Adverse childhood experiences in firstborns and mental health risk and health-care use in siblings: a population-based birth cohort study of half a million children in England

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Summary

Background Adverse childhood experiences (ACEs) often affect multiple children within families, yet studies tend to focus on the health outcomes of individual children, underestimating the needs of affected families. We aimed to examine the association between firstborns exposed to ACEs between 1 year before and 2 years after birth (the first 1000 days) and the risks of mental health problems, mental health-related health-care contacts, and all-cause hospital admissions in multiple children from the same mother, compared to firstborns without ACEs.

Methods We derived a population-based birth cohort in England using linked electronic health records for first-time mothers (aged 14–55 years) with their children (born 2002–18). We followed up the cohort from 1 year before birth up to 18 years after birth across the Clinical Practice Research Datalink GOLD and Aurum databases (primary care), Hospital Episode Statistics (secondary care), and the Office of National Statistics (death registrations) between April 1, 2001, and March 31, 2020. We included six different ACE domains, including child maltreatment, intimate partner violence, maternal substance misuse, maternal mental health problems, adverse family environments, and high-risk presentations of child maltreatment, in the records of the mother or the firstborn in the first 1000 days. The primary outcome was the number of children (aged 5–18 years) with recorded mental health problems per mother. We used adjusted and weighted negative binomial regression models to estimate incidence rate ratios.

Findings Of 333 048 firstborns and their mothers, 123 573 (37·1%) had any ACEs between 1 year before and 2 years after birth, and 65 941 (19·8%) of all mothers had at least one child with a mental health problem between ages 5 years and 18 years (median follow-up 11·4 years [IQR 9·2–14·1]). Mothers with firstborns with ACEs had 1·71 (95% CI 1·68–1·73) times as many children in total with mental health problems (mean 29·8 children per 100 mothers, 29·4–30·1) compared with mothers without firstborns with ACEs (mean 17·4 children per 100 mothers, 17·3–17·6), translating into a mean difference of 12·3 (95% CI 11·9–12·7) additional children with mental health problems per 100 mothers. These mothers also had increased incidence rates of children with all-cause emergency admissions and mental health-related contacts. There was no significant difference in the risk of mental health problems between firstborn and later-born children.

Interpretation ACEs in firstborns during the first 1000 days were associated with increased mental health problems and health-care needs in multiple children in the same family. The findings highlight the importance of early identification of vulnerable first-time parents and firstborns and increased policy focus on sustained support beyond the first 1000 days to promote healthier long-term family outcomes. Future evaluations of interventions should include the health outcomes of multiple children within families.

Funding NIHR Policy Research Programme.

Lancet Public Health 2025; 10: e111–23

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Introduction

Adverse childhood experiences (ACEs) are traumatic, violent, or neglectful experiences in childhood,[1,2] often co-occurring within families,[3,4] which can have a detrimental long-term and intergenerational effect on the health of families.[5–7] An estimated 51·1% of families with children in Europe have more than one child,[8] yet research that examines how ACEs affect the long-term health of multiple children within the same family is scarce. A scoping review of 148 qualitative and predominantly cross-sectional quantitative studies showed that ACEs often affect multiple siblings but found no studies on sibling health outcomes.[9] This research gap hinders the understanding of the number of children affected, the extent of support that families need, and evaluation of the benefits of early intervention.

In recent years, there has been a rise in public health programmes to support vulnerable first-time families with ACEs in the early years (prenatal period to age 2 years),[10–13] including perinatal mental health services, nurse-led intensive home visiting,[14–16] family hubs, and nationally funded targeted family interventions

Research in context

Evidence before this study

Adverse childhood experiences (ACEs) are associated with mental health problems and multimorbidity in children. Early childhood policies increasingly focus on early-year interventions for vulnerable families presenting to health care during the perinatal period. However, there is scarce evidence on whether ACEs in firstborns and mothers predict worse health in subsequent children in the family. We searched MEDLINE, Embase, Pubmed, and PsycINFO on March 22, 2024, for articles published in English between Jan 1, 2000 and March 22, 2024, with the key search terms ("adverse child*" OR "adversit*" OR "vulnerable" OR "teenage*") AND ("firstborn" OR "infant*" OR "early years" OR "newborn*" OR "first$time mother*" OR "first$time parent*" OR "new parent*") AND ("sibling*" OR "multiple children" OR "brother*" OR "sister*" OR "subsequent child*"). Of the 62 identified articles, no study reported the outcomes of multiple children in the same family exposed to ACEs before or after birth.

Added value of this study

To our knowledge, this study is the first comprehensive epidemiological study to examine whether ACEs in firstborns were associated with subsequent siblings' risk of mental health problems and all-cause and mental health-related health-care use. We used a nationally representative birth cohort of 333 048 first-time mothers with 534 904 children (firstborns and their siblings) followed up across general practices, emergency departments, outpatients, and hospital admissions from 1 year before birth up to 18 years after birth. Mothers with firstborns with ACEs had 1·71 times as many children in total with mental health problems between ages 5 years and 18 years compared with non-exposed first-time mothers and children. The risk of mothers having multiple children with mental health problems was consistent across all ACE indicators in the firstborn.

Implications of all the available evidence

ACEs in firstborns were associated with an increased risk of mental health problems and health-care needs in multiple children in the same family. These findings emphasise the importance of early and sustained support for vulnerable first-time parents and their newborns to reduce long-term health problems, health-care needs, and costs for the whole family. Findings are relevant to both primary and secondary care professionals responding to children and parents affected by parental mental health problems, substance use, household challenges, and domestic abuse. Future evaluations of family interventions should include the health outcomes of all children in affected families.

(UK Family Early Help System).[17] However, early-year interventions are only available to a small proportion of vulnerable families for a limited time,[18,19] and are often perceived to focus exclusively on the needs of the individual child or mother.[20]

In this study, we estimated the potential cascading health effects of ACEs in firstborns on multiple children in the family to inform increased resources and policy focus on early-year interventions and perinatal services, with continuous and integrated family support to promote healthier trajectories for all children. We used a large representative birth cohort of mothers and children in England followed up across primary and secondary health care. First, we examined the association between firstborn exposure to ACEs in the first 1000 days (1 year before and 2 years after birth) and the risk of mental health problems in multiple children (aged 5–18 years) from the same mother, compared with firstborns without ACEs. We focused on mental health-related outcomes, because they account for the largest proportion (around 20–30%) of years lived with disability among children and young people (aged 5–14 years).[21] Second, we compared the risk of mental health problems between siblings (firstborn *vs* later-born children) in families with and without firstborns with ACEs. Finally, we estimated the health-care use of children born to mothers with and without a firstborn with ACEs, including the number of all-cause emergency admissions and mental health-related health-care contacts, as indicators for higher levels of health needs.

See Online for appendix

Methods

Study design and participants

We derived a population-based birth cohort study in England using the mother–baby link within the Clinical Practice Research Datalink (CPRD) GOLD and Aurum datasets with data from April 1, 2001 to March 31, 2020, accessed via CALIBER (appendix pp 2–4).[22] These primary care databases contain anonymised patient data from general practices covering approximately 20–25% of the UK population and are broadly representative of the general population in terms of age, sex, and ethnicity.[23,24] Mothers and children were linked with high validity using practice-specific household identifications (eg, home address) and maternity records (figure 1).[25]

We linked the cohort to the Hospital Episodes Statistics (HES) Admitted Patient Care, HES Accident and Emergency, HES Outpatient, the Index of Multiple Deprivation (IMD) 2019, and the mortality register from the Office for National Statistics (figure 1). HES contains data from hospital admissions, accident and emergency attendances, and hospital outpatient appointments funded by the English National Health Service (NHS).[26] The IMD 2019 contains metrics for neighbourhood deprivation linked to patients' postcodes, which we

classified into five quantiles, from the least to the most deprived.[27] This study was approved by the Medicines and Healthcare products Regulatory Agency (UK) Independent Scientific Advisory Committee (Research Data Governance protocol 21_000261), under Section 251 (NHS Social Care Act 2006). CPRD hold ethics approval from the Health Research Authority for using anonymised patient data, which does not require informed consent.

Birth cohort

For the primary birth cohort, we included first-time mothers with singleton births between April 1, 2002, and April 1, 2012, with at least 9 years of follow-up of their firstborns (figure 1; appendix p 5). This requirement ensured adequate follow-up to age 5 years in subsequent siblings based on the time between births (median time between births 2·5 years [IQR 1·8–3·7]; appendix p 5). We included subsequent births until April 1, 2018, allowing a minimum of 2 years of follow-up (until 2020).

We excluded mothers with less than 2 years of follow-up after birth, late registration (after 2 months before delivery), or late child registration (after 6 months) to a CPRD practice. The follow-up of mothers spanned from 1 year before (minimum 2 months) to 2 years after birth, encompassing the first 1000 days of the child's life, aligning with policy and government focus on early family–child care interventions.[12,13,16] The follow-up of firstborns ranged from 9 years to 18 years after birth, whereas at least one of any subsequent child required 6–18 years of follow-up after birth (appendix p 5).

To enable analyses of sibling comparisons and secondary outcomes, we derived a secondary subcohort consisting of firstborn children with one to two siblings followed up to 18 years after birth (figure 1).

Outcomes: mental health problems and health-care use in children

The primary outcome was the number of children (aged 5–18 years) with at least one recorded mental health problem per mother, ascertained from any data source using validated algorithms.[2] Secondary outcomes in the sibling subcohort included the number of subsequent children (excluding firstborns) with mental health problems per mother, the total number of all-cause emergency hospital admissions for children aged 0–18 years (stratified into age groups 0–4 years, 5–11 years, and 12–18 years), and the total number of mental health-related health-care contacts, including hospital admissions, accident and emergency and outpatient attendances, and general practitioner contacts (stratified by sibling order: firstborn, second-born, and third-born). We selected emergency admissions as a secondary outcome commonly used to measure resource-intensive health-care use.[28] An admission was defined as a continuous episode of care in the same hospital for the same child.

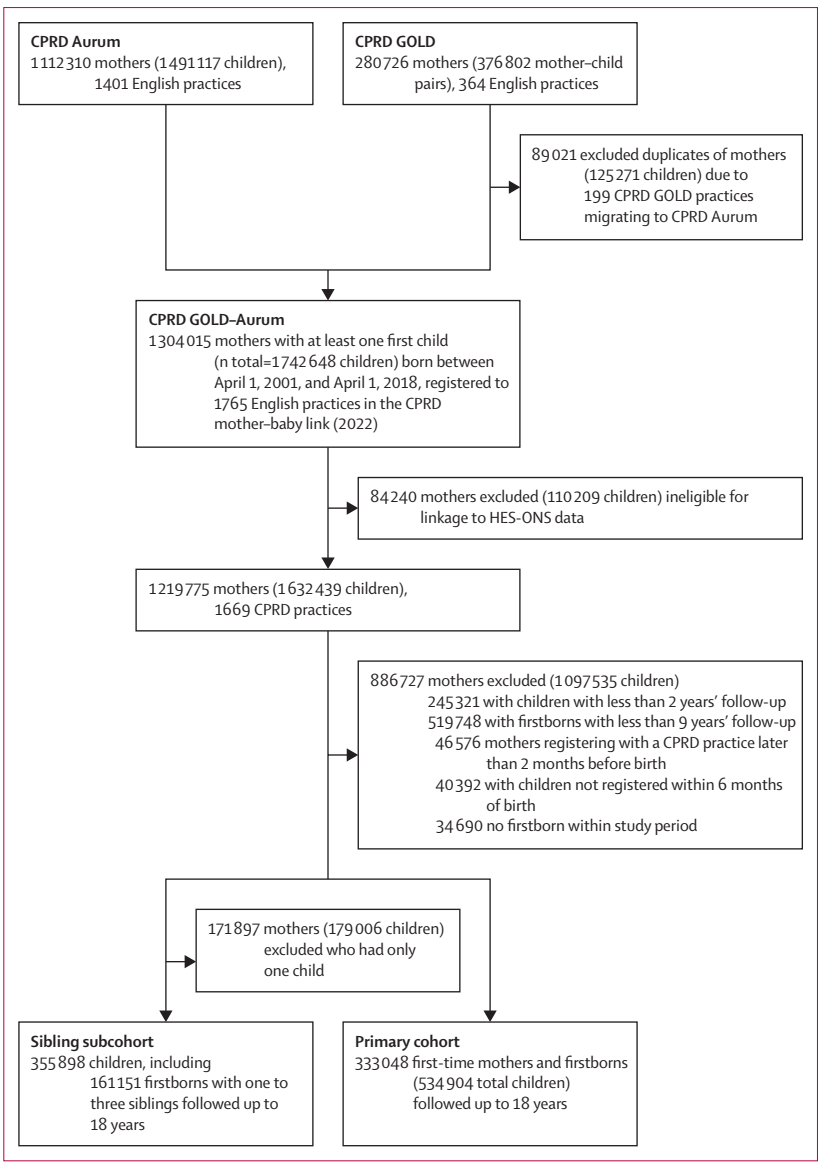


Figure 1: **Birth cohort selection**
Creation of the primary cohort and sibling subcohort, including children born between April 1, 2002, and April 1, 2018. CPRD=Clinical Practice Research Datalink. HES-ONS=Hospital Episodes Statistics and Office for National Statistics.

ACEs in firstborns

We included six domains of ACEs in firstborns recorded between 1 year before and 2 years after birth (except for maternal neurodevelopmental conditions or learning disabilities, which were included up to 5 years before birth).[2,4] The six ACE domains represent clinically meaningful and validated indicators (appendix pp 5–6) for identifying vulnerable families in health-care records consistent with national guidelines,[2,29,30] including child maltreatment, intimate partner violence, maternal substance misuse, maternal mental health problems, adverse family environments, and high-risk presentations of child maltreatment.[2] Child

	Overall cohort (n=333 048 families)	No children with mental health problems (n=267 107 [80·2%])	One child with a mental health problem (n=60 402 [18·1%])	At least two children with mental health problems (n=5539 [1·7%])
Maternal age at first birth, years				
≤19	13 878 (4·2%)	9691 (3·6%)	3659 (6·1%)	528 (9·5%)
20–29	131 784 (39·6%)	103 512 (38·8%)	25 298 (41·9%)	2974 (53·7%)
30–39	170 007 (51·0%)	139 613 (52·3%)	28 438 (47·1%)	1956 (35·3%)
≥40	17 379 (5·2%)	14 291 (5·4%)	3007 (5·0%)	81 (1·5%)
Years of follow-up of children				
Any	11·4 (9·2–14·1)	11·1 (9·1–13·8)	12·4 (9·7–15·2)	12·9 (10·2–15·4)
Firstborn	12·6 (10·4–15·2)	12·2 (10·2–14·9)	14·0 (11·5–16·3)	15·4 (13·2–17·1)
Second child	9·6 (7·3–12·2)	9·2 (7·1–11·8)	10·6 (8·2–13·0)	12·4 (10·2–14·3)
Third child	7·3 (4·9–9·9)	6·8 (4·7–9·4)	8·0 (5·5–10·5)	9·6 (7·4–11·6)
Fourth child	6·0 (4·0–8·4)	5·5 (3·7–7·9)	6·4 (4·3–8·9)	7·7 (5·4–9·7)
Total number of children				
1	171 897 (51·6%)	143 553 (53·7%)	28 344 (46·9%)	0
2	127 277 (38·2%)	99 604 (37·3%)	24 258 (40·2%)	3415 (61·7%)
≥3	33 874 (10·2%)	23 950 (9·0%)	7800 (12·9%)	2124 (38·3%)
Index of Multiple Deprivation quintile				
1 (least deprived)	77 411 (23·2%)	63 372 (23·7%)	12 975 (21·5%)	1064 (19·2%)
2	66 303 (19·9%)	53 997 (20·2%)	11 333 (18·8%)	973 (17·6%)
3	61 467 (18·5%)	49 643 (18·6%)	10 881 (18·0%)	943 (17·0%)
4	62 433 (18·7%)	49 795 (18·6%)	11 541 (19·1%)	1097 (19·8%)
5 (most deprived)	64 600 (19·4%)	49 552 (18·6%)	13 590 (22·5%)	1458 (26·3%)
Missing data	834 (0·3%)	748 (0·3%)	82 (0·1%)	4 (0·1%)
Maternal ethnicity				
White	276 841 (83·1%)	218 819 (81·9%)	52 988 (87·7%)	5034 (90·9%)
Asian	30518 (9·2%)	26 610 (10·0%)	3651 (6·0%)	257 (4·6%)
Black	14 243 (4·3%)	12 081 (4·5%)	2023 (3·3%)	139 (2·5%)
Mixed	4120 (1·2%)	3322 (1·2%)	739 (1·2%)	59 (1·1%)
Other	1928 (0·6%)	1669 (0·6%)	247 (0·4%)	12 (0·2%)
Missing data	5398 (1·6%)	4606 (1·7%)	754 (1·2%)	38 (0·7%)
Birthweight, g				
≥3500	110 489 (33·2%)	89 360 (33·5%)	19 459 (32·2%)	297 (5·4%)
2500–3499	143 341 (43·0%)	115 617 (43·3%)	25 449 (42·1%)	2275 (41·1%)
<2500	12 753 (3·8%)	9794 (3·7%)	2662 (4·4%)	1670 (30·1%)
Missing data	66 465 (20·0%)	52 336 (19·6%)	12 832 (21·2%)	1297 (23·4%)
Gestational age at birth, weeks				
≥37	234 624 (70·4%)	190 303 (71·2%)	40 822 (67·6%)	3499 (63·2%)
<37	19 387 (5·8%)	14 909 (5·6%)	4036 (6·7%)	442 (8·0%)
Missing data	79037 (23·7%)	61 895 (23·2%)	15 544 (25·7%)	1598 (28·8%)

(Table 1 continues on next page)

maltreatment included recordings of neglect and physical, sexual, or emotional abuse.[2] Adverse family environments referred to indicators of household challenges and concerns about the caring environment (eg, housing instability, parental criminality, or food insecurity) not covered by other ACE domains. Consistent with previous studies,[2,4] we derived variables for the total number of different ACE domains in firstborns (none, one, two, or three or more). We derived ACE indicators in the firstborn using several rule-based algorithms by combining coded information from the mother's or the firstborn's record in any data source.[2,4,29] We treated firstborns with no ACE indicator during the exposure period as unexposed. All code lists, definitions and algorithms (eg, instrument cutoffs and age restrictions of mental health problems in children) are available online.

For more on **definitions, code lists, and algorithms** see www.ACEsinEHRs.com

Birth cohort characteristics

To describe baseline cohort characteristics, covariates, and variables to calculate inverse probability weights (figure 1; appendix p 8),[31] we derived IMD, mother's age at first birth, birthweight, gestational age, and congenital anomalies (EUROCAT guidelines).[32] Covariates were

	Overall cohort (n=333 048 families)	No children with mental health problems (n=267 107 [80·2%])	One child with a mental health problem (n=60 402 [18·1%])	At least two children with mental health problems (n=5539 [1·7%])
(Continued from previous page)				
Location of general practice (region of England, UK)*				
London	52 057 (15·6%)	43 048 (16·1%)	8383 (13·9%)	626 (11·3%)
East and West Midlands	58 469 (17·6%)	46 904 (17·6%)	10 669 (17·7%)	896 (16·2%)
East of England	17 373 (5·2%)	13 978 (5·2%)	3084 (5·1%)	311 (5·6%)
North East and North West England, and Yorkshire	91 603 (27·5%)	72 479 (27·1%)	17 462 (28·9%)	1662 (30·0%)
South East and South West England	113 546 (34·1%)	90 698 (34·0%)	20 804 (34·4%)	2044 (36·9%)
Sex of firstborn child†				
Female	162 261 (48·7%)	132 997 (49·8%)	26 738 (44·3%)	2526 (45·6%)
Male	170 787 (51·3%)	134 110 (50·2%)	33 664 (55·7%)	3013 (54·4%)
Year of birth				
2002–10	276 617 (83·1%)	226 403 (84·8%)	46 496 (77·0%)	3718 (67·1%)
2011–18	56 431 (16·9%)	40 704 (15·2%)	13 906 (23·0%)	1821 (32·9%)

Data are median (IQR) or n (%). *English regions collapsed into five categories based on broader geographical areas for table presentation and consistency with previous studies. However, all nine original regions (shown in the appendix p 8) were used in the statistical analyses. †Time of follow-up measured from birth and equal to children's age.

Table 1: **Cohort characteristics of first-time mothers and firstborns by number of children with a mental health problem between 5 years and 18 years after birth**

selected based on previous studies,[2] and a directed acyclic graph (appendix p 9).

Statistical analysis

We present categorical variables of baseline characteristics as frequencies (percentages) and continuous variables as medians (IQR; table 1). Time at risk for mental health problems started at age 5 years (or birth for all-cause emergency hospital admissions) and ended at the earliest of practice deregistration, the last data collection date from the practice, death, the study end date, or the 18th birthday of the children (appendix p 5).

For the primary analysis (ie, unit of analysis being mothers with all their children), we used adjusted and weighted negative binomial regression models to examine the association between ACEs in firstborns and the incidence of children aged 5–18 years with mental health problems. We repeated analyses for individual ACE domains and indicators. We calculated incidence as the total number of children with mental health problems divided by the person-years contributed by all children per mother. The adjusted and weighted incidence rate ratios (awIRRs) represented the relative increase in children with mental health problems in ACE-exposed versus the unexposed groups. We used marginal predictions to estimate the average number of children with mental health problems per mother re-expressed into 100s to facilitate interpretation. Models were adjusted for the firstborn's birth year, general practice region, firstborn sex, and the number of children per mother. In two additional regression models, we adjusted estimates for neighbourhood deprivation (IMD) and maternal age to help understand to what extent associations could be explained by upstream risk factors defined elsewhere.[33] We used negative binomial models over Poisson models to account for overdispersion (appendix p 11). Sensitivity analyses showed that the Poisson and negative binomial models had very similar results.

For the secondary analysis (ie, the unit of analysis being children) in the sibling subcohort (children with siblings only; figure 1), we used adjusted and weighted Cox proportional hazard models to examine the association between firstborns with ACEs and time to first recorded mental health problem in any child. The adjusted and weighted hazard ratios (awHRs) represented the relative risk of a mental health problem in children in ACE-exposed firstborns versus the unexposed groups. We generated cumulative incidence curves to visualise probability of mental health problems over time stratified by birth order. For each child, the underlying timescale was time since their fifth birthday. To examine differences in the risk of mental health problems between siblings (firstborn, second born, and third born), we modelled the interaction of birth order and firstborn ACE exposure. We then estimated and compared predictive margins of the hazard ratios for each birth order category (eg, second born *vs* firstborn).[34] We included the family identification as a cluster variable to account for multiple children per mother. Model assumptions for Kaplan–Meier estimates were checked using log-log plots and Schoenfeld's residuals (appendix p 11).[35]

To evaluate health-care use, we used adjusted and weighted negative binomial regression models to estimate incidence rate ratios (IRRs) and marginal means of all-cause emergency admissions and mental health-related health-care contacts per 100 children born to mothers with and without a firstborn exposed to ACEs.

All models included inverse probability weights (IPWs),[31] to account for potential attrition and selection bias of firstborns as described elsewhere (appendix p 7).[2,4]

We conducted sensitivity analyses to assess the robustness of our findings. First, we restricted analyses to births between 2012 and 2020 to assess the influence of increased data collection rates in HES accident and emergency departments. Second, to assess the potential influence of increased surveillance on the increased rates of mental health problems in vulnerable families, we re-examined mental health problem outcomes using only hospital and mortality data, with ACEs restricted to primary care data only. Finally, we compared the primary results with the results from cohorts restricted to mothers with a single child versus multiple children, because mothers with only one child might have different circumstances than mothers with more children.

We imputed missing values for baseline characteristics used to calculate IPWs, including (table 1) parity, gestational age, birthweight, and social deprivation using multiple imputations by chained equations with 25 imputed datasets (25 iterations per imputation).[36] Predictors in the imputation models included all analysis variables (appendix p 8). We pooled the estimates across imputed datasets using Rubin's rule.[35] We conducted all analyses on the University College London (London, UK) secure analytic server using Stata 18 and R (version 4.4.0).

Role of the funding source

The funders of the study had no role in study design, data collection, data analysis, data interpretation, or writing of the report.

Results

The characteristics of the birth cohort of mother–child pairs and the number of children with mental health problems between age 5 years and 18 years after birth are shown in table 1. We included 333 048 first-time mothers with 534 904 children born between April 1, 2002, and April 1, 2018, registered to 1627 general practices. Of the 333 048 mothers, 161 151 (48·4%) had more than one child, and 140 497 (42·2%) had two or more children who could be followed up 6 years after first birth or longer. Median maternal age at first birth was 30·0 years (IQR 26·0–34·0; table 1). Median follow-up of firstborns exposed to ACEs was 15·6 years (IQR 11·4–21·6), and was 16·7 years (12·6–23·8) for unexposed firstborns. Mothers with and without firstborns with ACEs had a similar number of children (median 1 child [IQR 1·0–2·0]; appendix p 11). The cohort characteristics of the main analysis were similar to those used in the sensitivity analyses (appendix pp 20–21, 23–24).

Overall, 65 941 (19·8%) of 333 048 mothers had at least one child with a mental health problem, and 5539 (1·7%) mothers had two or more children with mental health problems between ages 5 years and 18 years during a median of 11·4 years' (IQR 9·2–14·1) follow-up (table 1; see appendix p 12 for prevalences of specific mental health problems). The median age for any child at their first recorded mental health problem was 8·6 years (IQR 6·6–11·8, range 5·0–17·9). An estimated 123 573 (37·1%) of 333 048 firstborns had at least one ACE between 1 year before and 2 years after birth, and 36e116 236 (10·9%) of 333 048 had at least two ACEs.

Mothers with firstborns exposed to ACEs had 1·71 (95% CI 1·68–1·73) times as many children with mental health problems compared with mothers with firstborns without ACEs (table 2). The mean difference translated to 12·3 (95% CI 11·9–12·7) additional children with mental health problems per 100 mothers.

Firstborn exposure to any of the six ACE domains was associated with an increased number of children with mental health problems per mother relative to mothers with firstborns without ACEs (table 2). The awIRR of the number of children with mental health problems to mothers with firstborns with ACEs ranged from 1·41 (1·39–1·44) for adverse family environments (mean 29·0 children with mental health problems per 100 mothers [95% CI 28·3–29·4]) and 1·81 (1·79–1·84) for maternal mental health problems (mean 33·5 children per 100 mothers [33·0–34·0]), to 1·75 (1·69–1·81) for child maltreatment (mean 39·0 children per 100 mothers [37·1–40·6]). The awIRR of children with a mental health problem increased for each additional ACE domain present in the firstborn (one ACE, IRR 1·52 [95% CI 1·50–1·55]; two ACEs 2·1 [2·01–2·11]; three or more ACEs 2·64 [2·54–2·74], mean range 26·3 [26·0–26·7] to 45·3 [43·8–46·8] children with mental health problems per 100 mothers). Results remained similar after adjusting for other risk factors such as socioeconomic status and maternal age at first birth (table 2), and when excluding firstborns with mental health problems in the outcome using the sibling cohort (awIRR for any ACE in the firstborn 1·63, 1·58–1·69; appendix p 13).

Of the 41 ACE-specific indicators in the firstborn (figure 2), those most strongly associated with an increased number of children with mental health problems were maternal personality disorders (IRR 2·4), maternal self-harm, severe maternal drug use, maternal intellectual disabilities (IRR range 1·9–2·2), and specific intimate partner violence indicators (eg, mother assaulted with co-occurring safeguarding referral IRR 2·3). Adverse family environment indicators such as maternal learning disabilities, psychosocial issues, concerns about maternal capacity, and housing problems in the firstborn were also notable ACE indicators associated with an increased number of children with mental health problems (IRR range 1·6–2·2). Among child-specific ACE indicators, failure to thrive or harm by undetermined intent and three or more missed health-care appointments relating to the firstborn were most strongly associated with an increased number of children with mental health problems (IRR range 1·5–1·9).

	Overall cohort (n=333 048 families)	No children with mental health problems (n=267 107 [80·2%])	One child with a mental health problem (n=60 402 [18·1%])	At least two children with mental health problems (n=5539 [1·7%])	Model 1: baseline-adjusted and weighted estimates*		Model 2: model 1 + IMD adjustment		Model 3: model 2 + maternal age adjustment	
					Mean number of children with mental health problem per 100 mothers (95% CI)	IRR (95% CI)	Mean number of children with mental health problem per 100 mothers (95% CI)	IRR (95% CI)	Mean number of children with mental health problem per 100 mothers (95% CI)	IRR (95% CI)
No ACE	209 475 (62·9%)	174 580 (65·4%)	32 349 (53·6%)	2546 (46·0%)	17·3 (17·2-17·5)	Ref	17·5 (17·3-17·7)	Ref	17·5 (17·3-17·7)	Ref
Any ACE	123 573 (37·1%)	92 527 (34·6%)	28 649 (47·4%)	3025 (54·6%)	29·8 (29·4-30·1)	1·7 (1·7-1·7)	28·7 (28·4-29·0)	1·7 (1·6-1·7)	28·6 (28·3-28·9)	1·7 (1·6-1·7)
AFEs	48 424 (14·5%)	36 458 (13·6%)	10 780 (17·8%)	1186 (21·4%)	28·9 (28·4-29·4)	1·4 (1·4-1·4)	28·2 (27·8-28·7)	1·4 (1·3-1·4)	28·1 (27·6-28·6)	1·4 (1·3-1·4)
Maternal mental health problems	72 075 (21·6%)	51 736 (19·4%)	18 269 (30·2%)	2070 (37·4%)	33·5 (33·1-34·0)	1·8 (1·8-1·8)	33·1 (32·6-33·5)	1·8 (1·7-1·8)	32·9 (32·5-33·4)	1·8 (1·7-1·8)
Maternal substance misuse	14 209 (4·3%)	10 636 (4·0%)	3238 (5·4%)	335 (6·0%)	32·6 (31·5-33·6)	1·5 (1·4-1·4)	31·6 (30·6-32·6)	1·5 (1·4-1·5)	31·3 (30·3-32·3)	1·5 (1·4-1·5)
High-risk presentations of child maltreatment	24 794 (7·4%)	18 264 (6·8%)	5908 (9·8%)	622 (11·2%)	31·8 (31·0-32·5)	1·5 (1·5-1·6)	30·7 (30·0-31·5)	1·5 (1·4-1·5)	30·5 (29·7-31·2)	1·5 (1·4-1·5)
Any child maltreatment or intimate partner violence	10 224 (3·1%)	7243 (2·7%)	2687 (4·4%)	294 (5·3%)	37·0 (35·7-38·2)	1·7 (1·7-1·8)	35·0 (33·7-36·1)	1·6 (1·6-1·7)	34·4 (33·2-35·6)	1·6 (1·6-1·7)
Child maltreatment	6418 (1·9%)	4538 (1·7%)	1693 (2·8%)	187 (3·4%)	38·3 (36·7-39·9)	1·8 (1·7-1·9)	36·3 (34·7-37·8)	1·7 (1·6-1·8)	35·7 (34·2-37·3)	1·7 (1·6-1·7)
Intimate partner violence	5264 (1·6%)	3664 (1·4%)	1448 (2·4%)	152 (2·7%)	37·8 (36·0-39·6)	1·8 (1·7-1·9)	35·3 (33·7-37·0)	1·6 (1·6-1·7)	34·6 (33·0-36·2)	1·6 (1·5-1·7)
Number of ACEs in firstborn										
0	209 475 (62·9%)	174 580 (65·4%)	32 349 (53·6%)	2546 (46·0%)	17·3 (17·1-17·5)	Ref	17·5 (17·3-17·6)	Ref	17·5 (17·3-17·7)	Ref
1	87 337 (26·2%)	67 203 (25·2%)	18 265 (30·2%)	1869 (33·7%)	26·3 (26·0-26·7)	1·5 (1·5-1·5)	26·2 (25·8-26·5)	1·5 (1·5-1·5)	26·2 (25·8-26·5)	1·5 (1·4-1·5)
2	27 380 (8·2%)	19 452 (7·3%)	7126 (11·8%)	802 (14·5%)	35·7 (34·9-36·4)	2·0 (2·0-2·1)	34·9 (34·2-35·6)	1·9 (1·9-2·0)	34·8 (33·3-34·7)	2·0 (1·9-2·0)
≥3	8856 (2·7%)	5872 (2·2%)	2662 (4·4%)	322 (5·8%)	45·3 (43·8-46·8)	2·6 (2·5-2·7)	43·4 (41·9-44·9)	2·5 (2·4-2·6)	43·1 (41·6-44·6)	2·5 (2·4-2·6)

Data are presented as IRRs and mean number of children with mental health problems per 100 mothers, stratified by firstborn exposure to ACEs. ACEs=adverse childhood experiences. AFE=adverse family environment. IMD=Index of Multiple Deprivation. IRR=incidence rate ratio. *All estimates were weighted using inverse probability weights to account for potential attrition and selection bias (appendix p 8). Model 1 is adjusted for the firstborn's birth year, general practice region, firstborn's sex, and the number of children per mother. Model 2 further adjusts for neighbourhood deprivation using IMD quantiles (from the most deprived socioeconomic quintile [five] to those in the least deprived [one] socioeconomic quintile). Model 3 additionally adjusts for maternal age at the birth of the firstborn.

Table 2: **IRRs and the mean number of children with a mental health problem per 100 mothers associated with firstborn exposure to ACEs**

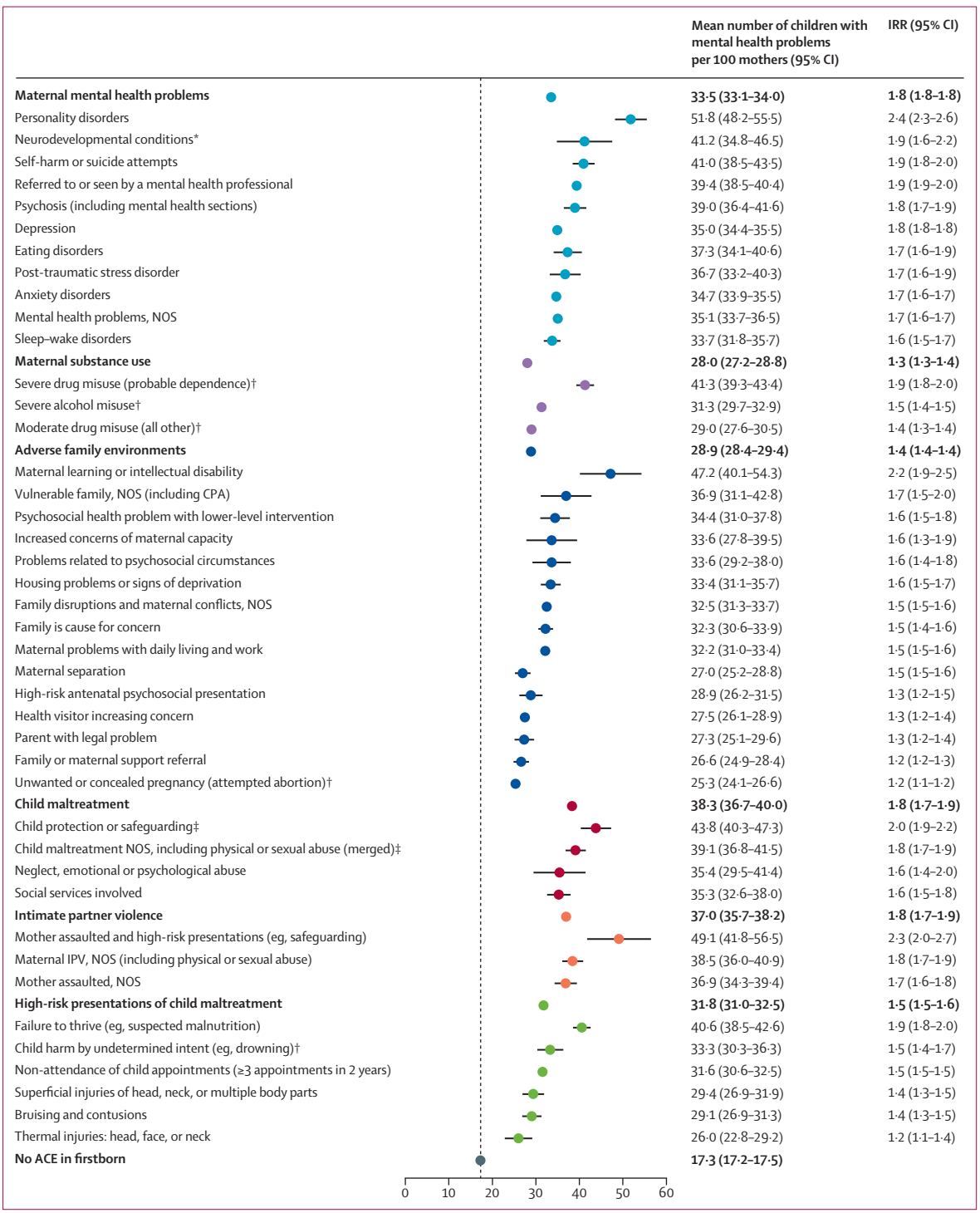
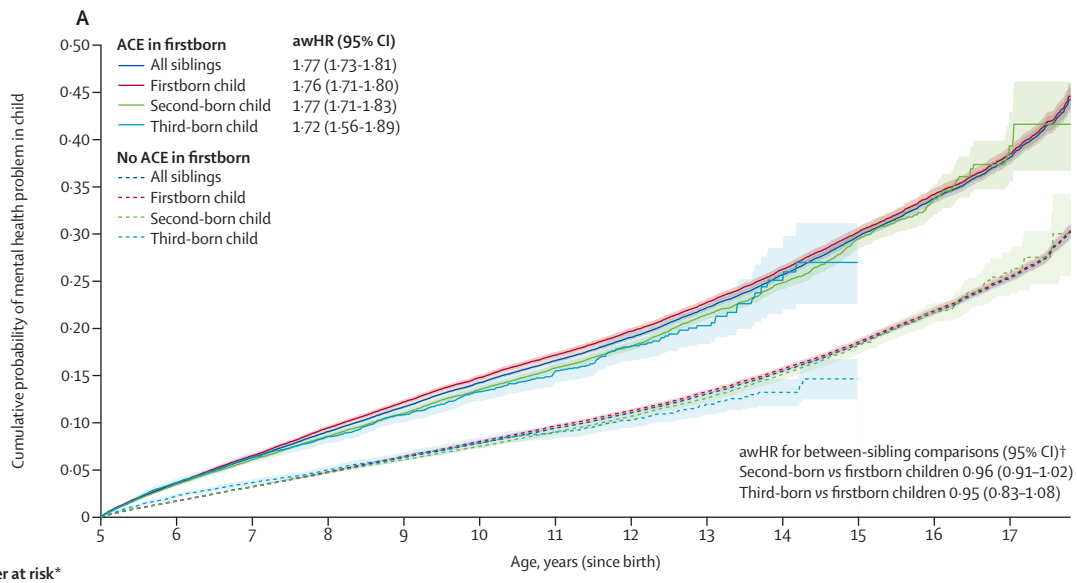


Figure 2: **Adjusted and weighted means and IRRs of children with mental health problems associated with domain-specific ACE indicators in firstborns between 1 year before and 2 years after birth**

Estimates are the mean number of children (aged 5–18 years) with mental health problems (per 100 mothers) and the associated IRRs for specific ACE indicators, relative to unexposed first-time mother–child pairs. All estimates are adjusted for the firstborn's birth year, general practice region, firstborn's sex, and the number of children per mother. All estimates were weighted using inverse probability weights (appendix p 8). The dashed line indicates the mean number of children with a mental health problem among unexposed pairs. Children can only be counted once per ACE domain or indicator. Indicators are presented in descending order of IRR (high to low). ACE=adverse childhood experiences. CPA=care programme approach. IPV=intimate partner violence. IRR=incidence rate ratio. NOS=not otherwise specified. *Neurodevelopmental conditions include attention deficit hyperactivity disorder, autism spectrum disorders, and conduct disorders. †Indicators are defined by several rule-based algorithms, including age restrictions in years (upper age cutoff denoted in parentheses).[2] ‡Domain-specific indicators present in fewer than 250 unique children were not disaggregated.



Number at risk*													
ACE in firstborn													
All siblings	117241	107325	97166	86580	71249	56874	44380	33520	24080	16069	10038	5540	2327
Firstborn child	57694	55602	53951	51827	44432	36808	29941	23750	18059	12867	8676	5171	2267
Second-born child	50900	44766	37797	30673	23920	18144	13259	9154	5752	3117	1340	363	59
Third-born child	8647	6957	5418	4080	2897	1922	1180	616	269	85	22	<7‡	<7‡
No ACE in firstborn													
All siblings	213379	201058	186244	169877	145865	120737	97241	75583	56065	38905	25162	14311	6266
Firstborn child	103440	101699	100124	98019	87906	75480	63191	51556	40639	30541	21678	13435	6109
Second-born child	95104	87066	76096	64031	52120	41146	31381	22528	14724	8119	3420	860	153
Third-born child	14835	12293	10024	7827	5839	4111	2669	1499	702	245	64	‡	‡

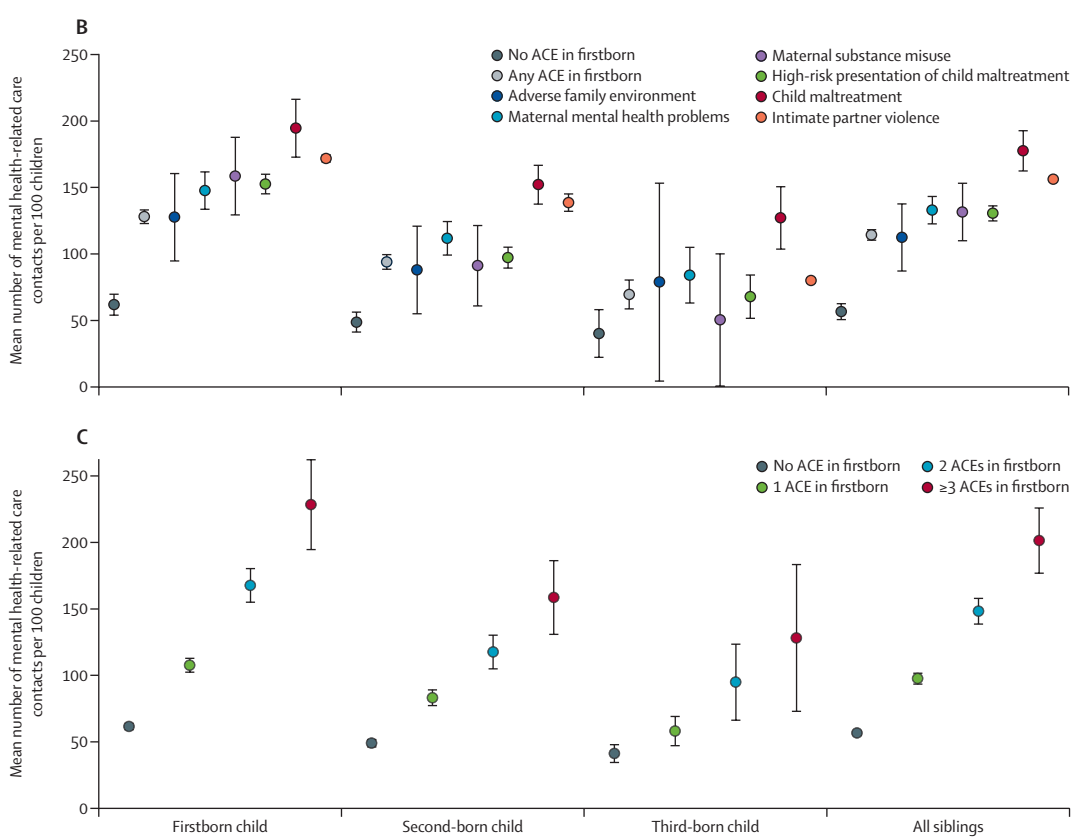


***Figure 3*: Cumulative probability of mental health problems and mean number of mental health-related health-care contacts in children aged 5–18 years, by sibling order and ACE exposure in firstborns (n=355 898)**

(A) Cumulative incidence of first-recorded mental health problem, stratified by sibling order and ACE exposure in firstborn. (B) Adjusted mean number of mental health-related health-care contacts (any general practitioner contact, hospital admission, outpatient, or accident and emergency contact) per 100 children (aged 5–18 years) stratified by ACE domain in firstborns. (C) Adjusted mean number of mental health-related health-care contacts stratified by the number of different ACE domains experienced by the firstborn. Estimates in panels B and C are adjusted for birth year, practice region, firstborn's sex, and number of children per mother. Accompanying incidence rate ratios are shown in the appendix (pp 10–14). Vertical lines represent 95% CIs. ACE=adverse childhood experience. awHR=adjusted and weighted hazard ratio. *25 278 (7·1%) of 355 898 children had less than 5 years' follow-up (including 11 282 [3·2%] children of mothers with a firstborn with ACEs *vs* 13 996 [3·9%] children of mothers without a firstborn with ACEs). †Sibling comparisons (A) show the relative risk of mental health problems in later-born children compared with firstborn children using estimated marginal differences, where HR=1 indicates equal risk, HR >1 indicates increased risk, and HR <1 indicates decreased risk. Accompanying marginal plot for sibling comparisons are shown in the appendix (p 14). ‡Numbers not for cells with fewer than seven mother–child pairs.

To compare the risk of mental health problems between different siblings, we analysed a sibling subcohort of 355 898 children (figure 1), involving 161 151 (45·3%) firstborns with at least one subsequent sibling (n=194 747 [54·7%] siblings; figure 3). Of these children, 43 263 (12·2%) of 355 898 had a mental health problem between ages 5 years and 18 years, and 128 523 (36·1%) of 355 898 were firstborns with ACEs between 1 year before and 2 years after birth. The risk of mental health problems in children in families with firstborns with ACEs was similar in the sibling subcohort (awHR 1·76 [95% CI 1·72–1·81]; figure 3) to estimates from the primary analysis. We found no significant differences in mental health problem risk between second-born versus firstborn children (awHR 0·96 [95% CI 0·91–1·02]) and third-born versus firstborn children (awHR 0·95, 0·83–1·08), suggesting similar risk of mental health problems across siblings in families with a firstborn with ACEs (appendix p 14).

In the sibling subcohort (figure 1), half of children had at least one (189 039 [53·1%] of 355 898) emergency hospital admission for any reason between 0 years and 18 years after birth, 37 013 (10·4%) children had at least one mental health-related primary care contact, and about 17 865 (5·0%) had any mental health-related hospital contact (accident and emergency, outpatient, or admission; appendix p13) between ages 5 years and 18 years. Children of mothers with a firstborn exposed to ACEs had significantly higher rates of mental health-related health-care contacts (awIRR 2·07 [95% CI 1·96–2·19], 114·33 mean number of contacts per 100 children [110·40–118·3]; appendix pp 16–17) and all-cause emergency admissions (awIRR 1·53 [1·52–1·54], 175·95 mean number of contacts per 100 children [175·22–176·68]; appendix p 18) compared with children in families without a firstborn exposed to ACEs. This association was consistent across all later-born siblings (ie, second-born and third-born children), different types of ACEs, and increased progressively with the number of different ACEs in the firstborn (figure 3B, 3C; appendix pp 16–19). The IRRs were also consistently elevated across all health-care settings, including general practitioner consultations, hospital admissions, accident and emergency attendances, and outpatient visits, and for different ages (appendix pp 16–19).

The IRRs of children with mental health problems remained robust in all sensitivity analyses (appendix pp 20–24).

Discussion

We examined the association between firstborn children's exposure to ACEs during the first 1000 days and the risk of mental health problems and increased health-care use in multiple children from the same mother between ages 5 years and 18 years. We found that the presence of any ACE in the firstborn child significantly increased the likelihood of multiple and subsequent children in the family having mental health problems, with higher rates of emergency admissions and mental health-related health-care use compared with children of mothers with firstborns without ACEs. Mothers with firstborns with three or more ACEs had the highest risk of having multiple children with mental health problems.

A key strength of this study was the large, nationally representative population-based birth-cohort design, which combined maternal and child data prospectively collected from primary and secondary care before and after birth. The design and the available follow-up data provided the statistical power to examine the association between ACEs and mental health problem risk in subsequent siblings. Electronic health-care records from the NHS ensured the clinical relevance of recorded ACEs and mental health problems, increasing the generalisability of findings to clinical practice.

Consistent with previous research, our findings showed that children with ACEs are at greater risk of mental health problems and increased health-care use relative to those unexposed.[1,2,5–7,37] We extend previous research by quantifying cascading health effects of ACEs in firstborns on their siblings. We found that for every 100 first-time mothers with a firstborn with ACEs in the first 1000 days, there were 1·7 times as many children in the family with mental health problems, compared with mothers without firstborns with ACEs. These children also had 50% more emergency admissions for any reason and double the mental health-related health-care contacts compared with children of mothers without firstborns with ACEs. These associations were consistent for all siblings, regardless of birth order, and after adjustment for wider social risk factors present at the firstborn's birth, including neighbourhood deprivation and maternal age. These findings suggest a pervasive risk for multiple children born to mothers whose first child experienced ACEs.

Consistent with previous studies,[4,12] we found a dose–response relationship between the number of ACEs and more severe types of ACEs (eg, child maltreatment or intimate partner violence and maternal substance use) and mental health problem risk in multiple children. Nonetheless, all types of ACE indicators were associated with mental health problems in multiple children. Therefore, these findings are relevant for clinicians in both primary and secondary care settings, where families might present with concerns related to parental mental health, substance use, household adversities, maltreatment, and child safeguarding.

Several mechanisms might explain the link between ACEs in firstborns and the increased risk of mental health problems in subsequent children in the family. Although previous studies suggest that later-born siblings generally have a higher mental health problem risk, potentially because of diluted family resources,[38] we found no such differences in mental health problem risk between different siblings of mothers with a firstborn

exposed to ACEs. The higher risk of mental health problems and health needs for firstborns and subsequent children is probably caused by continued exposure to ACEs and other familial risk factors, including underlying biological, genetic, and intergenerational factors that increase a families' vulnerability.[39,40] Recent cohort studies support this line of reasoning. A recent Swedish cohort study of discordant twin pairs found that the associations between ACEs and adult mental health problems remained after adjusting for shared and genetic factors.[41] An English birth cohort study showed that maternal depressive episodes and paternal absence partly mediated the risk of mental health problems in later-born siblings within the first 5 years after birth.[42] These findings highlight that ACEs and underlying family vulnerability, present at first birth, substantially influence the risks of mental health problems in all children in the family. Over time, this risk is probably exacerbated by increased family demands from more children, negatively affecting parental responses and potentially leading to a cycle of stress and persistent risk of mental health problems in children.[43,44]

This study has several limitations. First, electronic health-care records are limited to coded clinical observations and we are likely to have underestimated the effects of under-recorded ACEs such as intimate partner violence and child maltreatment.[45] Many first-time mothers might not disclose these experiences. Clinicians might delay recording until further monitoring or because of concerns about potential harm from information sharing (eg, if a perpetrator has access to the child's record). Similarly, mental health problems in children might be under-reported, particularly in younger children, and not accurately capture the onset of the actual mental health problem. Further research should focus on how the recording of child maltreatment, intimate partner violence, and mental health problems in children in electronic health-care records can be improved and how the risk of mental health problems varies by children's sex, age, and ethnicity.

Second, associations between ACEs in firstborns, mental health problems, and increased health-care use might reflect surveillance bias and supportive health-care responses rather than differences in the underlying risk of mental health problems in children. Similarly, we could not account for interventions received (eg, psychosocial therapies and family support), potentially leading to underestimated associations between ACEs and mental health problems in children. Nonetheless, the validity of ACEs and the mental health problem measures in our study have shown high predictive values for identifying families affected by ACEs,[2,29] and mental health problems.[46] Our sensitivity analyses using separate data sources for ACEs (primary care only) and children's mental health problems (hospital admissions) further confirm the robustness of our findings. Still, future research should explore how the association between ACEs and mental health problems varies across different levels of socio-economic disadvantage, informing targeted interventions and resource allocation.

Finally, because of the challenges in accurately linking children to their fathers in the UK, our findings are limited to first-time mothers and their children. Although we previously linked potential fathers in CPRD GOLD,[4] applying this additional linkage criterion would have significantly reduced the study's sample size and statistical power, and potentially introduced selection bias. Therefore, the findings must be interpreted cautiously to avoid solely associating ACEs with maternal difficulties. Also, by focusing solely on children of the same mother, our study may not capture the effects of ACEs on other children in the household, such as paternal half-siblings. Further research using linked paternal data is needed to understand the effect of ACEs on families' mental health across diverse family structures.

Our findings have implications for several global high-impact priorities by WHO and UNICEF,[11,47,48] and national policies in the UK and other countries that focus on think-family approaches and increased support during the first 1000 days for vulnerable families.[12,49] We show that ACEs in firstborns during the first 1000 days represent strong indicators of increased mental health problems for multiple children in the family, highlighting the need for early identification and increased policy focus on sustained family support beyond the first 1000 days to reduce the effect of ACEs. Given that most ACEs are preventable and that the most common ACEs were maternal mental health problems,[50] the findings emphasise the importance of strong links between primary care and easy access to perinatal, adult,[51] and child mental health services that can provide long-term support. Most ACEs were from the maternal records, highlighting the importance of reviewing parents' and children's records and asking about children when treating adults and vice versa. The perinatal period offers increased routine monitoring by health-care professionals with opportunities for early support via timely and accessible joined-up services (eg, Early Help System)[17] and longitudinal monitoring in primary care and connected services (eg, community hubs). However, access to specialist perinatal mental health services remains a challenge.[19] Qualitative studies also show that services often focus too narrowly on the needs of the individual mother or the child in isolation,[20] emphasising the need for more comprehensive think-family and integrated interventions across the family life course.[52]

Investing in targeted early identification and support for first-time parents and their children could yield economic benefits by reducing the intergenerational cycle of adversity,[16] fostering resilience and promoting better mental health for the whole family. However, to fully estimate these potential benefits, we need more

comprehensive evaluations of early-year interventions and perinatal services that capture siblings' and parents' health outcomes to inform resource allocation and policy decisions.

Contributors

SS, RG, LDH, JD, and REL conceived the study. SS and REL designed the study. SS completed the statistical analyses. RG and GF provided supervision for the study. SS, MQuA and REL had full access to the extracted CPRD data. SS, MQuA, and REL accessed and verified all the data in the study. All authors contributed to interpreting the data and drafting the manuscript revisions. All authors had full access to all the data in the study and accepted responsibility for the decision to submit the manuscript for publication. SS affirms that the manuscript is an honest, accurate, and transparent account of the study being reported; and that no important aspects of the study have been omitted.

Declaration of interests

We declare no competing interests.

Data sharing

This study uses data from the CPRD, a research service that provides primary care and linked data for public health research. CPRD data governance does not allow the distribution or access of data to other parties outside of the approved study protocol. Researchers can apply for data access with a study protocol at https://www.cprd.com/ and need approval from the Research Data Governance Secretariat. We provide all relevant code lists and coding scripts via https://ACEsinEHRs.com. All code is shared without investigator support.

Acknowledgments

We are grateful for the generosity of the patients and their families, along with the participating general practitioner practices and NHS staff, for their ongoing contribution to mental health and family violence research. We are grateful to Cathy Ghalib (Specialist Perinatal Clinical Psychologist, NHS) and the peer reviewers for their helpful feedback on the manuscript. This study is funded by the UK National Institute for Health and Care Research (NIHR) through the Children and Families Policy Research Unit (PR-PRU-1217-21301). The views expressed are those of the authors and not necessarily those of the NHS, NIHR, the UK Department of Health and Social Care or its arm's length bodies, and other Government Departments. This study was undertaken as part of the CALIBER resource by the UCL Institute of Health Informatics. This study is based in part on data from the CPRD obtained under licence from the UK Medicines and Healthcare products Regulatory Agency. The data are provided by patients and collected by the NHS as part of their care and support. The interpretation and conclusions contained in this study are those of the authors alone. Data from Hospital Episode Statistics and Office for National Statistics (copyright ©2024) were re-used with the permission of The Health and Social Care Information Centre. All rights reserved. RG was (in part) supported by the Health Data Research UK Social and Environmental Determinants of Health Programme. The study benefits from the NIHR Great Ormond Street Hospital Biomedical Research Centre. GF's salary was (in part) supported by the UK Prevention Research Partnership (Violence, Health, and Society; MR-VO49879/1), an initiative funded by the UK Research and Innovation Councils, the Department of Health and Social Care (England) and the UK devolved administrations, and leading health research charities. SS, RG, GF, REL, and JD received funding from the NIHR Children and Families Policy Research Unit.

References

1 Hughes K, Bellis MA, Hardcastle KA, et al. The effect of multiple adverse childhood experiences on health: a systematic review and meta-analysis. *Lancet Public Health* 2017; **2:** e356–66.

2 Syed S, Gonzalez-Izquierdo A, Allister J, Feder G, Li L, Gilbert R. Identifying adverse childhood experiences with electronic health records of linked mothers and children in England: a multistage development and validation study. *Lancet Digit Health* 2022; **4:** e482–96.

3 Belsky J. Child maltreatment: an ecological integration. *Am Psychol* 1980; **35:** 320–35.

4 Syed S, Gilbert R, Feder G, et al. Family adversity and health characteristics associated with intimate partner violence in children and parents presenting to health care: a population-based birth cohort study in England. *Lancet Public Health* 2023; **8:** e520–34.

5 Narayan AJ, Lieberman AF, Masten AS. Intergenerational transmission and prevention of adverse childhood experiences (ACEs). *Clin Psychol Rev* 2021; **85:** 101997.

6 Gilbert R, Widom CS, Browne K, Fergusson D, Webb E, Janson S. Burden and consequences of child maltreatment in high-income countries. *Lancet* 2009; **373:** 68–81.

7 Bellis MA, Hughes K, Ford K, Ramos Rodriguez G, Sethi D, Passmore J. Life course health consequences and associated annual costs of adverse childhood experiences across Europe and North America: a systematic review and meta-analysis. *Lancet Public Health* 2019; **4:** e517–28.

8 Eurostat. Household composition statistics: presence and number of children. May, 2024. https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Household_composition_statistics#Presence_and_number_of_children (accessed Oct 29, 2024).

9 Donagh B, Taylor J, Al Mushaikhi M, Bradbury-Jones C. Sibling experiences of adverse childhood experiences: a scoping review. *Trauma Violence Abuse* 2023; **24:** 3513–27.

10 Bacchus LJ, Colombini M, Pearson I, Gevers A, Stöckl H, Guedes AC. Interventions that prevent or respond to intimate partner violence against women and violence against children: a systematic review. *Lancet Public Health* 2024; **9:** e326–38.

11 WHO. Tackling adverse childhood experiences (ACEs). State of the art and options for action. January, 2023. https://www.ljmu.ac.uk/-/media/phi-reports/pdf/2023-01-state-of-the-art-report-eng.pdf (accessed Oct 29, 2024).

12 HM Government. The best start for life. A vision for the 1,001 critical days. The early years healthy development review report. March, 2021. https://www.gov.uk/government/publications/the-best-start-for-life-a-vision-for-the-1001-critical-days (accessed Oct 29, 2024).

13 Marie-Mitchell A, Kostolansky R. A systematic review of trials to improve child outcomes associated with adverse childhood experiences. *Am J Prev Med* 2019; **56:** 756–64.

14 Robling M, Bekkers M-J, Bell K, et al. Effectiveness of a nurse-led intensive home-visitation programme for first-time teenage mothers (Building Blocks): a pragmatic randomised controlled trial. *Lancet* 2016; **387:** 146–55.

15 Cavallaro FL, Gilbert R, Wijlaars LP, et al. Characteristics of enrolment in an intensive home-visiting programme among eligible first-time adolescent mothers in England: a linked administrative data cohort study. *J Epidemiol Community Health* 2022; **76:** 991–98.

16 Guinn AS, Ottley PG, Anderson KN, Oginga ML, Gervin DW, Holmes GM. Leveraging surveillance and evidence: preventing adverse childhood experiences through data to action. *Am J Prev Med* 2022; **62** (suppl 1)**:** S24–30.

17 Department for Education and Department for Levelling Up, Housing, and Communities. Supporting families programme guidance 2022 to 2025. April, 2022. https://www.gov.uk/government/publications/supporting-families-programme-guidance-2022-to-2025 (accessed Oct 29, 2024).

18 Calik A, Liu HM, Montgomery A, et al. Moving from idea to reality: the barriers and enablers to implementing Child and Family Hubs policy into practice in NSW, Australia. *Health Res Policy Syst* 2024; **22:** 83.

19 Webb R, Uddin N, Ford E, et al. Barriers and facilitators to implementing perinatal mental health care in health and social care settings: a systematic review. *Lancet Psychiatry* 2021; **8:** 521–34.

20 Lever Taylor B, Billings J, Morant N, Bick D, Johnson S. Experiences of how services supporting women with perinatal mental health difficulties work with their families: a qualitative study in England. *BMJ Open* 2019; **9:** e030208.

21 Reiner RC, Olsen HE, Ikeda CT, et al. Diseases, injuries, and risk factors in child and adolescent health, 1990 to 2017: findings from the global burden of diseases, injuries, and risk factors 2017 study. *JAMA Pediatr* 2019; **173:** e190337.

22 Denaxas S, Gonzalez-Izquierdo A, Direk K, et al. UK phenomics platform for developing and validating electronic health record phenotypes: CALIBER. *J Am Med Inform Assoc* 2019; **26:** 1545–59.

23 Herrett E, Gallagher AM, Bhaskaran K, et al. Data resource profile: clinical practice research datalink (CPRD). *Int J Epidemiol* 2015; **44:** 827–36.

24 Wolf A, Dedman D, Campbell J, et al. Data resource profile: clinical practice research Datalink (CPRD) aurum. *Int J Epidemiol* 2019; **48:** 1740.

25 Minassian C, Williams R, Meeraus WH, Smeeth L, Campbell OMR, Thomas SL. Methods to generate and validate a pregnancy register in the UK Clinical Practice Research Datalink primary care database. *Pharmacoepidemiol Drug Saf* 2019; **28:** 923–33.

26 Herbert A, Wijlaars L, Zylbersztejn A, Cromwell D, Hardelid P. Data resource profile: Hospital Episode Statistics admitted patient care (HES APC). *Int J Epidemiol* 2017; **46:** 1093–1093i.

27 Office for National Statistics. The English indices of deprivation 2019. Statistical release. September, 2019. https://assets.publishing.service.gov.uk/media/5d8e26f6ed915d5570c6cc55/IoD2019_Statistical_Release.pdf (accessed Oct 29, 2024).

28 Wijlaars LP, Hardelid P, Woodman J, Allister J, Cheung R, Gilbert R. Contribution of recurrent admissions in children and young people to emergency hospital admissions: retrospective cohort analysis of Hospital Episode Statistics. *Arch Dis Child* 2015; **100:** 845–49.

29 Syed S, Ashwick R, Schlosser M, Gonzalez-Izquierdo A, Li L, Gilbert R. Predictive value of indicators for identifying child maltreatment and intimate partner violence in coded electronic health records: a systematic review and meta-analysis. *Arch Dis Child* 2021; **106:** 44–53.

30 Government HM. Working together to safeguard children: a guide to multi-agency working to help, protect and promote the welfare of children 2023. December, 2023. https://assets.publishing.service.gov.uk/media/669e7501ab418ab055592a7b/Working_together_to_safeguard_children_2023.pdf (accessed Oct 29, 2024).

31 Seaman SR, White IR. Review of inverse probability weighting for dealing with missing data. *Stat Methods Med Res* 2013; **22:** 278–95.

32 Zylbersztejn A, Verfürden M, Hardelid P, Gilbert R, Wijlaars L. Phenotyping congenital anomalies in administrative hospital records. *Paediatr Perinat Epidemiol* 2020; **34:** 21–28.

33 Harron K, Gilbert R, Fagg J, Guttmann A, van der Meulen J. Associations between pre-pregnancy psychosocial risk factors and infant outcomes: a population-based cohort study in England. *Lancet Public Health* 2021; **6:** e97–105.

34 Altman DG, Bland JM. Interaction revisited: the difference between two estimates. *BMJ* 2003; **326:** 219.

35 Harrell FE. Regression modeling strategies: with applications to linear models, logistic regression, and survival analysis. Springer, 2001.

36 Van Buuren S, Groothuis-Oudshoorn K. Mice: multivariate imputation by chained equations in R. *J Stat Softw* 2011; **45:** 1–67.

37 Rod NH, Bengtsson J, Elsenburg LK, Taylor-Robinson D, Rieckmann A. Hospitalisation patterns among children exposed to childhood adversity: a population-based cohort study of half a million children. *Lancet Public Health* 2021; **6:** e826–35.

38 Downey DB. Number of siblings and intellectual development. The resource dilution explanation. *Am Psychol* 2001; **56:** 497–504.

39 Anda RF, Felitti VJ, Bremner JD, et al. The enduring effects of abuse and related adverse experiences in childhood. A convergence of evidence from neurobiology and epidemiology. *Eur Arch Psychiatry Clin Neurosci* 2006; **256:** 174–86.

40 Viner RM, Ozer EM, Denny S, et al. Adolescence and the social determinants of health. *Lancet* 2012; **379:** 1641–52.

41 Daníelsdóttir HB, Aspelund T, Shen Q, et al. Adverse childhood experiences and adult mental health outcomes. *JAMA Psychiatry* 2024; **81:** 586–94.

42 Easey KE, Mars B, Pearson R, Heron J, Gunnell D. Association of birth order with adolescent mental health and suicide attempts: a population-based longitudinal study. *Eur Child Adolesc Psychiatry* 2019; **28:** 1079–86.

43 Cummings EM, Davies PT. Effects of marital conflict on children: recent advances and emerging themes in process-oriented research. *J Child Psychol Psychiatry* 2002; **43:** 31–63.

44 Walker SP, Wachs TD, Grantham-McGregor S, et al. Inequality in early childhood: risk and protective factors for early child development. *Lancet* 2011; **378:** 1325–38.

45 Jackson J, Lewis NV, Feder GS, et al. Exposure to domestic violence and abuse and consultations for emergency contraception: nested case-control study in a UK primary care dataset. *Br J Gen Pract* 2019; **69:** e199–207.

46 Carreira H, Williams R, Strongman H, Bhaskaran K. Identification of mental health and quality of life outcomes in primary care databases in the UK: a systematic review. *BMJ Open* 2019; **9:** e029227.

47 Clark H, Coll-Seck AM, Banerjee A, et al. A future for the world's children? A WHO-UNICEF-*Lancet* Commission. *Lancet* 2020; **395:** 605–58.

48 Mikton CR, Tanaka M, Tomlinson M, et al. Global research priorities for interpersonal violence prevention: a modified Delphi study. *Bull World Health Organ* 2017; **95:** 36–48.

49 Public Health England. Early years high impact area 2: supporting maternal and family mental health. May, 2021. https://www.gov.uk/government/publications/commissioning-of-public-health-services-for-children/early-years-high-impact-area-2-supporting-maternal-and-family-mental-health (accessed Oct 29, 2024).

50 Centers for Disease Control and Prevention. Adverse childhood experiences (ACEs). Prevention resource for action: a compilation of the best available evidence. 2019. https://www.cdc.gov/violenceprevention/pdf/aces-prevention-resource_508.pdf (accessed Oct 29, 2024).

51 Clark DM, Canvin L, Green J, Layard R, Pilling S, Janecka M. Transparency about the outcomes of mental health services (IAPT approach): an analysis of public data. *Lancet* 2018; **391:** 679–86.

52 Woodman J, Simon A, Hauari H, Gilbert R. A scoping review of 'think-family' approaches in healthcare settings. *J Public Health* 2020; **42:** 21–37.