

# Trouble in the Nest: Antecedents of Sibling Bullying Victimization and Perpetration

Slava Dantchev and Dieter Wolke  
University of Warwick

Sibling bullying is highly prevalent and has been found to have adverse effects on mental health lasting into early adulthood. What is unknown is what predicts sibling bullying roles (uninvolved, victim, bully-victim and bully). This study aimed to identify precursors of sibling bullying roles in middle childhood using a large sample of 6,838 children from the Avon Longitudinal Study of Parents and Children, a prospective United Kingdom birth-cohort. The relative associations of four sets of precursors: (a) structural family characteristics, (b) parent and parenting characteristics, (c) early social experiences, and (d) child individual differences was assessed before 8 years of age. Structural family characteristics (being the firstborn and having older brothers) and sex (being male) were the strongest predictors of sibling bullying, consistent with an evolutionary model of sibling aggression. Parenting variables, early social experiences, and child individual differences made significant but smaller contributions. These findings may help to identify at-risk families, allowing for appropriate interventions to be implemented from birth.

*Keywords:* sibling bullying, predictors, childhood, adolescence, ALSPAC

*Supplemental materials:* <http://dx.doi.org/10.1037/dev0000700.supp>

Sibling relationships are ubiquitous, with studies reporting around 85% of children growing up with at least one brother or sister (Tippett & Wolke, 2015). Sibling bonds are one of the longest lasting interpersonal relationships and can benefit children's cognitive and socioemotional development (Yucel & Yuan, 2015). However, sibling relationships are also often characterized by emotional ambivalence and experiencing escalating conflict can lead to internalizing and externalizing problems (Buist, Deković, & Prinzie, 2013).

Sibling bullying has been defined as repeated aggressive behavior between siblings that is intended to inflict harm either physically (e.g., hitting, kicking, or pushing), psychologically (e.g., saying nasty and hurtful things), socially (e.g., telling lies or spreading rumors), or property based (e.g., stealing or damaging property) and involves perceived or real power imbalance (Wolke,

Tippett, & Dantchev, 2015). Prevalence estimates across childhood and adolescence range from 15–50% for sibling victimization and 10–40% for perpetrating sibling bullying (Wolke, Tippett et al., 2015), with victimization rates peaking between 2 and 9 years (Tucker, Finkelhor, Shattuck, & Turner, 2013). Sibling aggression is a key parental concern (Pickering & Sanders, 2016) and the most frequent form of family violence (Finkelhor, Turner, Shattuck, & Hamby, 2015). In contrast, it is often normalized or overlooked by parents and health professionals (Khan & Rogers, 2015).

There is increasing evidence that sibling bullying and victimization have adverse long-term consequences including increased loneliness, peer difficulties, delinquency, internalizing, externalizing, and mental health problems (Wolke, Tippett et al., 2015; van Berkel, Tucker, & Finkelhor, 2018). In order to reduce or avoid sibling aggression from emerging in the first place, it is essential to identify some of the potential risk factors. The aim of this study was to explore to what extent four potential precursor sets may predict sibling bullying, including structural family characteristics, parent and parenting characteristics, early social experiences, and child individual differences.

In the peer bullying literature, children are typically classified into one of four bullying groups: uninvolved, victims, bullies, or bully-victims (Wolke, Woods, Stanford, & Schulz, 2001). Distinctions between these bullying status groups are important. In the peer literature, there is robust evidence showing that each specific bullying group has its own set of unique predictors (Cook, Williams, Guerra, Kim, & Sadek, 2010) and is furthermore differentially associated with a range of psychosocial and behavioral outcomes (Copeland, Wolke, Angold & Costello, 2013; Wolke, Lereya, Fisher, Lewis, & Zammit, 2014). It may, therefore, be

---

This article was published Online First February 14, 2019.

Slava Dantchev and Dieter Wolke, Department of Psychology, University of Warwick.

We are extremely grateful to all the families who took part in this study, the midwives for their help in recruiting them, and the whole Avon Longitudinal Study of Parents and Children (ALSPAC) team, which includes interviewers, computer and laboratory technicians, clerical workers, research scientists, volunteers, managers, receptionists, and nurses. The UK Medical Research Council and Wellcome (Grant ref: 102215/2/13/2) and the University of Bristol provide core support for ALSPAC. This publication is the work of the authors and Slava Dantchev and Dieter Wolke will serve as guarantors for the contents of this paper.

Correspondence concerning this article should be addressed to Dieter Wolke, Department of Psychology, University of Warwick, Coventry, CV4 7AL, United Kingdom. E-mail: [d.wolke@warwick.ac.uk](mailto:d.wolke@warwick.ac.uk)

essential to consider sibling bullying status groups within the sibling domain as well.

Several theories have been put forward to explain the emergence of sibling aggression. Evolutionary perspectives argue that siblings are natural-born competitors for limited parental resources including affection, attention, or material goods (Tanskanen, Danielsbacka, Jokela, & Rotkirch, 2017). Sibling aggression over limited resources in nonhuman species is well documented (Salmon & Hehman, 2014). Studies on bird species show that in extreme cases, sibling rivalry may even result in siblicide through enforced starvation, physical aggression, or eviction from the nest (Morandini & Ferrer, 2015). In humans, resource control theory (RCT; Hawley, 1999) suggests that asymmetries within a social group lead to social dominance and resource-directed agonistic behavior is used for resource acquisition (Hawley, 1999). Siblings are inherently characterized by a power differential (e.g., differences in age, size, or strength). When they face divergent interests, conflictual competitive behavior may develop, in turn, fueling the emergence of sibling aggression (Archer, 2013; Felson, 1983). Indeed, it has been found that aggression is higher in households with more children, more brothers, and by older and firstborn siblings (Bowes, Wolke, Joinson, Lereya, & Lewis, 2014; Menesini, Camodeca, & Nocentini, 2010; Tucker et al., 2013). Evolutionary theories would therefore suggest that structural family characteristics that affect resource availability or access should best predict involvement in sibling bullying perpetration; either as a bully or bully-victims.

Social learning theory (SLT) proposes that aggression is learned through mechanisms of observation, reinforcement, and modeling (Bandura, 1977). Children exposed to indirect or direct forms of aggression within the family may adopt maladaptive models of social interaction and enact these in the sibling context (Eriksen & Jensen, 2009; Tucker, Finkelhor, Turner, & Shattuck, 2014). In line with SLT, children witnessing conflictual parent interactions and domestic violence or experiencing maltreatment and harsh parenting early in life are consistently found to engage in more sibling aggression (Button & Gealt, 2010; Tippett & Wolke, 2015; Updegraff, Thayer, Whiteman, Denning, & McHale, 2005). These children may hence be at a particular risk for perpetrating sibling bullying. Early social experiences beyond the family system may equally establish unhealthy models of interpersonal interactional styles that are applied to the sibling context. Peer bullying has, for example, been linked to sibling bullying (Menesini et al., 2010; Tanrikulu & Campbell, 2015). According to SLT then, exposure to early aggressive models of social interaction (parent-parent, parent-child, sibling-sibling, and peer-child) should predict sibling bullying perpetration. SLT would therefore argue that parenting characteristics and early social experiences (with siblings or peers) would be the strongest predictors of sibling bully or bully-victim status.

Coercion theory (Patterson, 1986; Patterson, Dishion, & Bank, 1984) further suggests that ineffective parenting (e.g., punishments including hitting or scolding) and failure to discipline a child produces coercive sibling exchanges marked by hostility. When parents are unable to intervene effectively (by ignoring or allowing negative behavior within the family system), the sibling relationship may become a training ground through which hostility is reinforced and eventually escalates into sibling bullying (victimization or perpetration). In support of coercion theory, inconsistent

parenting, poor parental supervision, and high levels of sibling conflict have been identified as early indicators of sibling aggression (Menesini et al., 2010; Tucker et al., 2014; Updegraff et al., 2005). Coercion theory would hence suggest that children who are permitted to freely engage in sibling aggression early on will be at risk for involvement in sibling bullying. According to coercion theory, parenting characteristics and early social experiences (between siblings) should therefore be the best predictors of involvement in any sibling bullying role.

Attachment theory (Bowlby, 1969) suggests that early parent-child interactions provide children with internal working models of social interactions, which guide children's responsiveness toward others. Children exposed to positive parenting, including parental warmth, allow children to form healthy relationships and have been shown to be protective against sibling aggression (Tippett & Wolke, 2015; Tucker et al., 2014; Updegraff et al., 2005). On the contrary, unresponsive and inconsistent parenting may compromise healthy models of social interaction. This may be more frequent if the mother has mental health problems (Smith, 2004). Attachment theory would therefore predict that parent and parenting characteristics, particularly positive parenting (e.g., maternal bonding with child), will act as a protective factor shielding against any form of sibling bullying involvement.

Alternatively, child individual differences may contribute to the development of sibling aggression. Indeed, children's temperament, early aggressive tendencies, psychopathology, or sociocognitive abilities have been associated with an increased risk for sibling aggression or bullying (Menesini et al., 2010; Phillips, Bowie, Wan, & Yukevich, 2018; Song, Volling, Lane, & Wellman, 2016; Toseeb, McChesney, & Wolke, 2018). The peer bullying literature further suggests that preterm-born children or those at extremely low birth weight, may be more vulnerable toward victimization (Wolke, Baumann, Strauss, Johnson, & Marlow, 2015). It then follows that child individual differences may be predictive of specific sibling bullying roles; specific predictions are, however, difficult to make, considering the lack of previous studies in respect to the domain of sibling bullying and individual differences.

Previous studies have not tested alternative predictions by these various theories. First, previous studies have been largely cross-sectional and did not allow for interpretation of the direction of associations (Button & Gealt, 2010; Eriksen & Jensen, 2009; Tippett & Wolke, 2015; Tucker et al., 2014; Updegraff et al., 2005). Second, only a small number of potential precursors were investigated and often predictors were not controlled for each other to determine unique independent predictors (Bowes et al., 2014; Dantchev, Zammit, & Wolke, 2018; Toseeb et al., 2018). Third, the focus of previous studies has been mainly on structural and parenting factors (Eriksen & Jensen, 2009; Tippett & Wolke, 2015; Tucker et al., 2014; Updegraff et al., 2005; van Berkel et al., 2018) but neglected other potential factors such as individual differences. Finally, there is a lack of studies that distinguished between roles in sibling bullying, but just considered victims or any conflict but not who perpetrated it.

The aims of the current study were to identify precursors of sibling bullying involvement in different roles (victim, bully-victim, and bully) compared with those uninvolved at 12 years using a prospective birth cohort from the United Kingdom. We investigated the relative associations of four sets of precursors to

roles in sibling bullying: (a) structural family characteristics, (b) parent and parenting characteristics, (c) early social experiences, and (d) child individual differences assessed before 8 years of age.

## Method

### Study Design

The Avon Longitudinal Study of Parents and Children (ALSPAC) is a birth cohort study that recruited 14,541 pregnant women from Avon, United Kingdom, with an expected delivery date between April 1, 1991 and December 31, 1992. Out of this initial number of pregnancies, where enrolled mothers had either returned at least one questionnaire or attended one "Children in Focus" clinic by June 19, 1999, there were 14,062 live births with 13,988 of these children still alive at the age of 12 months. A detailed report on the recruitment process of the mother and child cohorts are available in the cohort profiles (Boyd et al., 2013; Fraser et al., 2013). Children were invited to attend annual assessment clinics, including face-to-face interviews, and psychological and physical tests from 7 years onward. Please note that the study website (<http://www.bris.ac.uk/alspac/researchers/data-access/data-dictionary/>) contains details of all the data that is available through a fully searchable data dictionary. Ethical approval for the study was obtained from the ALSPAC Ethics and Law Committee (IRB No. 00003312) and the local research ethics committees (Bristol and Weston Health Authority, Southmead Health Authority, and Frenchay Health Authority).

### Sample

The starting sample consisted of all those children who successfully completed the "Brothers and Sisters" section of the "All Around Me" questionnaire administered to study children when they were, on average, 12.1 years old. Out of the 7,477 children who completed the questionnaire, 477 (6.4%) reported that they had no siblings at home. Children with no siblings were excluded from all further analyses. The final sample consisted of all those who completed items on both sibling bullying perpetration and victimization ( $N = 6,838$ ). An a priori analysis using G\*Power (Faul, Erdfelder, Buchner, & Lang, 2009) indicated that a sample size of at least 6,185 would be sufficient to detect a small effect size (i.e., odds ratio [ $OR$ ] = 1.1) using a two-tailed test, a power of .85, and an alpha level of .05. This study was therefore adequately powered.

### Assessment of Sibling Bullying

Sibling bullying was assessed when children were 12 years old via an adapted questionnaire from the Olweus Bullying Questionnaire (Olweus, 2007) addressing bullying between brothers and sisters (Dantchev et al., 2018). Children were told that sibling bullying is:

when a brother or sister tries to upset you by saying nasty and hurtful things, or completely ignores you from their group of friends, hits, kicks, pushes or shoves you around, tells lies or makes up false rumours about you.

They were then asked to report on their experience of sibling bullying within the last 6 months. On a 5-point Likert scale (0 = *never*; 1 = *only ever once or twice*; 2 = *2 or 3 times a month*; 3 = *about once a week*; 4 = *several times a week*) children were first asked to report whether they were ever bullied by a sibling at home (victimization) and later whether they had ever bullied a sibling at home (perpetration). Children were coded into sibling bullying status groups (uninvolved, victims, bully-victims, bullies) according to the following rules: those who reported being victimized by a sibling at least once a week were coded as victims, those who reported perpetrating sibling bullying at least once a week were coded as bullies, those who reported being victimized and perpetrating sibling bullying at least once a week were coded as bully-victims, while those not involved in any bullying were coded as uninvolved (Wolke, Copeland, Angold, & Costello, 2013). Children were also asked to report their age in years, at which they were first bullied by their siblings as well as their age at which they first bullied their siblings.

### Developmental Precursors

In order to explore and identify potential sets of precursors of sibling bullying, we grouped variables as following: (a) structural family characteristics (e.g., birth order), (b) parental and parenting characteristics (e.g., domestic violence), (c) early social experiences (e.g., sibling aggression), and (d) child individual differences (e.g., infant temperament). Table 1 provides an overview of all selected precursors for sibling bullying. All precursors were placed within their corresponding set and an indication of the time point at which these constructs were measured is provided.

#### Structural family characteristics.

**Household composition.** All household composition variables were obtained when children were 7 years old. Birth order was dichotomized as firstborn versus later born. Older brother and older sisters were coded as present or not (Bowes et al., 2014). The number of other children living in the household was used as a continuous variable ( $M = 1.38$ ;  $SD = 0.91$ ); scores were then  $z$ -standardized ( $M = 0$ ;  $SD = 1$ ).

**Sociodemographic characteristics.** Mother's marital status was assessed by classifying maternal responses as married versus single. Mothers were also asked to indicate their highest educational qualification. Maternal education was coded as advanced-level qualification/university degree/ordinary-level qualifications versus certificate of secondary education/vocational/none (Bowes et al., 2014). Occupational social class was assessed by dichotomizing maternal responses as professional/managerial/skilled versus partly or unskilled occupations. (Bowes et al., 2014). Finally, mothers were asked to assess how difficult it was to afford the following: food, clothing, heating, rent/mortgage, and things needed for their child on a Likert-type scale from 0–3 (0 = *not difficult*; 3 = *very difficult*). A sum score was constructed in order to reflect financial difficulties ( $M = 2.91$ ;  $SD = 3.54$ ), with higher scores reflecting more financial difficulties (Russell, Ford, & Russell, 2018). Scores were then  $z$  standardized ( $M = 0$ ;  $SD = 1$ ).

#### Parental and parenting characteristics.

**Antenatal mental health.** Maternal depression was assessed antenatally at 32 weeks' gestation via the 10-item Edinburgh Postnatal Depression Scale (Cox, Holden, & Sagovsky, 1987). Responses to individual items were given on a Likert-type scale

Table 1  
Overview of Selected Precursors to Sibling Bullying

Time point assessed	Precursor set			
	Structural family characteristics	Parental and parenting characteristics	Early social experiences	Child individual differences
Pregnancy	Financial difficulties Maternal social class Maternal education	Maternal depression Maternal anxiety	*****	*****
Birth	*****	*****	*****	Sex Gestation Birthweight
0–3 Years	*****	Maternal mental health Mother–child activities Maternal bonding Domestic violence Maltreatment Suboptimal parenting Conflicting partnership	*****	Regulatory problems (crying, sleeping or feeding) Difficult temperament
4–8 Years	Number of children in household Birth order Older brothers Older sisters Mother’s marital status	*****	Sibling aggression (victimization or perpetration) Time spent on activities with siblings Peer bullying (victimization or perpetration)	Psychiatric disorders Internalizing problems Externalizing problems Intelligence Emotion recognition Social cognition Self-esteem Locus of control Antisocial behavior

\*\*\*\*\* not assessed.

ranging from 0–3. A sum score was derived using all items and mothers were classified as reporting probable clinical postnatal major depression using a cutoff score of 13 or more (Heron et al., 2004).

Maternal anxiety was assessed antenatally at 32 weeks’ gestation via the eight-item Anxiety subscale taken from the Crown-Crisp Experiential Index (Crown & Crisp, 1979). Responses to individual items were given on a Likert-type scale ranging from 0–2. A sum score was derived using all items and mothers were classified as anxious if they scored above the 85th percentile (Heron et al., 2004); corresponding to a score of 9 or higher out of 16 points.

**Postnatal mental health.** When children were 4 months old, mothers were asked to answer a range of items identifying whether they had any mental health problems currently including schizophrenia, anorexia nervosa, severe depression, or any other psychiatric problems. Mothers who responded “yes” to any of these items were coded as having a mental health problem.

**Conflicting partnership.** Conflicting partnership was measured according to maternal reports at 22 and 33 months. Mothers were asked about their engagement in four conflicting exchanges with their partners; arguing, not speaking, walking out of the house, and shouting/calling names. Items were coded as present if either the mother, their partner, or both parties engaged in the behavior (Winsper, Lereya, & Wolke, 2012). A conflicting partnership score was created by summing all items, with higher scores reflecting higher levels of conflicting partnership ( $M = 2.24$ ;  $SD = 1.88$ ;  $\alpha = 0.71$ ). Scores were then  $z$  standardized ( $M = 0$ ;  $SD = 1$ ).

**Domestic violence.** Domestic violence was measured via a maternal questionnaire across four time points (8, 21, 33, 47 months; Bowen, Heron, Waylen, Wolke, & the ALSPAC Study

Team 2005). Physical violence included self-reports of being physically hurt, slapped or hit by their partner, or whether their partner broke or threw things. Emotional violence included self-reports of partners being emotionally cruel to the mother. Domestic violence was considered present if mothers reported any physical or emotional violence at any time point (Winsper et al., 2012) and was coded as 0 = *not present*; 1 = *present*.

**Maltreatment.** Child maltreatment was assessed across three time points (18, 30, and 42 months). Mothers were asked to report whether their children had ever been taken into care or whether anyone (e.g., family member, stranger, etc.) had ever physically hurt or sexually abused them previously. Maltreatment was considered present if mothers reported any incident at any time point up to 4 years of age (Bowes et al., 2014; Lereya, Copeland, Zammit, & Wolke, 2015) and was coded as 0 = *not present*; 1 = *present*.

**Suboptimal parenting index.** Suboptimal parenting considered four behaviors or emotions: hitting, shouting, hostility, and resentment (Winsper et al., 2012). We used these factors to construct a scale focusing on early childhood only (hitting and shouting at 24 and 42 months; hostility at 21 and 47 months; resentment at 21, 33, and 47 months; see Winsper et al., 2012 for details). Each factor was coded as present or not (Winsper et al., 2012) leading to a suboptimal parenting index by summing all four factors allowing for a potential score of 0–4, where higher scores reflect higher levels of suboptimal parenting ( $M = 2.60$ ;  $SD = 0.90$ ). Scores were then  $z$  standardized ( $M = 0$ ;  $SD = 1$ ).

**Maternal bonding.** Maternal reports at 8 and 33 months assessed maternal bonding with one subscale measuring maternal confidence (six items; e.g., “I feel confident with my baby”) and the other maternal enjoyment (five items; e.g., “I really enjoy my

baby"). Responses were given on a 4-point Likert-type scale ranging from 0–3 (0 = *never*; 3 = *feels exactly that way*), allowing for a range of potential scores from 0–33 at each time point (Thomson et al., 2014). Maternal bonding scores at both time-points were totaled ( $M = 55.82$ ;  $SD = 6.65$ ;  $\alpha = 0.72$ ) in order to construct a composite score. Higher scores reflect greater maternal bonding. Scores were then  $z$  standardized ( $M = 0$ ;  $SD = 1$ ).

**Mother-child activities.** Mothers were asked to report how often they engaged in a range of activities with their toddlers at 6 months and 3 years. At 6 months, mothers were asked about seven activities (playing, singing, showing pictures in books, playing with toys, cuddling, physical play, and taking child for walks) and responses were given on a 3-point Likert-type scale: 0 = *hardly ever*; 1 = *occasionally*; 2 = *often*. At 3 years mothers were asked about nine activities (bathing, feeding, singing, showing pictures in books, playing with toys, cuddling, physical play, taking child for walks, and putting child to bed). Responses were harmonized in order to match the 3-point Likert-type scale from the 6-month assessment (*never* and *hardly ever* response categories were collapsed into the same category: *hardly ever*): 0 = *hardly ever*; 1 = *sometimes*; 2 = *often*. Mother-child activity scores were summed across both time points allowing for a potential score of 0–34, with higher scores reflecting higher levels of mother-child activities ( $M = 28.2$ ;  $SD = 3.33$ ;  $\alpha = 0.71$ ). Scores were then  $z$  standardized ( $M = 0$ ;  $SD = 1$ ).

#### Early social experiences.

**Sibling aggression.** When children were 5 years old, mothers were asked to report on sibling aggression within their household. Mothers reported on how often their child perpetrated aggression toward their siblings via two items (teasing and provoking;  $M = 2.19$ ;  $SD = 0.98$ ;  $\alpha = 0.73$ ) and they were then asked how often their study child was victimized by their siblings (teased and provoked;  $M = 1.98$ ;  $SD = 1.12$ ;  $\alpha = 0.76$ ). All responses were given on a 3-point Likert-type scale (0 = *never*; 1 = *sometimes*; 2 = *often*). A sum score was constructed separately for sibling aggression perpetration (ranging from 0–4) and victimization (ranging from 0–4), with higher scores reflecting higher levels of aggression or victimization. Both scores were then  $z$  standardized ( $M = 0$ ;  $SD = 1$ ).

**Time spent on activities with siblings.** When children were 7 years old, mothers were asked to indicate how often their child would engage in a range of activities (e.g., “making things/drawing with siblings”) with their brothers or sisters. Responses were given on a 5-point Likert-type scale (0 = *never*; 4 = *nearly every day*). All seven items were summed to create a sibling interaction score with higher scores reflecting more time spent together ( $M = 26.79$ ;  $SD = 4.33$ ;  $\alpha = 0.76$ ). Scores were then standardized through conversion to  $z$ -scores ( $M = 0$ ;  $SD = 1$ ).

**Peer bullying.** Peer bullying was assessed at the 8-year clinic via a modified version of the Bullying and Friendship Interview Schedule (Wolke et al., 2014). Children were asked five questions about direct (e.g., hitting) and four questions about indirect (e.g., telling rumors) peer bullying victimization and perpetration. Children were coded as peer victims or bullies if they reported victimization or perpetration of these items at least four times in the last 6 months (Wolke et al., 2013). Both peer bullying victimization and perpetration were coded as 0 = *not present* or 1 = *present*.

#### Individual differences.

**Sex.** Children were coded as female or male.

**Prematurity and birth weight.** Children were coded as very preterm/very low birth weight if they met either of the following criteria: <32 week’s gestation or <1,500 g at birth (Wolke, Baumann, et al., 2015).

**Infant temperament.** The Carey Infant Temperament Scale (Carey, 1970) was used to assess infant temperament via maternal reports when the study child was 24 months of age. The construct of the “difficult child” is derived using five of the nine Carey Infant Temperament scales (Low Rhythmicity, Approach, and Adaptability; High Intensity and Mood, Carey, 1970). We created a sum score from these five subscales and considered children as “difficult” if they scored greater than one standard deviation above the mean (Carey, 1970).

**Infant regulatory problems.** Infant regulatory problems (RPs) were measured according to maternal reports on children’s sleeping, crying, and feeding problems during infancy. Sleeping and crying problems were assessed at 6, 18, and 30 months while feeding problems were assessed at 6, 15, and 24 months. We used a previously constructed multiple regulatory problems composite by Winsper and Wolke (2014) in order to indicate the number of RPs (0 = *no RPs*, 1 = *1 RP*, 2 = *2 RP*, 3 = *3 RP*) children were experiencing across the following time points: 6, 15–18, and 24–30 months. We then summed these composites into a score ranging from 0–9 (0 = *never a regulatory problem at any time*; 9 = *all regulatory problems at all three time points*), with higher scores indicating more regulatory problems. Scores were  $z$  standardized ( $M = 0$ ;  $SD = 1$ ). For more details, see Winsper et al. (2014).

**IQ.** Children were administered the United Kingdom version of the Wechsler Intelligence Scale for Children–III (WISC–III; Wechsler, Golombok, & Rust, 1992) at the 8-year clinic to assess their intelligence (IQ;  $M = 102.06$ ;  $SD = 16.54$ ). The WISC–III was administered by trained psychologist who assessed children’s IQ during the observational activities session at the clinic session. Scores were then  $z$  standardized ( $M = 0$ ;  $SD = 1$ ).

**Psychiatric diagnoses.** The Development and Wellbeing Assessment (Goodman, Ford, Richards, Gatward, & Meltzer, 2000) is a structured interview in order to assess psychiatric diagnosis within the past 6 months when children were 7 years old. Children were coded as presenting one or more *DSM–IV* Axis I diagnosis ( $N = 475$ ; 5.8%) of attention-deficit/hyperactivity disorder, conduct disorder, oppositional defiant disorder, depression, or anxiety (Schreier et al., 2009) or none.

**Internalizing and externalizing problems.** Maternal reports in the Strengths and Difficulties Questionnaire (Goodman, 2001) was used in order to assess children’s internalizing and externalizing problems at 7 years. We used the five-item Emotional subscale in order to reflect internalizing problems, with higher scores indicating more emotional problems ( $M = 1.51$ ;  $SD = 1.68$ ;  $\alpha = 0.67$ ). We further used the five-item Hyperactivity and the four-item Conduct Problems (peer bullying item was removed) subscales in order to assess externalizing problems ( $M = 4.80$ ;  $SD = 3.17$ ;  $\alpha = 0.72$ ), with higher scores reflecting more externalizing problems. Both scores were then standardized through conversion to  $z$  scores ( $M = 0$ ;  $SD = 1$ ).

**Facial emotion recognition.** The Diagnostic Analysis of Non-Verbal Accuracy (DANVA, Nowicki & Duke, 1994) was used in order to assess children’s facial emotion recognition. DANVA was administered via a computerized task at the 8-year clinic where children were asked to recognize emotion from facial cues. Facial

emotion recognition abilities were dichotomized with those children making seven or more errors being classified with poor emotion recognition (Kothari, Skuse, Wakefield, & Micali, 2013).

**Social cognition.** The 12-item Skuse Social Cognition Scale (Skuse et al., 1997) was used in order to measure children's social cognition behavior according to maternal reports when children were 7 years old. Mothers were asked to indicate whether a list of statements corresponded to their child's behavior (e.g., "not aware of other people's feelings"). Responses were given on a 3-point Likert-type scale with scores ranging from 0–2 (0 = *not true*; 1 = *quite/sometimes true*; 2 = *very/often true*). We used a sum score ranging from 0–24 to indicate children's social cognition, with higher scores indicating higher levels of social cognition ( $M = 2.80$ ;  $SD = 3.73$ ). Scores were then  $z$  standardized ( $M = 0$ ;  $SD = 1$ ).

**Self-esteem.** Self-esteem was measured at the 8-year clinic via the shortened 12-item version of the Harter Self Perception Profile for Children (Harter, 1985). Trained psychologists led a face-to-face activity session with children and collected their responses using a blinded procedure, in order to encourage truthful responses. We used the full Self-Esteem scale comprised of two subscales: Global Self-Worth and Scholastic Competence. Higher scores reflect higher levels of self-esteem ( $M = 19.23$ ;  $SD = 3.43$ ). Scores were then  $z$  standardized ( $M = 0$ ;  $SD = 1$ ).

**Locus of control.** Locus of control was assessed at the 8-year clinic via a short 12-item version of the Nowicki-Strickland Internal-External Scale (Nowicki & Strickland, 1973) for pre-school and primary schoolchildren. Trained psychologists led a face-to-face interview with children and recorded their responses. Children's responses either reflected an internal or external locus of control. A locus of control score was constructed as the sum of all external responses given by children, with higher scores reflecting more external locus of control in children ( $M = 5.99$ ;  $SD = 2.08$ ). Scores were then  $z$  standardized ( $M = 0$ ;  $SD = 1$ ).

**Antisocial behavior.** Antisocial behavior was assessed at the 8-year clinic via 11 items taken from the self-report Antisocial Behavior for Young Children Questionnaire (Loeber, Stouthamer-Loeber, Van Kammen, & Farrington, 1989). Children were asked to indicate whether they had ever been involved in any of the 11 behaviors described in the items (e.g., "have you ever taken something from a shop without paying for it?"). Trained psychologists led a face-to-face activity session with children and collected their responses using a blinded procedure, in order to encourage truthful responses. An antisocial sum score was created by adding up all items where children had responded with "yes." Higher scores reflect higher

levels of antisocial behavior ( $M = 0.36$ ;  $SD = 0.85$ ). Scores were then standardized through conversion to  $z$  scores ( $M = 0$ ;  $SD = 1$ ).

## Statistical Analysis

All analyses were performed using IBM SPSS Statistics 24 and Stata 14 (StataCorp, 2015). In order to allow for direct comparison of effect sizes across continuous and categorical variables, all continuous measures were transformed into  $z$  scores ( $M = 0$ ;  $SD = 1$ ). All of the following analyses have been performed using standardized  $z$  scores (of continuous variables) with odds ratios reflecting an increase of one standard deviation. Collinearity diagnostics were performed using the "collin" command in Stata. The variance inflation factor (VIF) measures the impact of collinearity among the variables in a regression model. A VIF of  $\geq 10$  or a tolerance level of 0.10 indicates significant multicollinearity (O'Brien, 2007). Further details can be found in the online supplemental materials (Tables S7 and S8).

First, in order to identify some of the potential precursors of sibling bullying, we ran a set of multinomial logistic regression (MLR) analysis using SPSS. Tables S2–S5 (in the online supplemental materials) show the crude associations between each individual precursor variable and sibling bullying roles. For clarity, the precursors belonging to the same precursor set have been placed within the same table (see Tables S2–S5).

Second, fully conditional specification equations as implemented in the multiple imputation by chained equations algorithm in Stata 14 were utilized in order to address possible bias in our findings, as a result of missing data by attrition. An averaged parameter estimate of over 60 imputed data sets was used according to Rubin's rule (Little & Rubin, 2002). Imputations allowed for a starting sample of 6,838.

Third, in order to test which precursors were most strongly associated with sibling bullying (within their corresponding precursor set), all precursors that were found independently associated with sibling bullying in the crude analysis per block were selected and entered simultaneously into the same models (Models 1–4) using the imputed dataset. In other words, four separate MLRs were run using the imputed dataset, one corresponding to each precursor set: (a) structural family characteristics (Model 1; Table 2), (b) parent and parental characteristics (Model 2; Table 3), (c) early social experiences (Model 3; Table 4), and (d) individual differences (Model 4; Table 5).

Table 2

Model 1: Imputed Adjusted Odd Ratios for Sibling Bullying Status at 12 Years According to Structural Family Characteristics

N = 6,838	Structural family characteristics		OR [95% CI]		
	Time point	Uninvolved	Victims	Bully-Victims	Bullies
Firstborn	7 years	Reference	.91 [.71, 1.16]	1.59 [1.25, 2.02]**	2.84 [2.10, 3.83]**
Older brothers	7 years	Reference	1.69 [1.35, 2.14]**	1.60 [1.26, 2.04]**	1.13 [.81, 1.59]
Number of children in household	7 years	Reference	1.09 [.98, 1.21]	1.29 [1.17, 1.41]**	1.33 [1.18, 1.49]**
>Financial difficulties	7 years	Reference	1.08 [.99, 1.19]	1.16 [1.07, 1.26]**	1.10 [.99, 1.23]

Note. All variables included in this table have been entered together into the same model and have thus been adjusted for one another. The imputed dataset has been used for this analysis. OR = Odd ratios; 95% CI = 95 percent confidence intervals.

\*\*  $p < .01$ .

Table 3  
Model 2: Imputed Adjusted Odd Ratios for Sibling Bullying Status at 12 Years According to Parental and Parenting Characteristics

N = 6,838	Parental and parenting characteristics		OR [95% CI]		
	Time point	Uninvolved	Victims	Bully-Victims	Bullies
Maternal depression	32 weeks' gestation	Reference	1.14 [.84, 1.54]	1.08 [.81, 1.45]	.95 [.66, 1.37]
Maternal anxiety	32 weeks' gestation	Reference	1.24 [.92, 1.66]	.93 [.70, 1.23]	1.10 [.77, 1.56]
Maternal psychiatric problems	4 months	Reference	.90 [.67, 1.21]	1.07 [.82, 1.40]	1.25 [.92, 1.72]
Conflicting partnership	0–3 years	Reference	.98 [.88, 1.09]	1.21 [1.09, 1.34]**	1.15 [1.02, 1.30]*
Maternal bonding	0–3 years	Reference	.91 [.83, 1.00]*	.87 [.80, .95]**	.90 [.80, 1.00]
Mother–child activities	0–3 years	Reference	.93 [.85, 1.02]	.94 [.87, 1.03]	1.03 [.92, 1.15]
Domestic violence	0–4 years	Reference	1.14 [.91, 1.44]	1.29 [1.04, 1.61]*	.93 [.70, 1.22]
Suboptimal parenting	0–4 years	Reference	1.01 [.91, 1.11]	1.13 [1.03, 1.24]*	1.23 [1.11, 1.37]**

Note. All variables included in this table have been entered together into the same model and have thus been adjusted for one another. The imputed dataset has been used for this analysis. OR = Odds ratio; 95% CI = 95 percent confidence intervals.

\*  $p < .05$ . \*\*  $p < .01$ .

Fifth, a final model was run (Model 5; Figure 1A and 1B), in which all significant precursors from Models 1–4 were selected and entered at the same time, in order to determine which precursors would survive when competing against all other remaining ones. Figure 1A and 1B have been split into two parts in order to allow for a larger image and better readability, however both parts of the figure correspond to the results within the same Model 5.

### Results

#### Prevalence of Sibling Bullying Involvement

A total of 6,838 children reported on sibling bullying status with 28.1% involved in any kind of sibling bullying (victim, bully-victim, or bully). The onset of sibling bullying was reported around the same time (victimization:  $M = 8.3$ ,  $SD = 2.51$ ; perpetration:  $M = 8.7$ ,  $SD = 2.38$ ) in years. Psychological sibling bullying (i.e., name calling) was reported as the most frequent type of bullying across both children who reported victimization (41.3%) as well as perpetration (33.9%). Further details in respect to the frequencies across all types of sibling bullying victimization and perpetration (physical, psychological, and property) can be found in the online supplemental materials (Table S1). In respect to sibling bullying groups, bully-victims made up the largest group with 11.3% of children, while 9.7% reported to be victims and 7.1% reported to be bullies. Males bullied their sibling more often than females.

Prevalence of sibling bullying according to role and sex are shown in Table 6. Descriptive statistics of potential precursor variables across sibling bullying roles are illustrated in Tables S2–S5 in the online supplemental materials.

#### Structural Family Characteristics and Sibling Bullying

Details on the crude associations between structural family characteristics and sibling bullying can be found in the online supplemental materials (Table S2). Imputed adjusted associations including all significant structural family characteristics (Model 1; see Table 2) indicated that children with older brothers were at increased risk of sibling bullying victimization (victim or bully-victim). Firstborn children and those growing up in families with more children at home were more likely to perpetrate sibling bullying (bully-victim or bully). Children coming from families with more financial difficulties were at increased odds of bully-victim status). The fully adjusted Model 5, which included all four sets of precursors (see Figure 1A), found that growing up in households with more children remained a significant risk factor for sibling bullying perpetration (bully-victim:  $OR = 1.28$ ; 95% CI [1.16, 1.42]; bully:  $OR = 1.30$ ; 95% CI [1.15, 1.48]). Similarly, having older brothers continued to predict sibling bullying victimization (victim:  $OR = 1.75$ ; 95% CI [1.38, 2.22]; bully victim:  $OR = 1.71$ ; 95% CI [1.32, 2.18]) while being firstborn was predictive of sibling bullying perpetration (bullies:  $OR = 2.64$ ; 95% CI [1.92, 3.69]; bully victims:  $OR = 1.68$ ; 95% CI [1.36, 2.30]).

Table 4  
Model 3: Imputed Adjusted Odd Ratios for Sibling Bullying Status at 12 Years According to Early Social Experiences

Early social experiences N = 6,838	Time point	Uninvolved	OR [95% CI]		
			Victims	Bully-Victims	Bullies
Sibling aggression victimization	5 years	Reference	1.25 [.11, 1.40]**	1.17 [1.05, 1.30]**	.75 [.66, .85]**
Sibling aggression perpetration	5 years	Reference	1.04 [.93, 1.17]	1.10 [.99, 1.22]	1.33 [1.18, 1.50]**
>Time spent on activities with siblings	7 years	Reference	1.04 [.95, 1.14]	1.17 [1.07, 1.29]**	1.17 [1.04, 1.31]**
Peer victimization	8 years	Reference	1.33 [1.09, 1.62]**	1.42 [1.18, 1.72]**	1.32 [1.06, 1.65]*
Peer perpetration	8 years	Reference	.98 [.67, 1.43]	1.53 [1.13, 2.07]**	1.42 [.96, 2.09]

Note. All variables included in this table have been entered together into the same model and have thus been adjusted for one another. The imputed dataset has been used for this analysis. OR = Odds ratios; 95% CI = 95 percent confidence intervals.

\*  $p < .05$ . \*\*  $p < .01$ .

Table 5

Model 4: Imputed Adjusted Odds Ratios for Sibling Bullying Status at 12 Years According to Child Individual Differences

Child individual differences	N = 6,838	Time point	Uninvolved	OR [95% CI]		
				Victims	Bully-Victims	Bullies
Male		Birth	Reference	.83 [.70, .98]*	.79 [.67, .92]**	1.69 [1.38, 2.06]**
Difficult temperament		24 months	Reference	1.19 [.94, 1.53]	1.03 [.81, 1.31]	.96 [.71, 1.30]
Regulatory problems		0, 3 years	Reference	1.05 [.96, 1.14]	1.09 [1.01, 1.18]*	1.03 [.93, 1.14]
Psychiatric disorders		7 years	Reference	1.41 [.91, 2.17]	.98 [.65, 1.46]	.81 [.51, 1.30]
Internalizing problems		7 years	Reference	1.05 [.96, 1.15]	1.09 [1.00, 1.18]	1.04 [.93, 1.16]
Externalizing problems		7 years	Reference	1.08 [.97, 1.21]	1.19 [1.07, 1.33]**	1.23 [1.09, 1.39]**
Poor social cognition		7 years	Reference	1.03 [.90, 1.17]	1.16 [1.03, 1.30]*	1.24 [1.09, 1.41]**
Poor emotion recognition		8 years	Reference	1.16 [.92, 1.45]	.97 [.78, 1.21]	1.04 [.81, 1.35]
High self-esteem		8 years	Reference	.88 [.80, .97]**	.93 [.85, 1.02]	.91 [.82, 1.02]
External locus of control		8 years	Reference	1.13 [1.02, 1.26]*	1.09 [.98, 1.21]	1.02 [.91, 1.15]
Antisocial behavior		8 years	Reference	1.05 [.94, 1.16]	1.22 [1.13, 1.33]**	1.19 [1.09, 1.31]**
IQ		8 years	Reference	1.07 [.96, 1.19]	.98 [.89, 1.08]	1.04 [.92, 1.18]

Note. All variables included in this table have been entered together into the same model and have thus been adjusted for one another. The imputed dataset has been used for this analysis. OR = Odds ratio; 95% CI = 95 percent confidence intervals.

\*  $p < .05$ . \*\*  $p < .01$ .

### Parental and Parenting Characteristics and Sibling Bullying

Crude associations (see Table S3) were attenuated and some predictors were no longer significant once all parental and parenting characteristics were accounted for (Model 2; see Table 3). Conflicting partnership as well as domestic violence remained significant predictors of bully-victim status in our imputed adjusted model. Suboptimal parenting increased the likelihood of children becoming bully-victims and bullies, while higher levels of maternal bonding protected against becoming a victim or bully-victim. Only two variables from the parenting set survived in our final imputed analysis (Model 5; see Figure 1A). Children who came from homes with conflicting partnership had increased odds of being bully-victims ( $OR = 1.16$ ; 95% CI [1.05, 1.28]), while those experiencing suboptimal parenting were most often bullies ( $OR = 1.123$ ; 95% CI [1.01, 1.27]).

### Early Social Experiences and Sibling Bullying

Crude analysis (see Table S4) as well as the imputed adjusted analysis (Model 3; see Table 4) indicated that being victimized by a sibling in preschool is a risk factor for any sibling bullying involvement in middle childhood. On the contrary, being involved in perpetrating aggression toward one's siblings in early childhood was a specific predictor of later bully status. Moreover, spending more time on activities with siblings predicted later perpetration (bully-victim and bully). Finally, being victimized by peers increased the likelihood for involvement in any sibling bullying role, while perpetrating peer bullying was associated with the likelihood of being a sibling bully-victim. The final imputed adjusted analysis (Model 5; see Figure 1B) revealed that being victimized at 5 years increased the odds of being a sibling bully-victim 7 years later ( $OR = 1.19$ ; 95% CI [1.06, 1.35]). Spending more time on activities with brothers and sisters increased the risk of sibling bullying involvement in any role (victim:  $OR = 1.10$ ; 95% CI [1.02, 1.22]; bully-victim:  $OR = 1.19$ ; 95% CI [1.08, 1.32]; bully:  $OR = 1.16$ ; 95% CI [1.03, 1.31]) by 12

years. Being victimized by peers was associated with both sibling victim ( $OR = 1.23$ ; 95% CI [1.01, 1.50]) and bully-victim ( $OR = 1.26$ ; 95% CI [1.03, 1.53]) status.

### Individual Differences and Sibling Bullying

Details on the crude associations between individual differences and sibling bullying can be found in the online supplemental materials (see Table S5). Imputed adjusted analysis (Model 4; see Table 5) found that male children were more often sibling bullies, while being male reduced the odds of becoming victims or bully-victims. Children with more externalizing problems, poorer social cognition and higher levels of antisocial behavior were at increased risk of becoming bullies and bully-victims. Having more regulatory problems in infancy made it more likely for children to become bully-victims. External locus of control increased the risk of becoming a sibling victim, while high-self-esteem was protective against becoming a victim. The imputed and fully adjusted model (Model 5; see Figure 1B) found that being male protected against becoming a victim ( $OR = 0.82$ ; 95% CI [0.69, 0.98]) or bully-victim ( $OR = 0.76$ ; 95% CI [0.64, 0.89]), while it increased the odds of becoming a bully ( $OR = 1.69$ ; 95% CI [1.38, 2.07]). Children with higher levels of previous externalizing problems and higher levels of antisocial behavior were more often bully-victims (externalizing:  $OR = 1.19$ ; 95% CI [1.07, 1.32]; antisocial:  $OR = 1.19$ ; 95% CI [1.09, 1.29]) and bullies (externalizing:  $OR = 1.22$ ; 95% CI [1.07, 1.38]; antisocial:  $OR = 1.20$ ; 95% CI [1.09, 1.32]). Having lower levels of social cognition similarly predicted sibling bully-victim ( $OR = 1.30$ ; 95% CI [1.02, 1.26]) and bully ( $OR = 1.19$ ; 95% CI [1.05, 1.34]) status. Finally, children with high self-esteem were protected against becoming a victim ( $OR = 0.90$ ; 95% CI [0.82, 0.99]), while those with higher levels of external locus of control were at increased risk of becoming victims ( $OR = 1.12$ ; 95% CI [1.01, 1.23]).



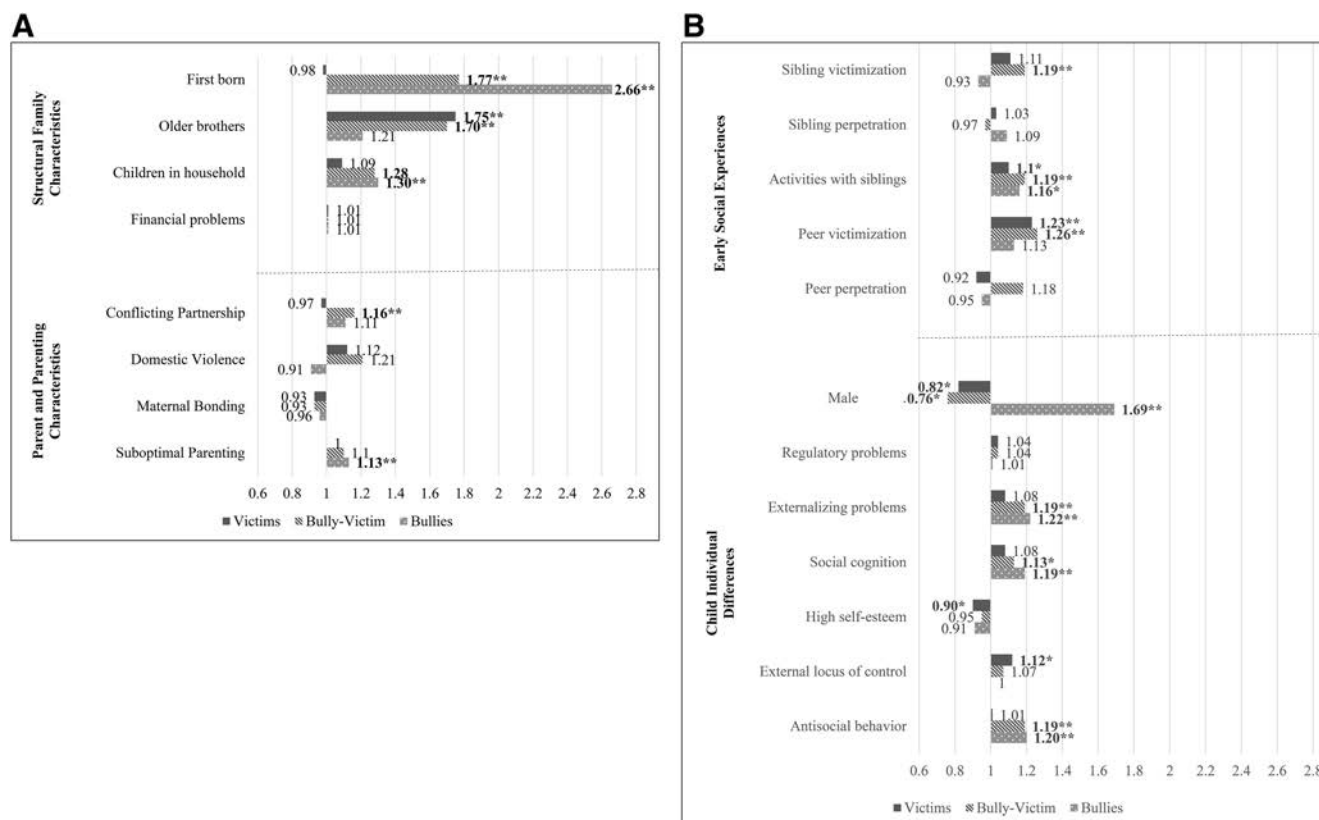


Figure 1. (A) Model 5: final model illustrating the imputed adjusted odd ratios for sibling bullying status at 12 years according to all remaining precursors across the four sets. All variables included in this figure have been entered together into the same model (including also all variables illustrated in Panel B) and have thus been adjusted for one another. The imputed dataset has been used for this analysis. (B) Model 5: final model illustrating the imputed adjusted odd ratios for sibling bullying status at 12 years according to all remaining precursors across the four sets. All variables included in this figure have been entered together into the same model (including also all variables illustrated in Panel A) and have thus been adjusted for one another. The imputed dataset has been used for this analysis.  $N = 6,831$ . \*  $p < .05$ . \*\*  $p < .01$ .

**Summary**

For none of the reported regression models was significant multicollinearity found (see Tables S7 and S8). An overview of all significant predictors of sibling bullying roles across all four sets of precursors using the final fully adjusted and imputed dataset (Model 5) can be found in Table 7.

Table 6  
Descriptives of Sibling Bullying Status and Distribution Across Gender

Sibling bullying status	Total	Sex	
		Male (%)	Female (%)
Uninvolved	4,915	2,262 (46.0)	2,653 (54.0)
Victim	664	285 (42.9)	379 (57.1)
Bully-Victim	773	336 (43.5)	437 (56.5)
Bully	486	305 (62.8)	181 (37.2)

**Discussion**

To our knowledge, this is the first prospective study to test a large range of potential precursors of sibling bullying roles in a systematic way. Resonating with previous studies (Toseeb et al., 2018; Wolke & Skew, 2012), the majority of children involved in sibling bullying were found to be bully-victims. This mirrors the nature of the sibling relationship, which is characterized by a high degree of familiarity, allowing children to have bidirectional power over one another and thereby creating frequent opportunities for siblings to act as both the bully and the victim within their relationship (Tippett & Wolke, 2015). The findings further indicate that structural family characteristics as well as sex were the strongest predictors of sibling bullying in middle childhood, even after accounting for a range of other individual differences, parenting characteristics, and social experiences in early childhood.

In line with previous cross-sectional and longitudinal studies, children who grow up in larger households were more likely to be involved in sibling bullying perpetration; male children were more often bullies, female children and those with older brothers were

Table 7  
Overview of Final Predictors of Sibling Bullying

Precursor set	Victim	Bully-Victim	Bully
Structural family characteristics	Older brothers	Firstborn Older brothers More children in the household	Firstborn More children in the household
Parent and parenting characteristics	*****	Conflicting partnership	Suboptimal parenting
Early social experiences	More time in joint sibling activities Peer victimization	Sibling victimization More time in joint sibling activities Peer victimization	More time in joint sibling activities
Child individual differences	Female Low self-esteem External locus of control	Female Externalizing problems Social cognition Antisocial behavior	Male Externalizing problems Social cognition Antisocial behavior

Note.  $N = 6,838$ . All precursors included in this table reflect the final fully imputed and adjusted analysis (Model 5) and illustrates only those precursors that survived the final analysis ( $p < .05$ ).

\*\*\*\*\* no significant predictor.

more often victimized (victim or bully-victim), and firstborn children were more likely to be perpetrators (bullies or bully-victims; Dantchev et al., 2018; Tippett & Wolke, 2015). Our findings support the evolutionary RCT arguing that sibling aggression is a consequence of competition over resources (Salmon & Hehman, 2014). Households with more children may limit availability and access to resources including parental affection, attention or material goods. Our results for sex composition and birth order further reflect the intrinsic power differential between siblings. RCT asserts that individuals in asymmetrical social groups are motivated toward acquiring social dominance in order to gain desired resources (Hawley, 1999). In contrast, other family structure variables such as single-mother households, lower maternal education, and social class were not found to predict sibling bullying similar to previous research (Bowes et al., 2014; Eriksen & Jensen, 2009; Tippett & Wolke, 2015; Tucker et al., 2013), suggesting that social conditions matter less or not at all. That these social conditions of the family are not related to sibling bullying may be explained by the fact that siblings within the same family may not be concerned with the overall value of a resource, as it is the same for all siblings, but it is the competition for preferential access to the resource.

Contrary to the majority of previous cross-sectional studies, parenting factors were not as strongly associated with sibling bullying (Button & Gealt, 2010; Tippett & Wolke, 2015) when controlled for other variables. Perhaps most surprising, parental maltreatment was not found to be independently associated with sibling bullying, which contrasts to other studies that suggested parent-to-child maltreatment as one of the strongest predictors of sibling aggression (Button & Gealt, 2010; Tucker et al., 2014). However, many previous studies did not account for other risk factors and thus potential confounders. Furthermore, parenting assessed concurrently may be misleading as it may reflect parenting reacting to sibling bullying and dealing with it, rather than a precursor or cause. Siblings may also pull together and support each other in situations where both of them are threatened with family breakdown (Beckett, 2018; Kempton, Armistead, Wierson, & Forehand, 1991; Milevsky, 2005). Nevertheless, after accounting for a range of confounders, we found that conflicting partnership was associated with bully-victim status, while suboptimal parenting (e.g., hitting child) was predictive of bully status. These

results are in accordance with previous research that has reported frequent parental arguments (Hoffman, Kiecolt, & Edwards, 2005; Tucker et al., 2014) and harsh parenting (Eriksen & Jensen, 2009; Toseeb et al., 2018) as predictive of sibling aggression. In line with SLT (Bandura, 1977), children that observe conflictual interpersonal interaction are at risk of adopting this model of socialization and directing it toward other social relationships (e.g., siblings). Furthermore, as suggested by attachment theory, exposure to harsh parenting may provide children with maladaptive internal working models of social relationships (Bowlby, 1969), where emotional or physical abuse become internalized as normative and useful.

In respect to early social experiences, children who were victimized by their siblings at 5 years were more likely to be bully-victims at 12 years. While this points to some continuity in sibling aggression across early to middle childhood, as suggested by previous research (Menesini et al., 2010; Updegraff et al., 2005), we did not find any crossover effects for sibling aggression perpetration, that is, sibling aggressors in early childhood were no more likely to become sibling bullies. It is possible that our measures of early sibling aggression were not detailed enough to detect or reflect the early sibling relationship dynamic appropriately. Future research should therefore focus on examining specific domains of the early sibling relationship dynamic in respect to sibling bullying at a later time point. This study did, however, find that siblings who spent more time with one another in early childhood were more likely to be involved in any sibling bullying status role. This supports the idea that extensive temporal involvement and familiarity is a potential vehicle that breeds contempt and hostility within the sibling relationship (Tucker et al., 2015). Moreover, peer victimization predicted bully-victim status, partially mirroring previous work reporting on a homotypic relationship between sibling and peer aggression (Tippett & Wolke, 2015; Tanrikulu & Campbell, 2015). Hence, peer relations, too, can serve as early socialization models for children's behavior within the sibling context (Bandura, 1977).

Finally, this study identified specific individual differences in children which may act as early indicators to sibling bullying. Children who display antisocial behavior and externalizing problems in early childhood were found to be at increased risk of becoming bully-victims and bullies, suggesting that sibling bullying perpetration may be a developmental marker for a child who is

already set on an antisocial behavior trajectory (Huesmann, Dubow, & Boxer, 2009). Furthermore, children who perpetrate sibling bullying either as a bully-victim or bully were found to have higher levels of social cognition in childhood. This resonates well with findings from the peer bullying literature, reporting peer bullies as highly socially skilled (Sutton, Smith, & Swettenham, 1999). Peer bullies are superior to their victims in regard to their social cognition, allowing them to adapt their bullying strategies effectively according to the situation (Guy, Lee, & Wolke, 2017; Sutton et al., 1999). Similarly, children who are victimized by their siblings have more likely been reported to have autism spectrum disorder (Toseeb et al., 2018) which is characterized by poorer recognition and understanding of social cues (Kothari et al., 2013). Furthermore, children who attribute their success and failures to external factors (e.g., luck), rather than internal ones (e.g., effort) were more often sibling victims, while high self-esteem was protective of victim status. This links well with the peer literature which has found that children who are victimized by their peers typically possess negative attitudes and beliefs about themselves (Cook et al., 2010) and that low self-esteem is a central characteristic of victimized children (Salmivalli, Kaukiainen, Kaistaniemi, & Lagerpetz, 1999).

### Strengths and Limitations

This study has several strengths. First, the longitudinal design allows for time-ordered conclusions to be drawn. Second, the use of a representative prospective birth cohort increases confidence in the generalizability of findings. Third, the inclusion of an extensive set of potential precursors and the well-controlled systematic analysis approach reduces the risk of confounding. Fourth, multicollinearity was checked in several ways and found to be low. Thus the estimates of the individual predictors identified may be considered safe within the confidence intervals. There are also limitations. Sibling bullying was assessed via self-report only. However, sibling aggression is often behind closed doors and thus parents may often be unaware of this problem behavior (Wolke et al., 2015). A large proportion of the early childhood predictors relied on parental reports. It cannot be excluded that this may have biased some of the findings: for example, the reporting of maltreatment or negative parenting. Future studies should aim toward a multi-informant approach. Nevertheless, it should be noted that a number of measures on child individual differences were reported by the children themselves (e.g., peer bullying or antisocial behavior) or observer based (e.g., IQ assessment). Furthermore, including a large number of predictor variables increases the possibility of overadjustment. However, using a theory-driven stepwise approach allows readers to judge and compare crude and within-block associations of predictors with sibling bullying roles. Finally, in this cohort study defined by geographical area and cohort recruitment timeframe, we only had access to detailed reports about the study child. Future family studies may incorporate information about the child who is being bullied or who is bullying the study child in order to better understand the mechanisms behind sibling bullying.

### Conclusion

Findings from this study suggest that sibling bullying is utilized as an evolutionarily driven strategy toward maintaining or achiev-

ing social dominance. Families with more children and older males are at particular risk for sibling bullying. Parents may benefit from education about how to deal with resource losses for firstborns and how to manage them in fostering improved sibling relationships. This may be important as more evidence emerges for the adverse mental health consequences for victims of sibling bullying (van Berkel et al., 2018) and interventions that may help both parents and children reduce aggression and bullying might be useful for affected families (Pickering & Sanders, 2016).

### References

- Archer, J. (2013). Can evolutionary principles explain patterns of family violence? *Psychological Bulletin*, *139*, 403–440. <http://dx.doi.org/10.1037/a0029114>
- Bandura, A. (1977). *Social learning theory*. Englewood Cliffs, NJ: Prentice Hall.
- Beckett, S. (2018). *Beyond together or apart. Planning for assessing and placing sibling groups*. London, UK: CoramBAAF.
- Bowen, E., Heron, J., Waylen, A., & Wolke, D., & the ALSPAC Study Team. (2005). Domestic violence risk during and after pregnancy: Findings from a British longitudinal study. *BJOG*, *112*, 1083–1089. <http://dx.doi.org/10.1111/j.1471-0528.2005.00653.x>
- Bowes, L., Wolke, D., Joinson, C., Lereya, S. T., & Lewis, G. (2014). Sibling bullying and risk of depression, anxiety, and self-harm: A prospective cohort study. *Pediatrics*, *134*, e1032–e1039. <http://dx.doi.org/10.1542/peds.2014-0832>
- Bowlby, J. (1969). *Attachment and loss* (Vol. 1). New York, NY: Basic Books.
- Boyd, A., Golding, J., Macleod, J., Lawlor, D. A., Fraser, A., Henderson, J., . . . Davey Smith, G. (2013). Cohort profile: The ‘children of the 90s’—the index offspring of the Avon Longitudinal Study of Parents and Children. *International Journal of Epidemiology*, *42*, 111–127. <http://dx.doi.org/10.1093/ije/dys064>
- Buist, K. L., Deković, M., & Prinzie, P. (2013). Sibling relationship quality and psychopathology of children and adolescents: A meta-analysis. *Clinical Psychology Review*, *33*, 97–106. <http://dx.doi.org/10.1016/j.cpr.2012.10.007>
- Button, D. M., & Gealt, R. (2010). High risk behaviors among victims of sibling violence. *Journal of Family Violence*, *25*, 131–140. <http://dx.doi.org/10.1007/s10896-009-9276-x>
- Carey, W. B. (1970). A simplified method for measuring infant temperament. *The Journal of Pediatrics*, *77*, 188–194. [http://dx.doi.org/10.1016/S0022-3476\(70\)80322-5](http://dx.doi.org/10.1016/S0022-3476(70)80322-5)
- Cook, C. R., Williams, K. R., Guerra, N. G., Kim, T. E., & Sadek, S. (2010). Predictors of bullying and victimization in childhood and adolescence: A meta-analytic investigation. *School Psychology Quarterly*, *25*, 65–83. <http://dx.doi.org/10.1037/a0020149>
- Copeland, W. E., Wolke, D., Angold, A., & Costello, E. J. (2013). Adult psychiatric outcomes of bullying and being bullied by peers in childhood and adolescence. *JAMA Psychiatry*, *70*, 419–426. <http://dx.doi.org/10.1001/jamapsychiatry.2013.504>
- Cox, J. L., Holden, J. M., & Sagovsky, R. (1987). Detection of postnatal depression. Development of the 10-item Edinburgh Postnatal Depression Scale. *The British Journal of Psychiatry*, *150*, 782–786. <http://dx.doi.org/10.1192/bjp.150.6.782>
- Crown, S., & Crisp, A. H. (1979). *Manual of the Crown-Crisp experiential index*. London: Hodder and Stoughton.
- Dantchev, S., Zammit, S., & Wolke, D. (2018). Sibling bullying in middle childhood and psychotic disorder at 18 years: A prospective cohort study. *Psychological Medicine*, *48*, 2321–2328. <http://dx.doi.org/10.1017/S0033291717003841>

- Eriksen, S., & Jensen, V. (2009). A push or a punch: Distinguishing the severity of sibling violence. *Journal of Interpersonal Violence, 24*, 183–208. <http://dx.doi.org/10.1177/0886260508316298>
- Faul, F., Erdfelder, E., Buchner, A., & Lang, A.-G. (2009). Statistical power analyses using G\*Power 3.1: Tests for correlation and regression analyses. *Behavior Research Methods, 41*, 1149–1160. <http://dx.doi.org/10.3758/BRM.41.4.1149>
- Felson, R. B. (1983). Aggression and violence between siblings. *Social Psychology Quarterly, 46*, 271–285. <http://dx.doi.org/10.2307/3033715>
- Finkelhor, D., Turner, H. A., Shattuck, A., & Hamby, S. L. (2015). Prevalence of childhood exposure to violence, crime, and abuse: Results from the National Survey of Children's Exposure to Violence. *Journal of the American Medical Association Pediatrics, 169*, 746–754. <http://dx.doi.org/10.1001/jamapediatrics.2015.0676>
- Fraser, A., Macdonald-Wallis, C., Tilling, K., Boyd, A., Golding, J., Davey Smith, G., . . . Lawlor, D. A. (2013). The Avon Longitudinal Study of Parents and Children: ALSPAC mothers cohort. *International Journal of Epidemiology, 42*, 97–110. <http://dx.doi.org/10.1093/ije/dys066>
- Goodman, R. (2001). Psychometric properties of the strengths and difficulties questionnaire. *Journal of the American Academy of Child & Adolescent Psychiatry, 40*, 1337–1345. <http://dx.doi.org/10.1097/00004583-200111000-00015>
- Goodman, R., Ford, T., Richards, H., Gatward, R., & Meltzer, H. (2000). The Development and Well-Being Assessment: Description and initial validation of an integrated assessment of child and adolescent psychopathology. *Journal of Child Psychology and Psychiatry, 41*, 645–655. <http://dx.doi.org/10.1111/j.1469-7610.2000.tb02345.x>
- Guy, A., Lee, K., & Wolke, D. (2017). Differences in the early stages of social information processing for adolescents involved in bullying. *Aggressive Behavior, 43*, 578–587. <http://dx.doi.org/10.1002/ab.21716>
- Harter, S. (1985). *Self-perception profile for children*. Denver, CO: University of Denver.
- Hawley, P. E. (1999). The ontogenesis of social dominance: A strategy-based evolutionary perspective. *Developmental Review, 19*, 97–132. <http://dx.doi.org/10.1006/drev.1998.0470>
- Heron, J., O'Connor, T. G., Evans, J., Golding, J., & Glover, V., & the ALSPAC Study Team. (2004). The course of anxiety and depression through pregnancy and the postpartum in a community sample. *Journal of Affective Disorders, 80*, 65–73. <http://dx.doi.org/10.1016/j.jad.2003.08.004>
- Hoffman, K. L., Kiecolt, K. J., & Edwards, J. N. (2005). Physical violence between siblings: A theoretical and empirical analysis. *Journal of Family Issues, 26*, 1103–1130. <http://dx.doi.org/10.1177/0192513X05277809>
- Huesmann, L. R., Dubow, E. F., & Boxer, P. (2009). Continuity of aggression from childhood to early adulthood as a predictor of life outcomes: Implications for the adolescent-limited and life-course-persistent models. *Aggressive Behavior, 35*, 136–149. <http://dx.doi.org/10.1002/ab.20300>
- Kempton, T., Armistead, L., Wierson, M., & Forehand, R. (1991). Presence of sibling as a potential buffer following parental divorce: An examination of young adolescents. *Journal of Clinical Child Psychology, 20*, 434–438. [http://dx.doi.org/10.1207/s15374424jccp2004\\_12](http://dx.doi.org/10.1207/s15374424jccp2004_12)
- Khan, R., & Rogers, P. (2015). The normalization of sibling violence: Does gender and personal experience of violence influence perceptions of physical assault against siblings? *Journal of Interpersonal Violence, 30*, 437–458. <http://dx.doi.org/10.1177/0886260514535095>
- Kothari, R., Skuse, D., Wakefield, J., & Micali, N. (2013). Gender differences in the relationship between social communication and emotion recognition. *Journal of the American Academy of Child & Adolescent Psychiatry, 52*, 1148–1157.e2. <http://dx.doi.org/10.1016/j.jaac.2013.08.006>
- Lereya, S. T., Copeland, W. E., Zammit, S., & Wolke, D. (2015). Bully/victims: A longitudinal, population-based cohort study of their mental health. *European Child & Adolescent Psychiatry, 24*, 1461–1471. <http://dx.doi.org/10.1007/s00787-015-0705-5>
- Little, R. J. A., & Rubin, D. B. (2002). *Statistical analysis with missing data* (2nd ed.). New York, NY: Wiley. <http://dx.doi.org/10.1002/9781119013563>
- Loeber, R., Stouthamer-Loeber, M., Van Kammen, W. B., & Farrington, D. P. (1989). Development of a new measure of self-reported antisocial behavior for young children: Prevalence and reliability. In M. W. Klein (Ed.), *Cross-national research in self-reported crime and delinquency* (pp. 203–225). Dordrecht, the Netherlands: Kluwer Academic. [http://dx.doi.org/10.1007/978-94-009-1001-0\\_10](http://dx.doi.org/10.1007/978-94-009-1001-0_10)
- Menesini, E., Camodeca, M., & Nocentini, A. (2010). Bullying among siblings: The role of personality and relational variables. *British Journal of Developmental Psychology, 28*, 921–939. <http://dx.doi.org/10.1348/026151009X479402>
- Milevsky, A. (2005). Compensatory patterns of sibling support in emerging adulthood: Variations in loneliness, self-esteem, depression and life satisfaction. *Journal of Social and Personal Relationships, 22*, 743–755. <http://dx.doi.org/10.1177/0265407505056447>
- Morandini, V., & Ferrer, M. (2015). Sibling aggression and brood reduction: A review. *Ethology Ecology and Evolution, 27*, 2–16. <http://dx.doi.org/10.1080/03949370.2014.880161>
- Nowicki, S., Jr., & Duke, M. (1994). Individual differences in the nonverbal communication of affect: The Diagnostic Analysis of Nonverbal Accuracy Scale. *Journal of Nonverbal Behavior, 18*, 9–35. <http://dx.doi.org/10.1007/BF02169077>
- Nowicki, S., & Strickland, B. R. (1973). A locus of control scale for children. *Journal of Consulting and Clinical Psychology, 40*, 148–154. <http://dx.doi.org/10.1037/h0033978>
- O'Brien, R. (2007). A caution regarding rules of thumb for variance inflation factor. *Quality & Quantity, 41*, 673–690. <http://dx.doi.org/10.1007/s11135-006-9018-6>
- Olweus, D. (2007). *The Olweus Bullying Questionnaire*. Center City, MN: Hazelden.
- Patterson, G. R. (1986). The contribution of siblings to training for fighting: A microsocial analysis. In D. Olweus, J. Block, & M. Radke-Yarrow (Eds.), *Development of antisocial and prosocial behavior: Research theories and issues* (pp. 235–261). New York, NY: Academic Press.
- Patterson, G. R., Dishion, T. J., & Bank, L. (1984). Family interaction: A process model of deviancy training. *Aggressive Behavior, 10*, 253–267. [http://dx.doi.org/10.1002/1098-2337\(1984\)10:3<253::AID-AB2480100309>3.0.CO;2-2](http://dx.doi.org/10.1002/1098-2337(1984)10:3<253::AID-AB2480100309>3.0.CO;2-2)
- Phillips, D. A., Bowie, B. H., Wan, D. C., & Yukevich, K. W. (2018). Sibling violence and children hospitalized for serious mental and behavioral health problems. *Journal of Interpersonal Violence, 33*, 2558–2578.
- Pickering, J. A., & Sanders, M. R. (2016). The protocol for a randomized controlled trial (RCT) of a brief intervention for parents of children experiencing sibling conflict. *Clinical Psychologist, 20*, 86–93. <http://dx.doi.org/10.1111/cp.12051>
- Russell, A. E., Ford, T., & Russell, G. (2018). The relationship between financial difficulty and childhood symptoms of attention deficit/hyperactivity disorder: A U. K. longitudinal cohort study. *Social Psychiatry and Psychiatric Epidemiology: The International Journal for Research in Social and Genetic Epidemiology and Mental Health Services, 53*, 33–44. <http://dx.doi.org/10.1007/s00127-017-1453-2>
- Salmivalli, C., Kaukiainen, A., Kaistaniemi, L., & Lagerspetz, K. M. J. (1999). Self-evaluated self-esteem, peer-evaluated self-esteem, and defensive egotism as predictors of adolescent's participation in bullying situations. *Personality and Social Psychology Bulletin, 25*, 1268–1278. <http://dx.doi.org/10.1177/0146167299258008>
- Salmon, C. A., & Hehman, J. A. (2014). The evolutionary psychology of

- sibling conflict and siblicide. In T. K. Shackelford & R. D. Hansen (Eds.), *The evolution of violence* (pp. 137–157). New York, NY: Springer. [http://dx.doi.org/10.1007/978-1-4614-9314-3\\_8](http://dx.doi.org/10.1007/978-1-4614-9314-3_8)
- Schreier, A., Wolke, D., Thomas, K., Horwood, J., Hollis, C., Gunnell, D., . . . Harrison, G. (2009). Prospective study of peer victimization in childhood and psychotic symptoms in a nonclinical population at age 12 years. *Archives of General Psychiatry*, *66*, 527–536. <http://dx.doi.org/10.1001/archgenpsychiatry.2009.23>
- Skuse, D. H., James, R. S., Bishop, D. V. M., Coppin, B., Dalton, P., Aamodt-Leeper, G., . . . Jacobs, P. A. (1997). Evidence from Turner's syndrome of an imprinted X-linked locus affecting cognitive function. *Nature*, *387*, 705–708. <http://dx.doi.org/10.1038/42706>
- Smith, M. (2004). Parental mental health: Disruptions to parenting and outcomes for children. *Child & Family Social Work*, *9*, 3–11. <http://dx.doi.org/10.1111/j.1365-2206.2004.00312.x>
- Song, J. H., Volling, B. L., Lane, J. D., & Wellman, H. M. (2016). Aggression, sibling antagonism, and theory of mind during the first year of siblinghood: A developmental cascade model. *Child Development*, *87*, 1250–1263. <http://dx.doi.org/10.1111/cdev.12530>
- StataCorp. (2015). *Stata Statistical Software: Release 14* [Computer software]. College Station, TX: Author.
- Sutton, J., Smith, P. K., & Swettenham, J. (1999). Social cognition and bullying: Social inadequacy or skilled manipulation? *British Journal of Developmental Psychology*, *17*, 435–450. <http://dx.doi.org/10.1348/026151099165384>
- Tanrikulu, I., & Campbell, M. A. (2015). Sibling bullying perpetration: Associations with gender, grade, peer perpetration, trait anger, and moral disengagement. *Journal of Interpersonal Violence*, *30*, 1010–1024. <http://dx.doi.org/10.1177/0886260514539763>
- Tanskanen, A. O., Danielsbacka, M., Jokela, M., & Rotkirch, A. (2017). Sibling conflicts in full- and half-sibling households in the UK. *Journal of Biosocial Science*, *49*, 31–47. <http://dx.doi.org/10.1017/S0021932016000043>
- Thomson, R. M., Allely, C. S., Purves, D., Puckering, C., McConnachie, A., Johnson, P. C., . . . Wilson, P. (2014). Predictors of positive and negative parenting behaviours: Evidence from the ALSPAC cohort. *BMC Pediatrics*, *14*, 247. <http://dx.doi.org/10.1186/1471-2431-14-247>
- Tippett, N., & Wolke, D. (2015). Aggression between siblings: Associations with the home environment and peer bullying. *Aggressive Behavior*, *41*, 14–24. <http://dx.doi.org/10.1002/ab.21557>
- Toseeb, U., McChesney, G., & Wolke, D. (2018). The prevalence and psychopathological correlates of sibling bullying in children with and without autism spectrum disorder. *Journal of Autism and Developmental Disorders*, *48*, 2308–2318. <http://dx.doi.org/10.1007/s10803-018-3484-2>
- Tucker, C. J., Finkelhor, D., Shattuck, A. M., & Turner, H. (2013). Prevalence and correlates of sibling victimization types. *Child Abuse & Neglect*, *37*, 213–223. <http://dx.doi.org/10.1016/j.chiabu.2013.01.006>
- Tucker, C. J., Finkelhor, D., Turner, H., & Shattuck, A. M. (2014). Family dynamics and young children's sibling victimization. *Journal of Family Psychology*, *28*, 625–633. <http://dx.doi.org/10.1037/fam0000016>
- Tucker, C. J., Van Gundy, K. T., Wiesen-Martin, D., Hiley Sharp, E., Rebellon, C. J., & Stracuzzi, N. F. (2015). Proactive and reactive sibling aggression and adjustment in adolescence. *Journal of Interpersonal Violence*, *30*, 965–987. <http://dx.doi.org/10.1177/0886260514539760>
- Updegraff, K. A., Thayer, S. M., Whiteman, S. D., Denning, D. J., & McHale, S. M. (2005). Relational aggression in adolescents' sibling relationships: Links to sibling and parent–adolescent relationship quality. *Family Relations: An Interdisciplinary Journal of Applied Family Studies*, *54*, 373–385. <http://dx.doi.org/10.1111/j.1741-3729.2005.00324.x>
- van Berckel, S. R., Tucker, C. J., & Finkelhor, D. (2018). The combination of sibling victimization and parental child maltreatment on mental health problems and delinquency. *Child Maltreatment*, *23*, 244–253. <http://dx.doi.org/10.1177/1077559517751670>
- Wechsler, D., Golombok, S., & Rust, J. (1992). *WISC-III U. K. Wechsler Intelligence Scale for Children*. Sidcup, UK: The Psychological Corporation.
- Winsper, C., Lereya, T., Zanarini, M., & Wolke, D. (2012). Involvement in bullying and suicide-related behavior at 11 years: A prospective birth cohort study. *Journal of the American Academy of Child and Adolescent Psychiatry*, *51*, 271–282.e273. <http://dx.doi.org/10.1016/j.jaac.2012.01.001>
- Winsper, C., & Wolke, D. (2014). Infant and toddler crying, sleeping and feeding problems and trajectories of dysregulated behavior across childhood. *Journal of Abnormal Child Psychology*, *42*, 831–843. <http://dx.doi.org/10.1007/s10802-013-9813-1>
- Wolke, D., Baumann, N., Strauss, V., Johnson, S., & Marlow, N. (2015). Bullying of preterm children and emotional problems at school age: Cross-culturally invariant effects. *The Journal of Pediatrics*, *166*, 1417–1422. <http://dx.doi.org/10.1016/j.jpeds.2015.02.055>
- Wolke, D., Copeland, W. E., Angold, A., & Costello, J. (2013). Impact of bullying in childhood on adult health, wealth, crime and social outcomes. *Psychological Science*, *24*, 1958–1970. <http://dx.doi.org/10.1177/0956797613481608>
- Wolke, D., Lereya, S. T., Fisher, H. L., Lewis, G., & Zammit, S. (2014). Bullying in elementary school and psychotic experiences at 18 years: A longitudinal, population-based cohort study. *Psychological Medicine*, *44*, 2199–2211. <http://dx.doi.org/10.1017/S0033291713002912>
- Wolke, D., & Skew, A. J. (2012). Bullying among siblings. *International Journal of Adolescent Medicine and Health*, *24*, 17–25.
- Wolke, D., Tippett, N., & Dantchev, S. (2015). Bullying in the family: Sibling bullying. *The Lancet Psychiatry*, *2*, 917–929. [http://dx.doi.org/10.1016/S2215-0366\(15\)00262-X](http://dx.doi.org/10.1016/S2215-0366(15)00262-X)
- Wolke, D., Woods, S., Stanford, K., & Schulz, H. (2001). Bullying and victimization of primary school children in England and Germany: Prevalence and school factors. *British Journal of Psychology*, *92*, 673–696.
- Yucel, D., & Yuan, A. V. (2015). Do siblings matter? The effect of siblings on socio-emotional development and educational aspirations among early adolescents. *Child Indicators Research*, *8*, 671–697. <http://dx.doi.org/10.1007/s12187-014-9268-0>

Received July 12, 2018

Revision received December 4, 2018

Accepted December 18, 2018 ■