

Oh half-brother, where art thou? – Defining the boundaries for full- and half-sibling interaction across the life course

ABSTRACT

The number of children who will ever have a half sibling is increasing. Both full and half siblingships has the potential to develop into enduring and important social relationships, providing that they overlap in time and space during childhood. It is not known, however, what proportion - out of the population that will ever have a half siblings - that potentially could engage in long-term social interaction with a half- sibling during childhood. This study estimates the boundaries of accumulated exposure to full and half siblings across childhood. I use Swedish register data to provide a broad overview of the upper and lower bounds of the probability of full- and half-sibling exposure from age zero to 18, estimated by age overlap and registered co-residence for all full and half siblings of a complete birth cohort. I find that a among all children who will ever have a half-sibling, a substantive share is most likely prevented from persistent social interaction with their half-sibling(s). This is due to lengthy cross-partner birth spacing and plausibly also due to gendered custodianship patterns. I show that these patterns do not differ substantially across socioeconomic groups. I demonstrate that individuals who are exposed to half siblings for a long time have very particular sibling-set configurations. This study is the first to quantify the role of birth spacing and residency patterns for the exposure to full and half siblings across childhood. It highlights the benefits of including a population perspective for understanding half sibling social relationships.

KEYWORDS: Half sibling, Family complexity, Multi partner fertility, Siblingship, Childhood

1. Introduction

Siblingship is among the strongest and most enduring types of social relationship (Rossi & Rossi 1990). Siblings act as socializing agents in childhood and provide support to each other in adulthood (White and Riedmann 1992). With increasing rates of parental separation and childbearing with new partners, the proportion of a given individual's siblings who are the progeny of both parents decreases, and the proportion linked via only one parent increases. This has spurred research to examine the extent to which half siblings are likely to form siblingship relationships similar to those of full siblings.

The main approach to answering this question has been to compare the closeness and support of full and half siblings, with findings showing that half siblings report lower emotional closeness and contact and living at greater geographic distances in adulthood compared to full siblings (Steinbach and Hank 2018; Tanskanen et al. 2017; Tanskanen and Rotkirch 2018; Danielsbacka, Tanskanen, and Rotkirch 2015; Danielsbacka and Tanskanen 2015; Tanskanen and Danielsbacka 2014; Ahrons 2007; Ganong and Coleman 1988; Anderson 1999; Kersting and Feldhaus 2016).

However, the prerequisite for affinity is some form of repeated social interaction, and the potential for this type of exposure differs between full and half siblings. Thus, as highlighted by recent research (Cancian, Meyer, and Cook 2011, see Wiemers et al. 2019 regarding step-relations), variations in demographic factors, such as between-partner birth spacing and co-residence patterns, are decisive proximate causes of the nature of half-sibling social relations.

This study provides a population perspective on the question of the future of siblingship relationships. What proportion of all individuals with a half sibling have the potential to engage

in full-sibling-like social relationships with their half siblings? We use register data to map variability in birth overlap and residential overlap onto all full- and half-sibling relations as these develop across the entire period of childhood for a complete recent Swedish birth cohort.

This paper makes two contributions. Firstly, it provides a demographic approach that substantiates the theoretical models used to explain qualitative differences between full and half siblingship. Prevailing explanations rest on a combination of (a) evolutionarily derived altruism towards close kin (Pollet 2007) and (b) cultural scripts governing behavior between step- and half-kin (Poortman and Voorpostel 2009; Cherlin 1978). Hard-wired psychology is assumed to be universal in humans and the cultural/cognitive perceptions and ideology of kinship are strikingly similar across large sociocultural entities (see review by Ganong and Coleman 2012, p. 22). For this reason, these theories will not be directly applicable (i.e. without added supportive hypothesis) to explain differences in half-siblingship closeness between populations (Thompson, Carlson and Svallfors 2019). Our measures of the proximate determinants of exposure, on the other hand, might ostensibly vary greatly between contexts, regions or sub-groups. Given this, a focus on life tables which map overlaps in relation to age/residence have potential as an explanatory framework.

Second, this study presents the first comprehensive analysis of the development of half-sibling relations in a representative population, a difficult task due to the paucity of available data (L. White 1998; Manning, Brown, and Stykes 2014; Brown and Manning 2009; Ganong and Coleman 2012, p. 8.; Wolfe et al. 1996). Indeed, the plastic nature of complex families and a reliance on modules constructed to focus on household members make it difficult to capture the full set of half siblings over the course of an extensive observation period. Half-sibling incidence inferred from individual-level adult data (multi-partner fertility) suffers from the same problem (Monte 2018) and, in addition, often only uses data on one parent. Methodological advances such as the childhood residential calendar of NLSY (Bloome 2017) and multi-actor prospective panel designs such PAIRFAM (Huinink et al. 2011) and OKiN (Kalmijn et al. 2018) will probably overcome many of these problems (Tanskanen and Danielsbacka 2019). Nonetheless, response rates, half-sibling/MPF under-reporting and attrition will remain an issue for generalizability. Sample sizes will limit the degree to which sub-group heterogeneity can be analyzed (Juby and Le Bourdais 1999; Müller and Castiglioni 2015; Aughinbaugh 2004). We consider the use of register sources to be a useful complement to these survey approaches. The data scope and coverage make it possible to reliably identify boundary limits for exposure to half and full siblingship throughout childhood. Moreover, in contrast to previous research (e.g. Cancian, Meyer, and Cook 2011), we are able to calculate the accumulated number of years of shared childhood among specific sibling pairs rather than years with any half sibling.

We find that, in a country with a high incidence of half siblingship, the probability of extended exposure to half siblings across the life course is limited. 27% of all individuals with a sibling had a half sibling by age 18. 14% had up to eight years of overlapping childhood. About 18 % of children had a half sibling registered in the dwelling of one or other of their biological parents for up to two years, and 12% for up to eight years. 14% of anchor children co-resided with a half sibling (were registered at the same dwelling) for two years and about eight % did so for up to eight years. Children with a high probability of half-sibling exposure more often had no full siblings, had both paternal and maternal half siblings. Further half siblings continued to be added throughout childhood, in contrast to the addition of full siblings, which levels off markedly after age 7. The development of half siblingship does not differ substantively by parental socioeconomic background. Instead, the proximate determinants of sibling exposure –

birth spacing and co-residency – appear to be intrinsic to the family-dynamics processes of separation, re-partnering and fertility. We conclude that half-siblingship incidence can be complemented using the incidence of cumulative exposure. Analyses and projections of the future of siblingship can contrast this exposure with the theoretically sufficient levels required to produce sibling-like relationships.

2. Theory & Previous Research

2.1. Sociocultural, Evolutionary and Population Perspectives on Full and Half Siblingship

Evolutionary psychology maintains that individuals are more likely to develop close relations with genetically close others (Hamilton 1964). A human capacity for altruistic and reciprocal behavior was adaptive only as long as it was directed at close kin, who could pass on the genotype to the next generation (Kaplan, Gurven, and Hooper 2009). Patterns supportive of inclusive fitness theory have been found in human and non-human populations. Primates rarely extend altruistic behavior beyond kin, and highly cooperative communities such as beehives consist solely of biological full siblings (Chapais 2009). Indeed, closeness and resource investments are often found to be lower among non-biological family compared to biological family (e.g. Van Houdt, Kalmijn, and Ivanova 2018). Accordingly, half-sibling relationships should be characterized by less affection compared to full-sibling relationships, since the former dyad shares a quarter of its genetic material and the latter around half (Tanskanen and Rotkirch 2018).

Another branch of the literature emphasizes the importance of cues from macro-level institutions. Drawing on Cherlin (1978), step-relations and other forms of complex relations are considered incomplete institutions. Lacking guidance from normative beliefs and expectations, individuals remain ambivalent about their relationships. Empirical studies have found a lack of consensus between stepfamily members with regard to roles and responsibilities (Ganong and Coleman 1988). Step and half siblings are often depicted in terms of negative or stigmatizing stereotypes (Hadfield and Nixon 2013). Moreover, institutions such as schools, healthcare, inheritance law and custodianship law are aligned to cater for marital and nuclear families, which both creates problems for complex relations and perpetuates their status as secondary (Mason, M. A., Fine, & Carnochan, 2004). Above and beyond the incomplete institutions argument, family systems theory emphasizes the functioning of the family environment itself as a determining relationship over the long term (Poortman and Voorpostel 2009). Taken together, these contextual effects would be expected to hamper the development of reciprocity and trust among half siblings, resulting in less intimate relationships.

Interaction is fundamental to both biological and sociocultural explanations of siblingship affinity. Within a family systems framework, having the opportunity to interact is a necessary condition. Whether due to extensive spacing or lack of day-to-day contacts as a result of living apart, half siblings may be less able to influence each other in the type of dynamics thought to produce strong siblingship relations (Goetting 1986). Informal institutions influence how full and half siblings relate to each other, but exposure will dictate the possibilities for either type of relationship. Exposure is essential to kin selection theory. The identification of genetic closeness occurs either through repeated interaction in general or by identifying alters who interact frequently with known biological kin, i.e. persons whom one's mother/father treats as close kin (Lieberman, Tooby, and Cosmides 2007). Thus, the distribution of exposure and its potential variation across groups is of consequence for the degree to which the increasing

population of half-sibling dyads will generate siblingship-like relationships.

2.2. Determinants of Sibling Exposure

Gendered custodial residency patterns are perhaps the most salient factor determining exposure among siblings. Since mothers care for children more often than fathers after (and before) separation, children more often live with their maternal half siblings. Even with the diffusion of alternating-residence custodial arrangements, maternal half siblings continue to be characterized by a higher probability of interacting with one another (van der Heijden, Poortman, and van der Lippe 2016). For higher order births with the same partner, parity progression is often rapid due to financial motivations and ideals favoring closely spaced siblings (Henz and Thomson 2005). Between-partner birth spacing, however, most often includes the process of union separation and/or re-partnering. This dynamic favors greater variation in age between half siblings (Kreyenfeld et al. 2017). As a result, the childhood years of many half siblings do not overlap in time. Between births with first and higher order reproductive partners, some parents may migrate to new regions, which will reduce the social connection between half siblings, although parents often tend to move rather short distances (Dommermuth 2017). In contrast to full siblings, half siblings are often separated following union dissolution. These dynamics are often taken for granted, yet they are likewise overlooked: socialization into siblingship requires exposure, and exposure is most parsimoniously explained by context-specific, particular family dynamics.

2.3 Measures of Siblingship Exposure

Half siblingship is the product of higher order partner reproduction and is thus preceded by separation or single parenthood or the death of a partner. As rates of divorce and single parenthood differ greatly between countries, the occurrence of half siblingship is very varied (Kreyenfeld et al. 2017). In the US, every second child born to urban mothers out of wedlock, every fifth child experiencing parental divorce, and every third child born to mothers on welfare, will have a half sibling at some point (Carlson and Furstenberg 2006; Cancian and Meyer 2006). Nationally representative data suggest that 13 percent of all children reside with a half sibling (Manning, Brown, and Stykes 2014; Kennedy and Fitch 2012) with higher estimates found in other sources (e.g. Tillman 2008). In Sweden, Thomson (2014) has reported that every third child has at least one half sibling by age 15. About 13 percent of all children, and 60 % of children with separated parents in Sweden, reside with a half or step sibling at some point (SCB 2016). Maternal half siblingship has been estimated at about 12 % in Australia, 23 % in the US and 16 % in Norway (Thomson et al. 2014), 12 % percent in West Germany, 23 % in East Germany and 14 % in Finland (Kreyenfeld and Jalovaara 2018). Between 17 and 23 % have a paternal or maternal half sibling in the US (Guzzo and Furstenberg 2007; Dorius 2011; Monte 2018). Register data support similar incidence rates for paternal half siblings in Norway (Lappegård and Rønsen 2013; Lappegård and Thomson 2018). Half siblingship through widowhood and remarriage is not uncommon in historical populations (Laslett 1980). Current estimates describe an ongoing trend of increasing multiple-partner fertility (MPF) throughout the twentieth century. In Sweden, Kolk and Turunen (2019) estimate a fifteen percentage point increase in complete cohort multiple-partner fertility from 1919 to 2017, while Manlove et al. (2008) report higher incidence levels in recent cohorts in the US.

Andersson and colleagues have shown that, across countries, measures of cumulative experiences of divorce and stepfamily formation reveal higher levels of family complexity than cross-sectional measures (Andersson 2001). We know of two studies that have quantified the development of half siblingship across the life course. Using a select sample of unmarried mothers who were in receipt of welfare, Cancian and colleges (2011) showed an accumulation of half siblingship to 60 % from birth to age 10. Moreover, they found that MPF in one parent was

positively correlated with MPF in the other. In a sample of adults, Tanskanen and Danielsbacka (2019) found that 40 % of respondents with half siblings reported never having resided with these.

3. Methods

3.1. Data and Sample

We use Swedish administrative registers to link all biological relationships from the (anchor) 1994 birth cohort (N=110,535). This cohort was chosen because it is the most recent that we can follow until adulthood. Deceased anchor children are excluded from the sample. Older and younger full and half siblings are followed to age 18. Overlap among siblings sets the boundaries for potential exposure and is referred to as overlap or exposure for reasons of parsimony. We include the full cohort as anchor children and thus do not differentiate between full- and half-sibling order (i.e. sibling order within the parent-couple or offspring order in relation to either parent). Supplementary figure 1 shows sibling set size of the cohort.

3.2 Analytical Approach

We identify anchor-child overlap to living full and half siblings at each year from birth to age 18. We calculate the cumulative years of exposure to a particular sibling at each age. The anchor child and sibling childhood relationships only accumulate if the sibling is 18 or younger. Thus, the measure captures exposure time for dyadic full/half-sibling childhood relationships. We consider this an improvement on previous approaches, which show the presence of any half sibling at a given point (e.g. Cancian et al. 2011, Figure 1). Such approaches are problematic because they equate the presence of any older and younger maternal and paternal half-sibling with the continuing presence of specific individual children. Confounding the exposure time of all siblings hides the duration of individual half-sibling relationships, which we would argue is a more accurate proxy of the foundations for social relationships.

We first estimate exposure as the accumulated yearly overlap between siblings below age 19. We calculate, at every age, the proportion of the population who has been exposed to at least one sibling for k number of years. Second, we follow the same routine but construct an exposure measure based on different conditions of residential exposure. We use registered residency for probabilistic exclusion criteria, presented in Table 1. A_k is the same as the previous measure and is not conditional on residency. B_k is conditional on at least one member of the sibling dyad living with a shared biological parent. C_k is conditional on both siblings being registered as living with the same parent. While this does not account for the possibility of alternating, shared residency, it is nonetheless valid to argue that half siblings registered as living with the biological parents whom they do not share are on average less likely to be exposed to each other than populations of half siblings who are registered as living at the same or at a shared biological parent's residence.

Table 1. Siblingship exposure measures

<i>Measure</i>	<i>Conditional on half sibling</i>
A_k	Living & aged < 19
B_k	A + One residential tie
C_k	A + Shared residency

k = years of exposure

We present the parental and sibling characteristics of anchor children who are in a high-end sibling exposure group (C_8 and more) contrasted against all other. Spacing refers to the birth

interval between ego and the closest half sibling. Half-sibling antecedence denotes half siblingship on the maternal or paternal side, or on both sides. We also show the number of maternal/paternal childbearing partners, the number of full and maternal/paternal half siblings, whether at least one of the parents' second childbearing unions dissolves (or if the partners never cohabit), the anchor child's sibling position (younger, older or both), and full- and half-sibling composition.

We examine population sub-group differences in childhood exposure to half siblings, focusing on three measures of parental socioeconomic origin. We use a dummy which takes the value zero if at least one of the anchor child's parents has a post-secondary education and one otherwise. We construct age-specific disposable income ranking, taking the average between ages 37-42, or the latest available date. We use paternal rather than maternal income because the data is of higher quality for men and because unobserved fluctuations in hours worked and lapses from the labor market make net income measures less straightforward to interpret for women. Finally, we construct a measure of parental vulnerability, as indicated by a dummy taking the value one if one or both parents have repeatedly been in receipt of social benefits.

4. Results

4.1 Full- and Half-siblingship Exposure Across the Life Course

Figure 1 contrasts the overlap in years between full and half siblingship. Figure 1a includes children born in 1994 with at least one full sibling. Figure 1b includes children born in 1994 with at least one half sibling. The colored lines mark the fraction of the respective populations, at ages 1 to 18, who overlap with a specific living non-adult half sibling for k years. For example, in Figure 1a, the steep incline shows that at age 12, almost 90% of anchor children had potentially been exposed to their respective closest full sibling for ten years (bright yellow line). In Figure 1b, the increase is gentler, but does not level off, and by age 12 up to 33% of anchor children may have been exposed to their closest born half sibling for 10 years. In Figure 1a, a majority (75%) of those with a full sibling will have at least 15 years (orange line) of potential exposure to a full sibling by age 18. In contrast, the corresponding potential half-sibling exposure (Figure 1b) is 7%.

Under the assumption that full and half siblings both have the same potential to produce sibling-like relationships as a function of interaction, how many such relationships might we expect to see simply on the basis of considering overlap in age? Figure 1c shows the fractions of the population with any (full and/or half) siblings. Full siblings appear in the top lines and half siblings in the bottom bundle. A sizable number, 27%, can count a half sibling in their respective kin-tree at age 18 (blue line in bottom bundle). However, this proportion declines rapidly when the cumulated number of years of potential exposure is considered. For example, if we set the threshold at 10 years (bright yellow line), then the upper-bound estimate is about 14%. Or, put differently, as many as 14% of the 1994 birth cohort may have developed a close relationship with half siblings.

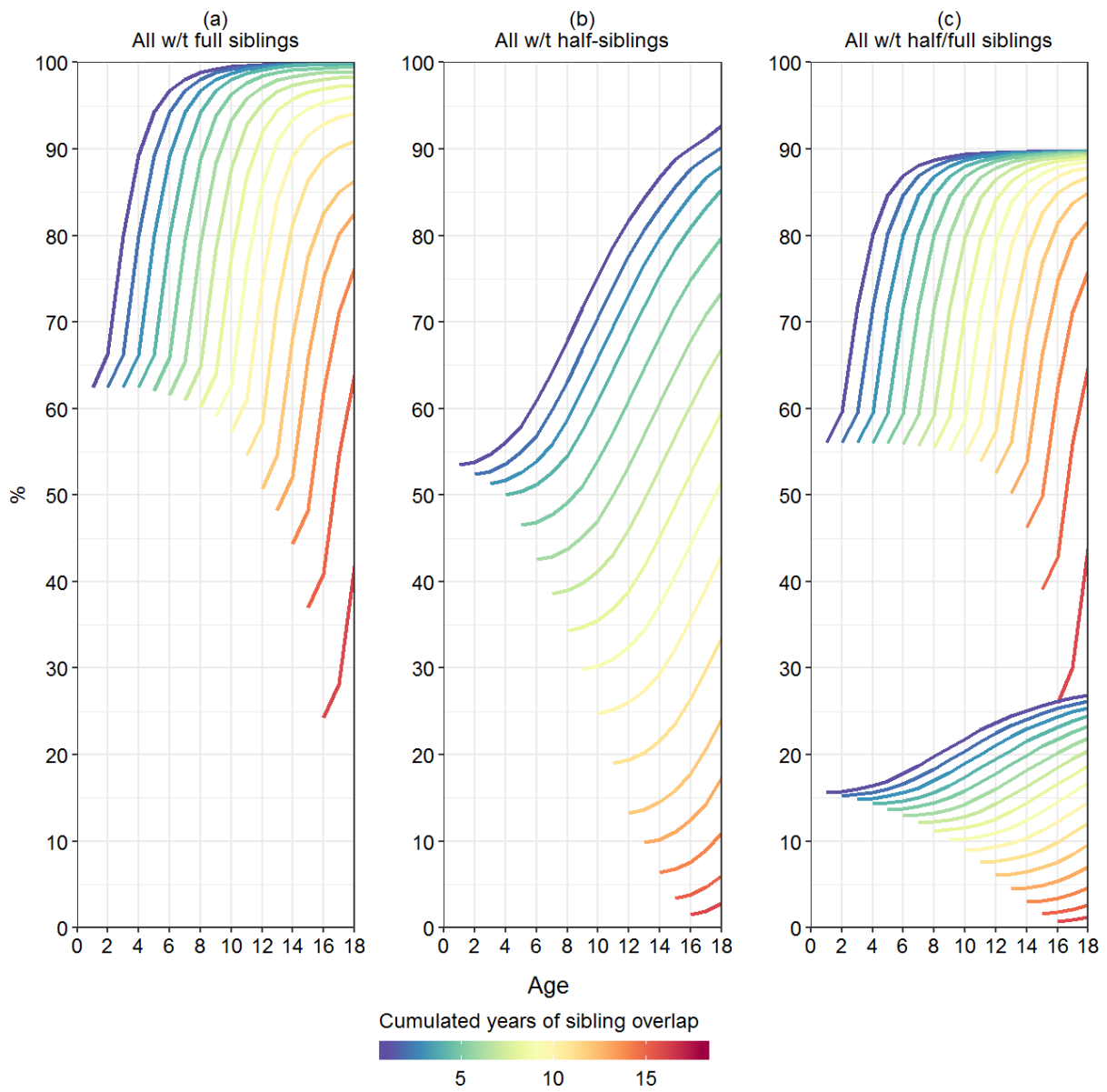
Figure 2 shows potential exposure conditioned on the registered residency of the siblings. For reference, blue lines are identical to those in Figure 1, i.e. they show the influence of age overlap without considering the residency situation. Green lines are conditional on at least one child in the anchor-sibling dyad living with the common biological parent. Yellow lines are conditional on co-residency, i.e. that the sibling pair lives in the same dwelling. Solid lines indicate a

cumulated time of at least two years. Dashed lines indicate a cumulated time of at least eight years. Figure 1a shows that close to all full siblings co-reside, and that almost all have done so for at least eight years by the end of childhood. In contrast, Figure b shows, for example, that only 30% of children with half siblings have co-resided with them for eight or more years (yellow dashed line).

Figure 2c includes all children who had a full and/or half sibling by age 18. If we believe that the formation of bonds as salient as those observed among full siblings requires sharing a household for an extended period of time, how many children will form such a relationship with a half sibling? If the threshold for potential exposure is set at eight years of co-residence, the answer is around 10%.

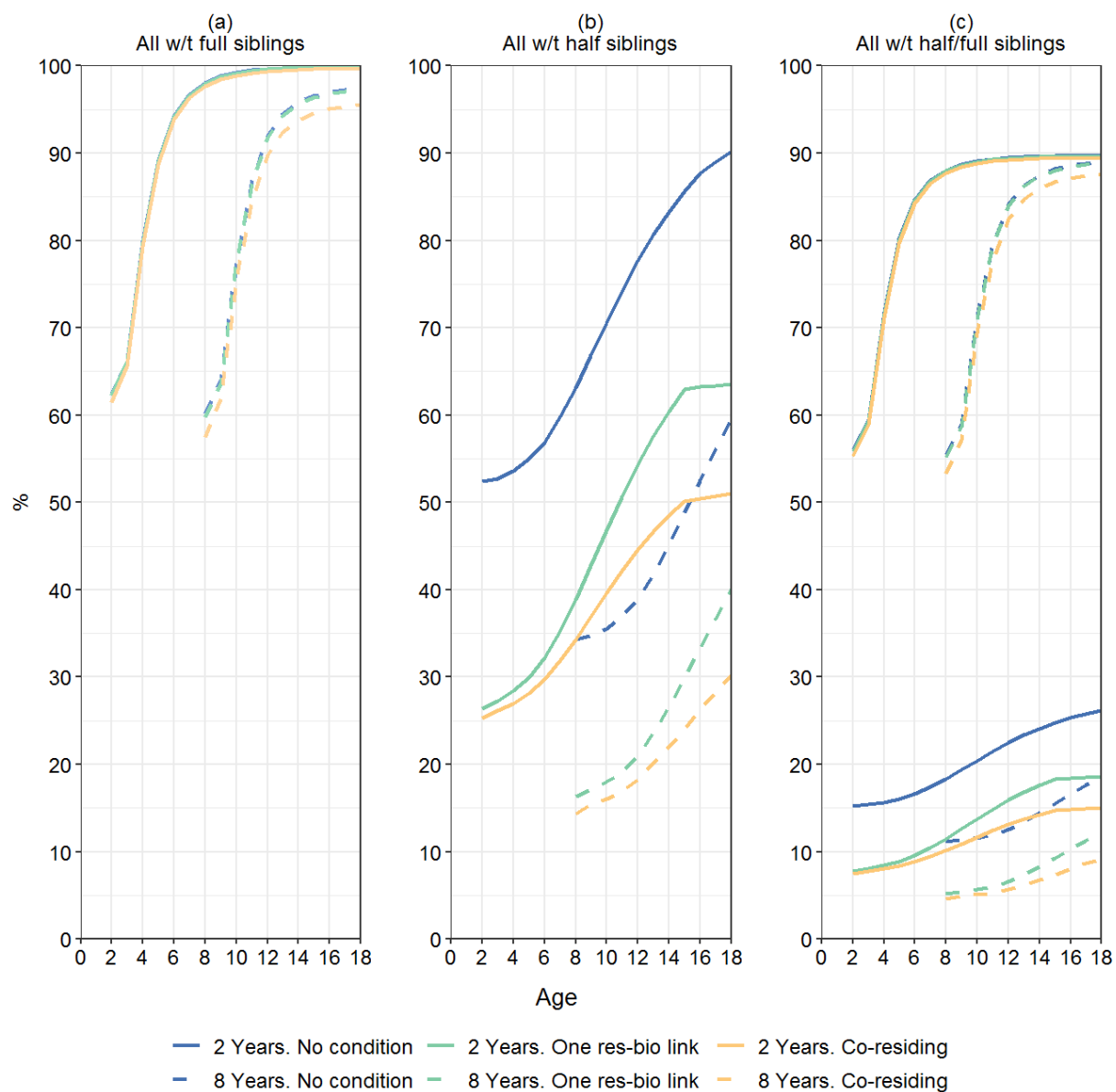
Figure 1 and figure 2 use data from the whole birth cohort. Some previous work present results separately for first and later born children (Thomson 2014) while some data sources only identify maternal half-siblingship. To facilitate comparison with such material, figure S2 and figure S3 in the supplemental appendix reproduce figure 1c and figure 2c across these dimensions.

Figure 1. Cumulated years of life overlap with closest sibling. (a): All who have had at least one full sibling by age 18 ($N=99,217$). (b): All who have had at least one half sibling by age 18 ($N=31,636$). (c): All who have ever had a half or full sibling by age 18 ($N=110,535$).



Source: STAR register data.

Figure 2. Cumulated years of residential overlap with closest sibling (a): All who have had at least one full sibling by age 18 (N=99,217). (b): All who have had at least one half sibling by age 18 (N=31,636). (c): All who have ever had a half or full sibling by age 18 (N =110,535).



Source: STAR register data.

4.2 Siblingship Composition of Children with Low and High Levels of Exposure to Half Siblings

Figures 1 and 2 showed that full-sibling exposure is rather homogenous whereas half-sibling exposure is heterogeneous. What is the variability in sibling constellation and parental reproductive behavior for those with high and low exposure to half siblings? Table 2 presents descriptive statistics for those with eight years or more of co-residence with a half sibling by age 18 (corresponding to the yellow dashed line in Figures 2 a-c), compared to all others with a half sibling. As expected, the high exposure group present a shorter average-age interval and the majority have maternal half siblings. A less self-evident finding is that about half also have a paternal half sibling, whereas only 37% (100-63.7) in the low-exposure group have a maternal half sibling. Moreover, about half of high-exposure children have no full siblings, compared to 29.2% in the low exposure group. Paternal and maternal childbearing with three or more partners is more common in the high exposure group; despite being less likely to have full siblings overall, the high exposure group more often have sibling sets that consist of both full siblings, and maternal and paternal half siblings (18.4% versus 8.1%).

Table 3. Sibling composition and parental fertility among children who have markedly low and high exposure to half siblings. (Children with half siblings by age 18).

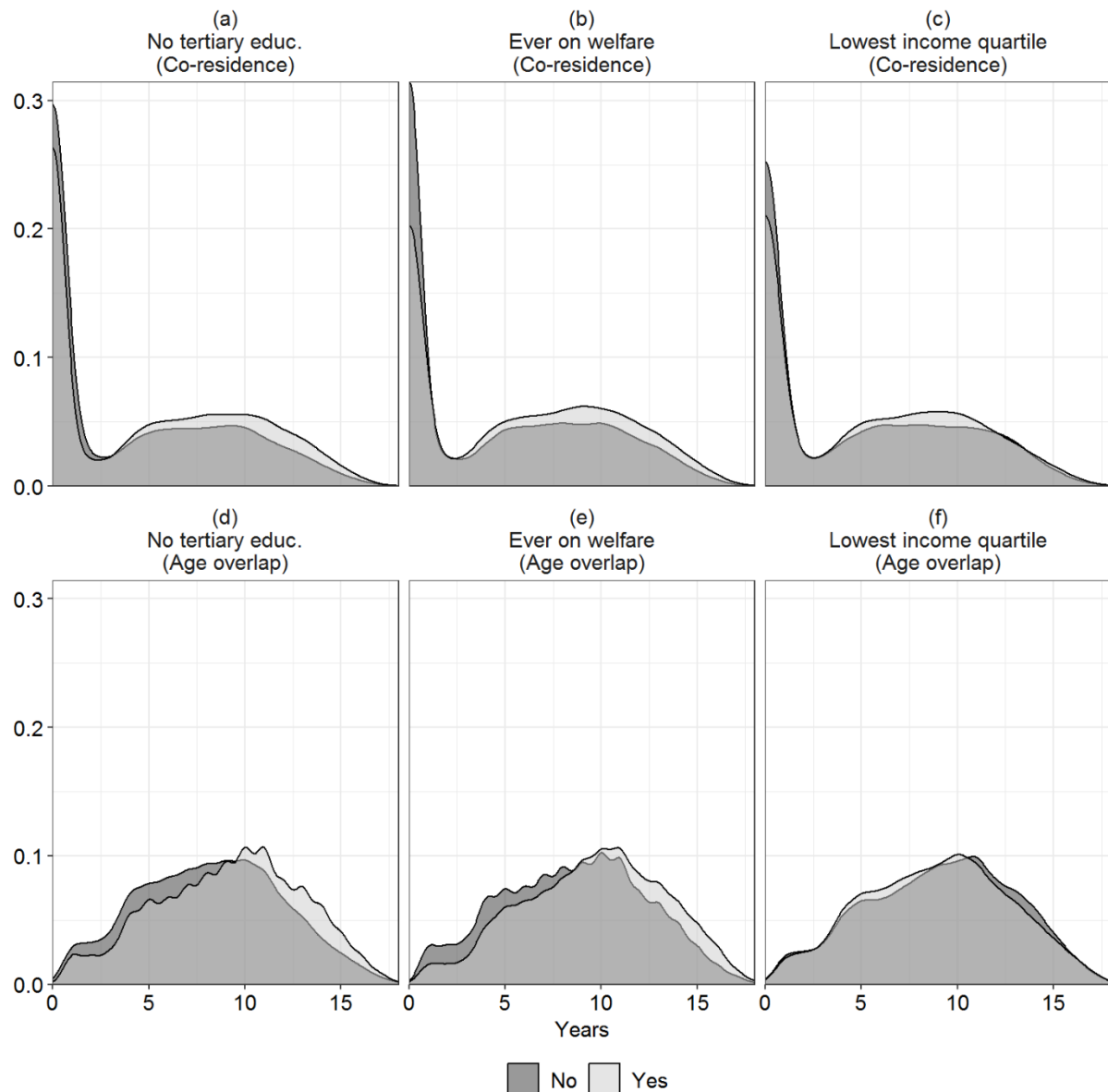
	Eight or more years co-residence	Other
<i>Half-sibling spacing</i>		
Mean	6	11
Median	6.0	11.0
Q1, Q3	4.0, 8.0	7.0, 14.0
<i>Full siblings</i>		
None	5292 (48.0%)	6026 (29.2%)
One	4377 (39.7%)	9622 (46.7%)
Two	973 (8.8%)	3427 (16.6%)
Three or more	387 (3.5%)	1530 (7.4%)
<i>Maternal half siblings</i>		
None	568 (5.2%)	13134 (63.7%)
One	6022 (54.6%)	4540 (22.0%)
Two	3151 (28.6%)	2100 (10.2%)
Three or more	1288 (11.7%)	831 (4.0%)
<i>Paternal half siblings</i>		
None	5574 (50.5%)	4432 (21.5%)
One	2382 (21.6%)	8682 (42.1%)
Two	2042 (18.5%)	5129 (24.9%)
Three or more	1031 (9.3%)	2362 (11.5%)
<i>Maternal childbearing partners</i>		
One	568 (5.2%)	13134 (63.7%)
Two	8993 (81.5%)	6660 (32.3%)

Three or more	1468 (13.3%)	811 (3.9%)
<i>Paternal childbearing partners</i>		
One	5574 (50.5%)	4432 (21.5%)
Two	4513 (40.9%)	14036 (68.1%)
Three or more	942 (8.5%)	2137 (10.4%)
<i>Antecedence</i>		
Maternal only	5574 (50.5%)	4432 (21.5%)
Paternal only	568 (5.2%)	13134 (63.7%)
Both	4887 (44.3%)	3039 (14.7%)
<i>Total sibling-set composition</i>		
Maternal half	2275 (20.6%)	1365 (6.6%)
Paternal half	162 (1.5%)	3285 (15.9%)
Mat. & Pat. half	2855 (25.9%)	1376 (6.7%)
Full & Mat. half	3299 (29.9%)	3067 (14.9%)
Full & Pat. half	406 (3.7%)	9849 (47.8%)
Full & Mat & Pat. Half	2032 (18.4%)	1663 (8.1%)
<i>Sibling position relative to half sibling(s)</i>		
Older	4440 (40.3%)	8170 (39.7%)
Younger	4648 (42.1%)	10960 (53.2%)
Older & Younger	1941 (17.6%)	14752%

4.3 Social Origin of Children with Low and High Levels of Exposure to Half siblings

Previous research has established a negative SES gradient in the occurrence of half siblingship and other forms of family complexity. Within this group, are patterns of vulnerability correlated with the length of exposure? Figure 3 presents the association between three dichotomized socioeconomic measures of social origin and the probability of exposure: both parents lacking tertiary education (a and d), either parent ever receiving welfare benefits (b and e) and the residential parent being in the lowest income quartile (c and f). Coming from a vulnerable background (light gray) in terms of parental educational level and welfare uptake is slightly more common among children with more exposure to their half siblings. This is the case both in terms of years of co-residence (upper half) and age overlap (lower half). However, the association is weak, corresponding to less than half a year on average. There is no apparent pattern with regard to parental income.

Figure 4. Half-sibling overlap and half-sibling extended co-residency by measures indicating parents having a vulnerable social position.



Source: STAR register data.

4. Discussion

The growth of half and step siblingships is a key feature of modern kinship patterns. While repeated and close socialization during childhood is quintessential to the sibling relationship, there is a paucity of research about divergences between full and half siblings in their potential to interact. Studies on the development of half siblingship from the child’s perspective are particularly rare. This study has described the development of half siblingship from birth to adulthood in a recent Swedish birth cohort.

The study has shown how birth spacing among full and half siblings translates into very different levels of accumulated exposure to full and half siblings, resulting in low variability among full siblings and high variability among half siblings. Using data on registered residency, we estimate further how gendered residency patterns impact on the likelihood of exposure to half siblings. We have used these parameters to quantify upper and lower bounds of probability

for sibling interaction. We find that in the 1994 birth cohort, the occurrence of half-sibling interaction may vary from 10% to 27% of the population, simply on the basis of different definitions of what constitutes a substantive minimum level of exposure.

The factors underlying the divergence between full- and half-sibling exposure, extended birth spacing and maternal residential custodianship, are well established in the existing research (Thomson 2015). We provide the first birds-eye perspective on how these factors translate into half siblings across the childhood of a given focal child, using information on all older and younger half siblings from the mother's and father's side as they accumulate over an 18 year period. We are able to transcend many of the difficulties faced by this exercise: we have almost no missing data on paternal fertility, we account for regional migration and our data cover biological kin independent of recall bias or measurement errors stemming from respondents or survey design.

In addition to quantifying the probability of interaction, we have explored differences in children with a high and low likelihood of exposure to their half siblings. Children with more exposure to their half siblings tend either to have no full siblings or to simultaneously have maternal half siblings, paternal half siblings and full siblings. The heterogeneity in birth spacing, residency and parental fertility patterns within the group of individuals with half siblings entails two crude but important points with regard to family complexity. First, in contrast to full-sibling sets, it is not possible to define a substantive "modal" half-sibling relationship: many have very limited overlap with their half siblings, while for others the overlap is greater, and this gives rise to very heterogeneous substantive experiences with respect to sibling composition and antecedence. Second, it entails major challenges for producing aggregate descriptions of family complexity in terms of cumulated experiences from survey data (Wolfe et al. 1996). In this respect, this study contributes to the literature by employing administrative data to offer a life-course depiction of half siblingship that is otherwise hard to obtain.

We analyzed whether children from different social origins have different kinds of exposure to their half siblings and found only minor variations in this respect. Previous research has been fairly conclusive in finding that half siblingship and other complex family relations are overrepresented among low SES and vulnerable populations. Our findings are, to our knowledge, the first to show that while there is a social origin gradient for the likelihood of ever having a half sibling, it is not salient to the likelihood of exposure to overlapping years of childhood with half siblings.

The present study has important limitations. Due to data limitations, this study does not measure stepchildren, and so a complete picture of the development of children's relations in complex family forms still remains to be developed. We have focused on accurately covering all full- and half-sibling relations, but our data are less accurate in covering their movements in and out of households. While the registers give a precise image of living sibling overlap, approximating residency on the basis of being registered at a given dwelling should be considered a rough measure. However, the possibility of mapping out even a relative measure of residency for each and every half sibling over an 18-year period is a worthwhile exercise.

Our findings have bearing for research on differences in the qualitative nature of full- and half-sibling relationships. Evolutionary explanations of why half siblings are less likely to be close confidants focus on the advantages for fitness of investing in more closely related kin. Sociological explanations include the argument that step- and half-sibling relations are

incomplete institutions which cannot provide the default toolkit or social cohesion that produce close affinity among full siblings. Both frameworks are mainly targeted towards explaining variation among full- and half-sibling pairs that actually interact and thus have the opportunity to form a relationship of a given kind. The present study highlights the presence of substantial variation in the opportunities for contact among half siblings. Taking a population perspective, we have drawn attention to the denominator, which is comprised of all half siblings, rather than those nominated by respondents or counted within a household at a given point in time. Above and beyond existing frameworks, a focus is needed on composition that takes into consideration the variation that exists in exposure to day-to-day interactions with half siblings.

One consequence of this argument is that proximate determinants of siblingship exposure need to be studied across contexts. Even at similar levels of incidence of completed multi-partner fertility, exposure to half siblings will differ substantially from the perspective of the child. This is contingent on whether the time to cross-partner births is short or long, whether men or women are more likely to have children with more than one partner, in interaction with gendered childrearing practices, and the practice of shared post-separation custody and alternating residence. Analyzing the proximate antecedents to half-sibling interaction would be an interesting avenue for future research.

References

- Ahrons, Constance R. 2007. 'Family Ties after Divorce: Long-Term Implications for Children'. *Family Process* 46 (1): 53–65.
- Anderson, Edward R. 1999. 'Sibling, Half Sibling, and Stepsibling Relationships in Remarried Families'. *Monographs of the Society for Research in Child Development*, in X ED Monographs of the society for research in child development, , 101–126.
- Aughinbaugh, Alison. 2004. 'The Impact of Attrition on the Children of the NLSY79'. *Journal of Human Resources* XXXIX (2): 536–63. <https://doi.org/10.3368/jhr.XXXIX.2.536>.
- Bloome, Deirdre. 2017. 'Childhood Family Structure and Intergenerational Income Mobility in the United States'. *Demography* 54 (2): 541–69. <https://doi.org/10.1007/s13524-017-0564-4>.
- Brown, Susan L., and Wendy D. Manning. 2009. 'Family Boundary Ambiguity and the Measurement of Family Structure: The Significance of Cohabitation'. *Demography* 46 (1): 85–101.
- Cancian, Maria, and Daniel R. Meyer. 2006. 'Alternative Approaches to Child Support Policy in the Context of Multiple-Partner Fertility'. *Report to the Wisconsin Department of Workforce Development*.
- Cancian, Maria, Daniel R. Meyer, and Steven T. Cook. 2011. 'The Evolution of Family Complexity from the Perspective of Nonmarital Children'. *Demography* 48 (3): 957–82. <https://doi.org/10.1007/s13524-011-0041-4>.
- Carlson, Marcia J., and Frank F. Furstenberg. 2006. 'The Prevalence and Correlates of Multipartnered Fertility among Urban US Parents'. *Journal of Marriage and Family* 68 (3): 718–732.
- Chapais, Bernard. 2009. *Primeval Kinship: How Pair-Bonding Gave Birth to Human Society*. Harvard University Press.
- Cherlin, Andrew. 1978. 'Remarriage as an Incomplete Institution'. *American Journal of Sociology* 84 (3): 634–650.
- Danielsbacka, Mirkka, and Antti O. Tanskanen. 2015. 'The Association between Unequal Parental Treatment and the Sibling Relationship in Finland: The Difference between

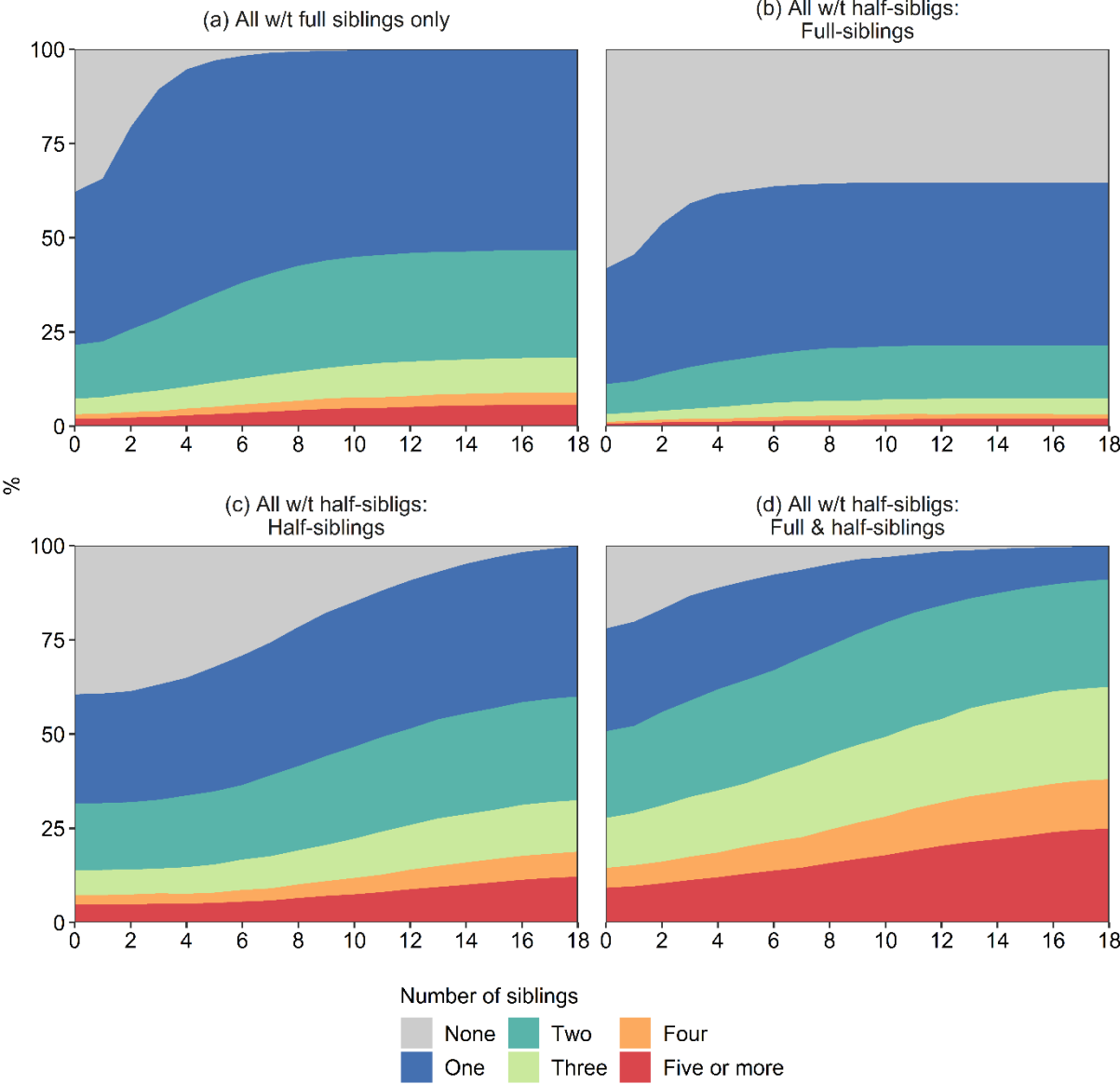
- Full and Half-Siblings'. *Evolutionary Psychology* 13 (2): 147470491501300220. <https://doi.org/10.1177/147470491501300211>.
- Danielsbacka, Mirkka, Antti O. Tanskanen, and Anna Rotkirch. 2015. 'Impact of Genetic Relatedness and Emotional Closeness on Intergenerational Relations'. *Journal of Marriage and Family* 77 (4): 889–907. <https://doi.org/10.1111/jomf.12206>.
- Dommermuth, Lars. n.d. 'The Geographical Distance between Nonresident Parents and Children in Norway'. *Population, Space and Place* 2017: 1–12. <https://doi.org/10.1002/psp.2089>.
- Dorius, Cassandra. 2011. 'Reconceptualizing Family Instability to Include Measures of Childbearing: The Practical Value of Assessing Multiple Partner Fertility'. In *Proceedings of the Annual Meeting for the Population Association of America, Washington, DC, March 31-April*. Vol. 2.
- Ganong, Lawrence H., and Marilyn Coleman. 1988. 'Do Mutual Children Cement Bonds in Stepfamilies?' *Journal of Marriage and the Family*, 687–698.
- . 2012. *Stepfamily Relationships*. Springer.
- Goetting, Ann. 1986. 'The Developmental Tasks of Siblingship over the Life Cycle'. *Journal of Marriage and Family* 48 (4): 703–14. <https://doi.org/10.2307/352563>.
- Guzzo, Karen Benjamin, and Frank F. Furstenberg. 2007. 'Multipartnered Fertility among American Men'. *Demography* 44 (3): 583–601.
- Hadfield, Kristin, and Elizabeth Nixon. 2013. 'Including Those That Exclude Themselves: Comparisons of Self-Identifying and Non-Self-Identifying Stepfamilies'. *Journal of Family Studies* 19 (2): 207–216.
- Hamilton, W.D. 1964. 'The Genetical Evolution of Social Behaviour. II'. *Journal of Theoretical Biology* 7 (1): 17–52.
- Heijden, Franciëlla van der, Anne-Rigt Poortman, and Tanja van der Lippe. 2016. 'Children's Postdivorce Residence Arrangements and Parental Experienced Time Pressure'. *Journal of Marriage and Family* 78 (2): 468–481.
- Henz, Ursula, and Elizabeth Thomson. 2005. 'Union Stability and Stepfamily Fertility in Austria, Finland, France & West Germany'. *European Journal of Population / Revue Européenne de Démographie* 21 (1): 3–29. <https://doi.org/10.1007/s10680-004-7267-4>.
- Houdt, Kirsten van, Matthijs Kalmijn, and Katya Ivanova. 2018. 'Family Complexity and Adult Children's Obligations: The Role of Divorce and Co-Residential History in Norms to Support Parents and Step-Parents'. *European Sociological Review* 34 (2): 169–83. <https://doi.org/10.1093/esr/jcy007>.
- Huinink, Johannes, Josef Brüderl, Bernhard Nauck, Sabine Walper, Laura Castiglioni, and Michael Feldhaus. 2011. 'Panel Analysis of Intimate Relationships and Family Dynamics (Pairfam): Conceptual Framework and Design'. *ZfF—Zeitschrift Für Familienforschung/Journal of Family Research* 23 (1).
- Juby, Heather, and Céline Le Bourdais. 1999. 'Where Have All the Children Gone? Comparing Mothers' and Fathers' Declarations in Retrospective Surveys'. *Canadian Studies in Population* 26 (1): 1–20.
- Kalmijn, Matthijs, Katya Ivanova, Ruben van Gaalen, De Leeuw, Suzanne G, Kirsten van Houdt, Frederique van Spijker, and Maaïke Hornstra. 2018. 'A Multi-Actor Study of Adult Children and Their Parents in Complex Families: Design and Content of the OKiN Survey'. *European Sociological Review*. <https://doi.org/10.1093/esr/jcy016>.
- Kaplan, H, Michael Gurven, and Paul Hooper. 2009. 'The Evolutionary and Ecological Roots of Human Social Organization'. *Philosophical Transactions of the Royal Society B: Biological Sciences* 364 (1533): 3289–99. <https://doi.org/10.1098/rstb.2009.0115>.

- Kennedy, Sheela, and Catherine A. Fitch. 2012. 'Measuring Cohabitation and Family Structure in the United States: Assessing the Impact of New Data from the Current Population Survey'. *Demography* 49 (4): 1479–1498.
- Kersting, L, and M Feldhaus. 2016. 'Die Qualität von Geschwisterbeziehungen Im Jungen Und Mittleren Erwachsenenalter in Abhängigkeit Des Verwandtschaftsstatus'. *Zeitschrift Für Soziologie Der Erziehung Und Sozialisation* 36: 382–401.
- Kreyenfeld, Michaela, Esther Geisler, Teresa Castro-Martín, Tina Hannemann, Valerie Heintz-Martin, Marika Jalovaara, Hill Kulu, et al. 2017. 'Social Policies, Separation, and Second Birth Spacing in Western Europe'. *Demographic Research* S21 (37): 1245–74. <https://doi.org/10.4054/DemRes.2017.37.37>.
- Kreyenfeld, Michaela, and Marika Jalovaara. 2018. 'Childbearing across Partnerships in Finland and Germany'.
- Lappegård, Trude, and Marit Rønsen. 2013. 'Socioeconomic Differences in Multipartner Fertility Among Norwegian Men'. *Demography* 50 (3): 1135–53. <https://doi.org/10.1007/s13524-012-0165-1>.
- Lappegård, Trude, and Elizabeth Thomson. 2018. 'Intergenerational Transmission of Multipartner Fertility'. *Demography* 55 (6): 2205–28. <https://doi.org/10.1007/s13524-018-0727-y>.
- Laslett, Peter. 1980. 'Introduction: Comparing Illegitimacy over Time and between Cultures'. *Studies in Social and Demographic History*, 1–68.
- Lieberman, Debra, John Tooby, and Leda Cosmides. 2007. 'The Architecture of Human Kin Detection'. *Nature* 445 (7129): 727.
- Manlove, Jennifer, Cassandra Logan, Erum Ikramullah, and Emily Holcombe. 2008. 'Factors Associated With Multiple-Partner Fertility Among Fathers'. *Journal of Marriage and Family* 70 (2): 536–48. <https://doi.org/10.1111/j.1741-3737.2008.00499.x>.
- Manning, Wendy D., Susan L. Brown, and J. Bart Stykes. 2014. 'Family Complexity among Children in the United States'. *The ANNALS of the American Academy of Political and Social Science* 654 (1): 48–65. <https://doi.org/10.1177/0002716214524515>.
- Monte, Lindsay M. 2018. 'Multiple-Partner Fertility in the United States: A Demographic Portrait'. *Demography*, December. <https://doi.org/10.1007/s13524-018-0743-y>.
- Müller, Bettina, and Laura Castiglioni. 2015. 'Stable Relationships, Stable Participation? The Effects of Partnership Dissolution and Changes in Relationship Stability on Attrition in a Relationship and Family Panel'. *Survey Research Methods* 9 (3): 205–19. <https://doi.org/10.18148/srm/2016.v10i1.6207>.
- Pollet, Thomas V. 2007. 'Genetic Relatedness and Sibling Relationship Characteristics in a Modern Society'. *Evolution and Human Behavior* 28 (3): 176–185.
- Poortman, Anne-Rigt, and Marieke Voorpostel. 2009. 'Parental Divorce and Sibling Relationships: A Research Note'. *Journal of Family Issues* 30 (1): 74–91.
- Rossi, Peter Peter Henry. 1990. *Of Human Bonding: Parent-Child Relations across the Life Course*. Transaction Publishers.
- Steinbach, Anja, and Karsten Hank. 2018. 'Full-, Half-, and Step-Sibling Relations in Young and Middle Adulthood'. *Journal of Family Issues* 39 (9): 2639–2658.
- Tanskanen, Antti O., and Mirkka Danielsbacka. 2014. 'Genetic Relatedness Predicts Contact Frequencies with Siblings, Nieces and Nephews: Results from the Generational Transmissions in Finland Surveys'. *Personality and Individual Differences* 69 (October): 5–11. <https://doi.org/10.1016/j.paid.2014.04.034>.
- . 2019. 'Relationship Quality Among Half Siblings: The Role of Childhood Co-Residence'. *Evolutionary Psychological Science* 5 (1): 13–21. <https://doi.org/10.1007/s40806-018-0161-9>.

- Tanskanen, Antti O., Mirkka Danielsbacka, Markus Jokela, and Anna Rotkirch. 2017. 'Sibling Conflicts in Full-and Half-Sibling Households in the UK'. *Journal of Biosocial Science* 49 (1): 31–47.
- Tanskanen, Antti O, and Anna Rotkirch. 2018. 'Sibling Similarity and Relationship Quality in Finland'. *Acta Sociologica*, June, 0001699318777042. <https://doi.org/10.1177/0001699318777042>.
- Thomson, Elizabeth. 2014. 'Family Complexity in Europe'. *The Annals of the American Academy of Political and Social Science* 654 (1): 245–258.
- . 2015. 'Family Complexity and Kinship'. In *Emerging Trends in the Social and Behavioral Sciences*. John Wiley & Sons, Inc. <https://doi.org/10.1002/9781118900772.etrds0437>.
- Thomson, Elizabeth, Trude Lappegård, Marcia Carlson, Ann Evans, and Edith Gray. 2014. 'Childbearing Across Partnerships in Australia, the United States, Norway, and Sweden'. *Demography* 51 (2): 485–508. <https://doi.org/10.1007/s13524-013-0273-6>.
- Tillman, Kathryn Harker. 2008. 'Coresident Sibling Composition and the Academic Ability, Expectations, and Performance of Youth'. *Sociological Perspectives* 51 (4): 679–711.
- White, Lynn. 1998. 'Who's Counting? Quasi-Facts and Stepfamilies in Reports of Number of Siblings'. *Journal of Marriage and the Family*, 725–733.
- White, Lynn K., and Agnes Riedmann. 1992. 'When the Brady Bunch Grows up: Step/Half-and Fullsibling Relationships in Adulthood'. *Journal of Marriage and the Family*, 197–208.
- Wiemers, Emily E., Judith A. Seltzer, Robert F. Schoeni, V. Joseph Hotz, and Suzanne M. Bianchi. 2019. 'Stepfamily Structure and Transfers Between Generations in U.S. Families'. *Demography* 56 (1): 229–60. <https://doi.org/10.1007/s13524-018-0740-1>.
- Wolfe, Barbara, Robert Haveman, Donna Ginther, and Chong Bum An. 1996. 'The "Window Problem" in Studies of Children's Attainments: A Methodological Exploration'. *Journal of the American Statistical Association* 91 (435): 970–982.

Supplementary material

Figure S1. Proportion of number of full siblings, half siblings and full & half sibling among anchor children (1994 birth cohort), at age of anchor child. (a): All with full siblings only by age 18 (N=78,901). (b-d): All with at least one half-sibling by age 18 (N=31,634).



Source: STAR register data.

Figure S2. Cumulated years of life overlap with closest sibling: All who have ever had a half or full sibling by age 18 and who are (a) firstborn ($N=36,080$); (b) later born ($N=74,455$). Counting only (c) maternal half siblings as half siblings ($N=110,535$); (d) paternal half siblings as half siblings ($N=110,535$).

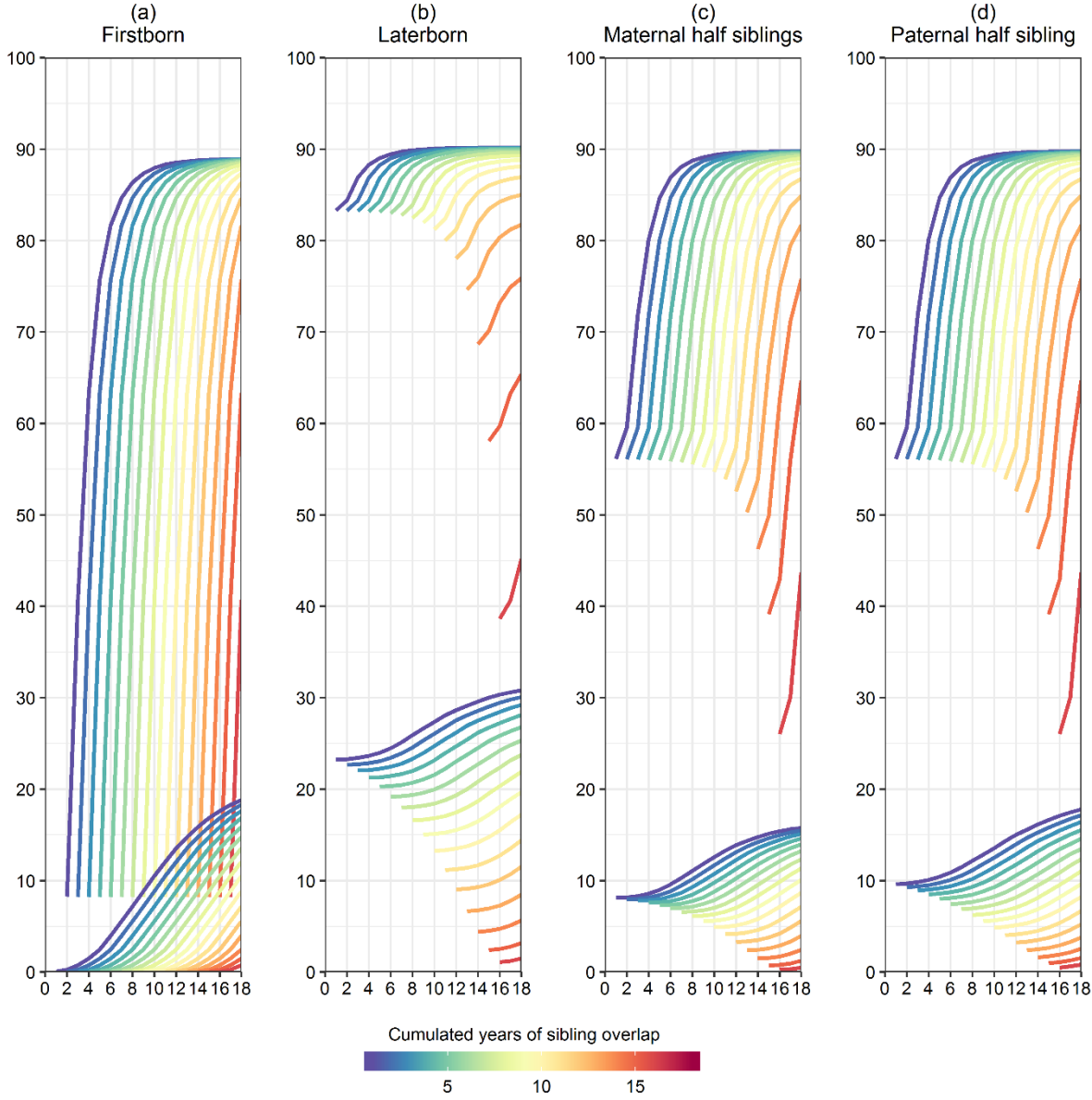


Figure S3. Cumulated years of residential overlap with closest sibling: All who have ever had a half or full sibling by age 18 and who are (a) firstborn ($N=36,080$); (b) later born ($N=74,455$). Counting only (c) maternal half siblings as half siblings ($N=110,535$); (d) paternal half siblings as half siblings ($N=110,535$).

