to 1.75) | 1.06 (0.68 to 1.66) |
| Humiliation | 0.35 (−0.03 to 0.73) | 0.25 (−0.12 to 0.63) | 0.28 (−0.09 to 0.68) | 1.21 (1.03 to 1.42)[e] | 1.18 (1.00 to 1.39) | 1.19 (1.00 to 1.40) | 1.33 (0.89 to 2.00) | 1.24 (0.82 to 1.86) | 1.15 (0.74 to 1.80) |
| Physical abuse | 0.73 (0.31 to 1.16)[f] | 0.58 (0.17 to 1.01)[g] | 0.64 (0.22 to 1.10)[g] | 1.39 (1.17 to 1.65)[f] | 1.34 (1.13 to 1.61)[f] | 1.33 (1.11 to 1.60)[g] | 1.39 (0.90 to 2.13) | 1.25 (0.81 to 1.93) | 1.02 (0.63 to 1.65) |
| Sexual abuse | 0.09 (−0.68 to 0.89) | −0.18 (−0.91 to 0.6) | −0.09 (−0.82 to 0.72) | 0.96 (0.68 to 1.35) | 0.88 (0.62 to 1.25) | 0.88 (0.61 to 1.26) | 0.75 (0.23 to 2.37) | 0.62 (0.19 to 1.98) | 0.42 (0.12 to 1.50) |
| Physical neglect | | | | | | | | | |
| Neglected | 0.32 (−0.29 to 0.95) | 0.16 (−0.42 to 0.78) | 0.22 (−0.37 to 0.87) | 1.34 (1.03 to 1.73)[e] | 1.28 (0.98 to 1.66) | 1.32 (1.01 to 1.73)[e] | 1.47 (0.79 to 2.73) | 1.30 (0.70 to 2.44) | 1.32 (0.68 to 2.57) |
| Emotional neglect | | | | | | | | | |
| Father not affectionate | 0.05 (−0.29 to 0.39) | −0.09 (−0.42 to 0.24) | −0.13 (−0.44 to 0.21) | 1.04 (0.90 to 1.21) | 0.99 (0.85 to 1.15) | 0.97 (0.83 to 1.13) | 1.01 (0.69 to 1.49) | 0.94 (0.64 to 1.39) | 0.93 (0.61 to 1.42) |
| Mother not affectionate | −0.16 (−0.68 to 0.38) | −0.37 (−0.87 to 0.15) | −0.34 (−0.83 to 0.19) | 0.96 (0.76 to 1.21) | 0.89 (0.70 to 1.13) | 0.89 (0.70 to 1.14) | 1.22 (0.67 to 2.21) | 1.08 (0.59 to 1.98) | 1.15 (0.59 to 2.23) |
| Household dysfunction | | | | | | | | | |
| Father depression | −0.53 (−0.84 to −0.21)[f] | −0.42 (−0.72 to −0.11)[g] | −0.29 (−0.58 to 0.03) | 0.95 (0.82 to 1.10) | 0.98 (0.85 to 1.13) | 1.05 (0.90 to 1.21) | 0.77 (0.50 to 1.17) | 0.80 (0.52 to 1.23) | 0.82 (0.51 to 1.29) |
| Mother depression | −0.34 (−0.58 to −0.09)[g] | −0.38 (−0.6 to −0.14)[g] | −0.31 (−0.53 to −0.07)[e] | 0.92 (0.83 to 1.03) | 0.91 (0.82 to 1.02) | 0.93 (0.83 to 1.04) | 0.95 (0.71 to 1.28) | 0.92 (0.68 to 1.24) | 0.97 (0.70 to 1.35) |
| Father drink/drugs | −0.04 (−0.35 to 0.28) | −0.24 (−0.54 to 0.08) | −0.21 (−0.51 to 0.11) | 1.07 (0.93 to 1.23) | 1.00 (0.86 to 1.15) | 0.99 (0.86 to 1.15) | — | — | — |
| Men | — | — | — | — | — | — | 1.63 (1.06 to 2.51)[e] | 1.47 (0.94 to 2.29) | 1.70 (1.05 to 2.76)[e] |
| Women | — | — | — | — | — | — | 0.76 (0.40 to 1.42) | 0.70 (0.37 to 1.33) | 0.70 (0.33 to 1.46) |
| Mother drink/drugs | 0.19 (−0.28 to 0.68) | 0.15 (−0.31 to 0.63) | 0.26 (−0.20 to 0.77) | 1.21 (0.99 to 1.49) | 1.20 (0.98 to 1.48) | 1.23 (1.00 to 1.53) | 0.75 (0.40 to 1.43) | 0.71 (0.37 to 1.35) | 0.54 (0.27 to 1.12) |
| Conflict/tension | 0.17 (−0.11 to 0.47) | 0.05 (−0.22 to 0.34) | 0.10 (−0.18 to 0.4) | 1.18 (1.04 to 1.34)[g] | 1.14 (1.01 to 1.29)[e] | 1.14 (1.00 to 1.30) | 1.10 (0.79 to 1.52) | 0.99 (0.71 to 1.39) | 0.87 (0.60 to 1.26) |
| Strict upbringing | 0.26 (0.04 to 0.48)[e] | 0.24 (0.03 to 0.47)[e] | 0.26 (0.04 to 0.5)[e] | 1.13 (1.03 to 1.25)[e] | 1.13 (1.02 to 1.24)[e] | 1.13 (1.02 to 1.25)[e] | 1.40 (1.10 to 1.78)[g] | 1.33 (1.04 to 1.71)[e] | 1.22 (0.93 to 1.59) |
| Physical punishment | 0.27 (−0.10 to 0.64) | 0.12 (−0.24 to 0.49) | 0.16 (−0.20 to 0.55) | 1.29 (1.10 to 1.51)[g] | 1.24 (1.06 to 1.46)[g] | 1.24 (1.05 to 1.47)[g] | 1.28 (0.86 to 1.91) | 1.14 (0.76 to 1.71) | 0.99 (0.63 to 1.54) |
| Witnessed abuse | 0.48 (0.06 to 0.90)[e] | 0.26 (−0.14 to 0.68) | 0.33 (−0.08 to 0.78) | 1.30 (1.09 to 1.55)[g] | 1.21 (1.01 to 1.45)[e] | 1.23 (1.02 to 1.48)[e] | 1.25 (0.79 to 1.98) | 1.08 (0.68 to 1.71) | 0.90 (0.54 to 1.50) |
| Parents divorced[h] | 0.18 (−0.15 to 0.52) | 0.02 (−0.31 to 0.36) | 0.01 (−0.32 to 0.37) | 1.00 (0.86 to 1.16) | 0.95 (0.81 to 1.11) | 0.92 (0.78 to 1.09) | 1.03 (0.69 to 1.54) | 0.93 (0.62 to 1.41) | 0.88 (0.56 to 1.38) |

Sample sizes are based on valid data for outcome and completion of childhood adversity questionnaire at 45 years: $n = 9219$ for BMI, $n = 9165$ for WC, and $n = 7784$ for HbA1c.

[a] Data show the geometric mean difference.

[b] Model 1 was adjusted for gender (plus current diabetes treatment, family history of diabetes for type 2 diabetes mellitus, or HbA1c ≥6).

[c] Model 2 was model 1 adjusted for BGA, childhood SEP, general ability (11 years), free school meals (11 and 16 years), type of housing (7, 11, and 16 years), and number of persons per room (7, 11, and 16 years).

[d] Model 3 was model 2 adjusted for SEP at 42 years, qualifications at 33 years, smoking and alcohol intake at 42 years, and diet and physical activity at 33 and 42 years. HbA1c was additionally adjusted for BMI and WC.

[e] *P* value was <.05.

[f] *P* value was ≤.001.

[g] *P* value was ≤.01.

[h] Data were reported at 33 years of age.

imputation to minimize bias associated with missing data. Finally, the prevalence of more extreme adversities was low, and, as a result, study power may have been inadequate for some associations potentially resulting in false-negative results.

We found that several different experiences, ranging from severe adversities, such as physical abuse, to other experiences, such as less severe forms of emotional neglect, increased the risk for obesity and, in doing so, increased the risk for poor glucose control. There was little evidence that family problems, such as parental separation or poor family relationships, increased the risk of obesity or poor glucose control, although some studies have reported associations with health behaviors and self-reported health problems.[16,19,21,49] Also, results from our study failed to confirm previous reports of increased risk of obesity in association with sexual abuse from North America, where a greater prevalence of sexual abuse has been reported, than from elsewhere.[11,32,50–53] But to date, only a limited number of population-based studies have reported associations for childhood abuse or neglect and obesity,[10,11] and there is a lack of information for the wider range of stressful emotional experiences that exist for type 2 diabetes.

For some time, research on childhood adversity and adult health has focused on single types of adversity, particularly sexual or physical abuse. It is increasingly recognized that adversities tend to co-occur. We found modest evidence for specificity on the influence of any particular type of childhood adversity on adult health: in particular parental depression had inverse effects, physical abuse positive associations, whereas no effects were observed for other adversities, such as parental separation and relationships with parents. Clusters of other adversities demonstrated little specificity, thus, for some adversities at least, the long-term effects of adversity may not be because of any one adversity but may be related to unique combinations of adversities.[54–56] In addition, adversities may occur within an unfavorable context, which may also be related to poor adult health. We found that less severe adversities, particularly those measured in childhood that reflected parental emotional involvement, were largely explained by other childhood factors with no more than an additional 20% explained by adulthood factors. This suggests that such adversities are linked to an unfavorable socioeconomic context, for which a relationship with obesity and diabetes risk has been demonstrated previously in the literature.[1–5]

For more severe adversities (eg, physical abuse), the associations were insufficiently explained by childhood factors, suggesting either direct effects on adult health or indirect effects through setting individuals on trajectories to poorer health in later life. Although we found little mediation by adult socioeconomic and behavioral factors, trajectories leading from childhood adversity to adult health are likely to be more complex. For example, adversity may impair psychosocial function in childhood that, in turn, limits educational and socioeconomic attainment in adulthood, increasing the risk for poor physical health outcomes. One study has suggested a role for psychosocial function as a mediator between "harsh parenting" and the metabolic syndrome.[57] In addition, the physical health effects of adversity may be felt in childhood, such as slower development (if undernourished) or obesity (poor quality diet or lack of physical activity), that influences body size in adulthood. It is also possible that obesity in childhood would, per se, influence the risk of being abused, thereby leading to spurious associations with adult health. However, we found no evidence of this in the 1958 cohort, and although abused children had higher BMIs in adulthood, they had lower BMIs than nonabused children at 7 and 11 years of age (data not shown). There is also evidence for biological pathways that severe adversities experienced in childhood could affect the brain, and, through the effects of increased glucocorticoid secretion and neuroendocrine regulation of eating and smoking behaviors, increase the risk for poor physical health.[51,58] Thus, additional research is needed to delineate the mechanisms linking childhood adversity to adult health.

## CONCLUSIONS

This study, using data from a general population sample representative of British adults in midlife, suggests that stressful emotional experiences in childhood are associated with an increased likelihood of obesity and thereby a greater risk of type 2 diabetes. Research is needed to understand the interrelatedness of adversities, the social context of their occurrence, and trajectories from adversity to adult disease.

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# Obesity and Type 2 Diabetes Risk in Midadult Life: The Role of Childhood Adversity

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