Timing of sibling complexity during children's early life courses and subsequent psychiatric morbidity and education

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EXTENDED ABSTRACT

1. BACKGROUND

Children are increasingly exposed to instability and complexity within the family environment. The rise in changes in parental union status, including union dissolution, single parenthood, and repartnering, have led to a growing number of children who are exposed to one or more alternative family structures throughout their early life courses (Sobotka & Toulemon, 2008). Moreover, increases in multi-partner fertility and stepfamily formation have yielded a rise in sibships containing half- or stepsiblings in addition to or instead of full siblings (Thomson, 2014; Guzzo, 2014; Stykes & Guzzo, 2015). Such sibling complexity has increased over the past decades (Brown et al., 2015; Sanner & Jensen, 2021), with emerging research from Finland suggesting that the proportion of children who experienced sibling complexity by age 16 increased by nearly 20% between 1988 and 2000 (Junna et al., *unpublished*). Yet, sibling complexity remains an understudied domain of contemporary family organization.

The growing body of literature on sibling complexity has largely focused on sibling composition, which has been associated with wellbeing throughout childhood and adolescence. A systematic review highlights that living in a sibship containing half- and/or stepsiblings is associated with a higher risk of health-risk behaviors and mental ill-health, and poorer educational outcomes compared to those living in compositions comprised only of full siblings (Sanner et al., 2018). Sibling composition has been found to have a potentially more salient influence on children's mental health and educational outcomes than parental union status (Sanner & Jensen, 2021). Emerging research on the dynamic nature of the sibship underscores these findings, suggesting that sibling complexity accumulated across children's early life courses is associated with higher risks of subsequent mental ill-health and lower educational attainment in emerging adulthood (Bishop et al., *unpublished*). However, given that the timing of exposures in childhood may have a differential influence on later outcomes (Ben-Shlomo & Kuh, 2002), the contribution of sibling complexity for later psychiatric morbidity and education may depend on the developmental stage in which the child was exposed.

The extant literature highlights that exposure to family instability during early childhood may be more strongly associated with consequences for children's later well-being (Russell et al., 2018; Cavanagh & Fomby, 2019). Early childhood is characterized by ongoing cognitive, physical, and emotional development (Ben-Shlomo & Kuh, 2002), which may increase children's vulnerability to adverse outcomes following such structural changes in the family environment. However, it remains unclear whether changes to the sibship during the first five years of life would yield similar consequences. Children who experience very early changes within the sibship may develop relationships with their half- or stepsiblings that become similarly long-lasting as those of biological siblings, serving as valuable sources of support (Sanner & Jensen, 2021). Similarly, adolescence is also typically considered a sensitive period characterized by ongoing physical, emotional, and cognitive development combined with increased autonomy (Ben-Shlomo & Kuh, 2002). During adolescence, peers become increasingly important sources of social interaction and social learning (Crosnoe et al., 2008; del Valle et al., 2010). Yet, siblings of all types may occupy a uniquely dual role as both family member and peer. Exposure to sibling complexity within this developmental stage, including transitions in which half- or stepsiblings are gained or stepsiblings are lost due to parental union dissolution, may lead to a greater disruption in both family and peer contexts that may affect adolescents' later psychiatric morbidity and educational outcomes.

Finally, associations between differential exposure to sibling complexity and later psychiatric morbidity and education may be socially patterned. The extant literature tends to support the social causation hypothesis, wherein static sibship compositions or instability within the sibship may adversely affect later health and social outcomes (Sanner et al., 2018; Sanner & Jensen, 2021). However, selection into families characterized by greater instability may also play a role (Cavanagh & Fomby, 2019). Union dissolution and multi-partner fertility—two key processes that contribute to sibling complexity—are associated with lower parental education and disadvantaged economic circumstances (Dorius et al., 2025; Stannard et al., 2024; Jalovaara, 2012). Selection into early childbearing is similarly associated with relative sociodemographic disadvantage in early life (Hobcraft & Kiernan, 2001).

Dynamic sibship compositions are an important consideration in contemporary family life courses with potential implications for children's subsequent psychiatric wellbeing and educational outcomes. In this study, we employ the high-quality longitudinal Finnish data to calculate unweighted and weighted sibling complexity indices for three age bands (0–5, 6–10, and 11–15) across the early life courses of children from seven Finnish birth cohorts. For each age band, we estimate associations between exposure to sibling complexity and psychiatric morbidity and education (ages 16–23). Finally, we consider effect heterogeneity by three measures of childhood socioeconomic position (SEP): parental education, parental economic hardship, and maternal age at entry into childbearing.

2. Materials and methods

2.1 Data and ethical approval

The study is based on a total population sample of individuals residing in Finland at the end of years 1970, 1975, 1980, 1985, and/or 1987–2020. The data material contains sociodemographic and mortality information maintained, pseudonymized, and approved for research by Statistics Finland (TK-53-1490-18). These data were linked to records from the Care Register for Healthcare, maintained by the Finnish Institute for Health and Welfare and approved for research by the Social and Health Data Permit Authority (Findata; THL/2180/14.02.00/2020).

2.2 Study population

The study population consists of children born between 1990–1996 and permanently residing in Finland (*n*=514,051). We excluded children missing biological parent information at birth (*n*=57,007) or annual sociodemographic information for themselves or a biological parent (e.g., due to emigration; *n*=35,703) and those who died during the observation period (*n*=2,948). These criteria yielded an analytic sample of 418,393 index children.

We derived each index child's annual sibling constellation (ages 0–15) by triangulating data sources maintained by Statistics Finland. The index children's biological (full and half-) siblings were identified using biological linkages. We then annually identified any new union formations for each biological parent using household identifiers and data on cohabiting, marital and registered unions (including same sex partners if married or in a registered union). Stepsiblings were subsequently identified using annually updated family and cohabitation data (capturing cohabiting unions lasting ≥90 days) for the biological parents and their partners. We identified 789,891 full, half-, and stepsiblings, of whom 529,538 are not index children.

2.3 Measures

2.3.1 Sibling complexity

The main independent variable is sibling sequence complexity (Gabadinho et al., 2010): an index that quantifies sibship transitions based on a sequence analysis approach. Specifically, the sequence complexity index reflects the unpredictability and uncertainty of individual sibship trajectories experienced between ages 0–15. The construction of this measure is detailed in section 2.4.

2.3.2 Model outcomes

Variables for psychiatric morbidity and educational attainment were included as outcomes in the regression models. Psychiatric morbidity was defined as a treatment event for mental and behavioral disorders, identified using hospital discharge records for inpatient (1979–2020) and outpatient specialized psychiatric care (2006–2020), defined by diagnostic codes F10–F99 (excluding F17 and F70) from the International Classification of Diseases, tenth revision (ICD-10). The measure was dichotomized to indicate whether an event occurred between ages 16–23. Our education variable was defined as the highest attained education between ages 16–23. We considered three categories: completed basic (International Standard Classification of Education (ISCED) 2011 levels 1–2), completed upper secondary (ISCED 3–4), and entered tertiary education (ISCED 5–8).

2.3.3 Effect modifiers

To examine effect heterogeneity by childhood socioeconomic position, we plan to consider several different measures of parental socioeconomic resources. To account for potential differences in the onset of the mother's reproductive career, including selection into early childbearing and subsequent multi-partner fertility, we will consider differences by maternal age at first birth (<20, 20–30, >30). We will further consider a measure of parental educational attainment at birth (basic, upper secondary, tertiary), as well as a measure of economic hardship at birth, defined as parental recipiency of at least one euro of means-tested, last-resort social assistance.

2.4 Empirical approach

2.4.1 Estimation of sibling complexity

The main independent variable is weighted sibling complexity, measured using a weighted sequence complexity index (Ritschard et al., 2018; Hiekel & Vidal, 2020). This index is a modified version of the composite sequence complexity index, which quantifies variability within sequences by computing the geometric mean of normalized transitions and normalized longitudinal entropy (Gabadinho et al., 2011; Van Winkle, 2018). This complexity *C* of sequence *x* is defined as

$$C(x)=\sqrt{\frac{q(x)}{q_{max}}\times\frac{h(x)}{h_{max}}}$$

where *q(x)* represents the number of transitions within a sequence, divided by the theoretical maximum number of transitions q_{max}. The longitudinal entropy *h(x),* which quantified the unpredictability of a sequence, is divided by the theoretical maximum of the longitudinal entropy, represented by h_{max}. The longitudinal entropy of sequence *x* is given by

$$h(x)=-\sum_{i}^{s}\pi_i\log\pi_i$$

where $\pi_i$represents the proportion of time spent in state *i* within the sequence. The maximum entropy h_{max} occurs when all states are equally represented, formally defined as:

$$h_{max}=-\log\frac{1}{A}$$

where A is the number of unique states in the sequence.

While the complexity index $C(x)$ captures the number of sibling states and their unpredictability, it does not differentiate between potentially advantageous and disadvantageous transitions. The precarity index (Ritschard et al., 2018) addresses this by introducing a correction factor that accounts for the proportion of potentially negative transitions:

$$wC(x)=C(x)^{\alpha}(1+q(x))^{\beta}$$

where $(1+q(x))$ is a non-negative correction factor. The term $q(x)$ represents the difference between the proportion of disadvantageous and advantageous transitions. The weights α and β adjust the influence of the complexity and correction factors. In our analyses, we set α to 1 and β to 1.5 to amplify the correction, but sensitivity tests with varying β produced similar results.

We calculate both unweighted and weighted sibling complexity indices for each age band (0–5, 6–10, and 11–15).

2.4.3 Regression analyses

We will estimate associations between sibling complexity and psychiatric morbidity and education using OLS regressions. We will estimate associations between the outcomes and both the non-weighted and weighted sequence complexity indices for each age band. For both sets of analysis, we control for current sibship composition to examine whether sibling complexity during each age band is independently associated with the outcomes. For the weighted complexity indices, we also add a dummy variable (1=no complexity; 0=any complex transitions) to address the inclusion of zero-inflated independent variables (He et al., 2014)

3. Expected results

We expect that exposure to sibling complexity in early adolescence will be associated with higher risks of psychiatric morbidity and lower educational attainment, relative to exposure during earlier developmental stages in childhood. We further expect that exposure to potentially disadvantageous transitions (e.g., gaining or losing stepsiblings) during any of the three studied developmental periods will be more strongly associated with both psychiatric morbidity and lower educational attainment than exposure to other, more typical, transitions within the sibship. Finally, we expect to find increased support for the social selection hypothesis, wherein fewer socioeconomic resources at birth may be associated with accumulated transitions and sibling complexity, regardless of the developmental period in which the children were exposed. Regardless of whether we find support for our preliminary hypotheses, this study will highlight the developmental periods in children's early life courses during which exposure to sibling complexity has a more salient influence on their subsequent mental health and educational outcomes. It will moreover shed light on the extent to which parental socioeconomic resources modify these associations. The findings from this study should yield important insights into during which developmental stage and within which socioeconomic strata children may most benefit from additional emotional and academic support after exposure to transitions within the sibship.

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