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Joint developmental trajectories of internalizing and externalizing problems from mid-childhood to late adolescence and childhood risk factors: Findings from a prospective pre-birth cohort

Sarita Bista[1] , Robert J. Tait[2], Leon M. Straker[3], Ashleigh Lin[4], Katharine Steinbeck[5,6], Petra L. Graham[7] , Melissa Kang[8], Sharyn Lymer[9], Monique Robinson[10], Jennifer L. Marino[1,11,12] and S. Rachel Skinner[1,6]

[1]Specialty of Child and Adolescent Health, Faculty of Medicine and Health, The University of Sydney, Westmead, NSW, Australia, [2]National Drug Research Institute & enAble Institute, Faculty of Health Sciences, Curtin University, Perth, WA, Australia, [3]School of Allied Health, Faculty of Health Science, Curtin University, Perth, WA, Australia, [4]The University of Western Australia, Perth, WA, Australia, [5]Discipline of Child and Adolescent Health, Faculty of Medicine and Health, The University of Sydney, Sydney, Australia, [6]The Children's Hospital at Westmead, Westmead, NSW, Australia, [7]School of Mathematical and Physical Sciences, Macquarie University, Macquarie Park, NSW, Australia, [8]General Practice Clinical School, Sydney Medical School, Faculty of Medicine and Health, The University of Sydney, Sydney, NSW, Australia, [9]Biostatistics Consultant, Sydney, NSW, Australia, [10]Telethon Institute for Child Health Research, Telethon Kids Institute, The University of Western Australia, Perth, WA, Australia, [11]Department of Obstetrics and Gynaecology, Royal Women's Hospital, The University of Melbourne, Parkville, VIC, Australia and [12]Centre for Adolescent Health, Murdoch Children's Research Institute, Parkville, VIC, Australia

Abstract

There is limited evidence on heterogenous co-developmental trajectories of internalizing (INT) and externalizing (EXT) problems from childhood to adolescence and predictors of these joint trajectories. We utilized longitudinal data from Raine Study participants ($n = 2393$) to identify these joint trajectories from 5 to 17 years using parallel-process latent class growth analysis and analyze childhood individual and family risk factors predicting these joint trajectories using multinomial logistic regression. Five trajectory classes were identified: *Low-problems* (Low-INT/Low-EXT, 29%), *Moderate Externalizing* (Moderate-EXT/Low-INT, 26.5%), *Primary Internalizing* (Moderate High-INT/Low-EXT, 17.5%), *Co-occurring* (High-INT/High-EXT, 17%), *High Co-occurring* (Very High-EXT/High-INT, 10%). Children classified in *Co-occurring* and *High Co-occurring* trajectories (27% of the sample) exhibited clinically meaningful co-occurring problem behaviors and experienced more adverse childhood risk-factors than other three trajectories. Compared with *Low-problems*: parental marital problems, low family income, and absent father predicted *Co-occurring* and *High Co-occurring* trajectories; maternal mental health problems commonly predicted *Primary Internalizing, Co-occurring*, and *High Co-occurring* trajectories; male sex and parental tobacco-smoking uniquely predicted *High Co-occurring* membership; other substance smoking uniquely predicted *Co-occurring* membership; speech difficulty uniquely predicted *Primary Internalizing* membership; child's temper-tantrums predicted all four trajectories, with increased odds ratios for *High Co-occurring* (OR = 8.95) and *Co-occurring* (OR = 6.07). Finding two co-occurring trajectories emphasizes the importance of early childhood interventions addressing comorbidity.

Keywords: internalizing; externalizing; co-occurring psychopathology; joint developmental trajectories; parallel-process growth mixture modeling

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Introduction

Internalizing (i.e., social withdrawal, anxiety, depression, and somatic complaints) and externalizing (i.e., destructive behaviors, aggression, and attention difficulties) problems often develop in early childhood (Achenbach, 2001). These problems can be persistent, potentially leading to an adverse developmental pathway

through adolescence and young adulthood (Angold & Costello, 1993; Costello et al., 2003). High internalizing and externalizing problem behaviors in early childhood are associated with several poor outcomes across childhood, adolescence, and adulthood, including poor academic results, alcohol use disorders, and mood and anxiety disorders (Brennan et al., 2012; Korhonen et al., 2018; Loth et al., 2014; Meque et al., 2019; Roza et al., 2003; Wiggins et al., 2015). There is a growing body of literature on individual-level trajectories of childhood internalizing and externalizing problems. Most studies investigating individual trajectories have considered internalizing and externalizing problem behaviors as two different pathways to different outcomes and, therefore, focused on either internalizing or externalizing problems (e.g., Achenbach et al., 2016 for review; Bongers et al., 2004; Sterba et al., 2007). What is unclear is

how changes in these two problem behaviors are related to each other and how their combined effect influences outcomes (Achenbach et al., 2016; Gilliom & Shaw, 2004).

Co-occurring development of internalizing and externalizing problems

Internalizing and externalizing problems are not mutually exclusive nor independent. Evidence suggests that the childhood psychopathologies categorized as internalizing and externalizing problems are continuous and often co-occur or overlap (Achenbach et al., 2016; Angold et al., 1999; Caspi & Moffitt, 2018; Colder et al., 2013; Gilliom & Shaw, 2004; Oland & Shaw, 2005; Willner et al., 2016). However, the pathways to co-occurrence are not well understood, although several hypotheses have been studied (Angold et al., 1999; Oland & Shaw, 2005 for review). Some studies support a causal (directional) hypothesis that early externalizing problems prospectively predict risk for internalizing problems or vice versa (Flouri et al., 2019; Gooren et al., 2011; Loeber & Keenan, 1994; Moilanen et al., 2010; Van der Ende et al., 2016). Other studies support a reciprocal hypothesis that internalizing and externalizing problems are reciprocally related to each other and changes in one are often associated with changes in the other (Gilliom & Shaw, 2004; Keiley et al., 2000). The general developmental psychopathology model suggests individual differences in the origin, course, and outcomes of normative and psychopathological developmental processes with shared vulnerabilities or risks (e.g., genetic, and environmental influence) causing internalizing and externalizing problems to co-occur (Caspi & Moffitt, 2018; Fanti & Henrich, 2010; Oland & Shaw, 2005 for review; Rutter & Sroufe, 2000; Wang et al., 2016, 2020). Irrespective of approach, co-occurring problems are associated with unique outcomes. For example, compared to children having internalizing or externalizing problems alone, children with co-occurring internalizing and externalizing problems often show more mental health and physical problems, increased behavioral and/or psychosocial maladjustment, and poorer academic performance during their childhood and adolescence (Newman et al., 1998; Oland & Shaw, 2005). However, the etiology of co-occurring internalizing and externalizing problems remains unclear. Moreover, many studies have distinguished internalizing and externalizing problems as distinct forms of problem behaviors, despite evidence showing co-occurrence of these problem behaviors (Achenbach et al., 2016). Methodologically strong empirical research is needed to understand the etiology of this co-occurrence from childhood to adolescence.

Previous studies of developmental psychopathology propose that co-occurring problems represent distinct, meaningful syndromes, and therefore, highlight the importance of investigating co-occurrence from a developmental perspective using longitudinal statistical methods to understand how children diverge from healthy development (low or moderate internalizing and externalizing) and follow trajectories of primary (high internalizing with low externalizing or vice versa) or co-occurring problem behavior (high internalizing with high externalizing) (e.g., Fanti & Henrich, 2010; Gilliom & Shaw, 2004; Keiley et al., 2003; Oland & Shaw, 2005; Shi et al., 2020). Advances in person-centered methods allow researchers to investigate heterogeneity in co-occurring developmental trajectories over time (Fanti & Henrich, 2010; Gilliom & Shaw, 2004; Hinnant & Mona, 2013; Wiggins et al., 2015). Among these methods, longitudinal data-driven methods such as parallel-process latent growth mixture models (e.g., latent

class growth analysis (LCGA), growth mixture model (GMM)) are useful for identifying heterogeneous subclasses with varying joint trajectories (Muthén & Muthén, 2000). Few studies have used such methods to detect distinct joint trajectories of internalizing and externalizing problems from childhood to adolescence (e.g., Duprey et al., 2020; Fanti & Henrich, 2010; Picoito et al., 2020; Shi et al., 2020; Wiggins et al., 2015), with most providing evidence of different trajectory subtypes including primary internalizing, primary externalizing, co-occurring internalizing and externalizing, and with a relatively larger proportion of the sample having low internalizing and externalizing problems (normative or low-problems). However, less is known about the etiology of these trajectory subtypes.

Childhood individual and family environmental factors

Understanding how individual factors and family environment relate to changing problem behaviors and their co-occurrence across childhood and adolescence is key to understanding the etiology of developmental psychopathology (Angold et al., 1999; Cicchetti & Rogosch, 1996, 2002; Leve et al., 2005; Oland & Shaw, 2005). Developmental psychopathological research encourages consideration of the matrix of individual and social-contextual contributors or antecedents, and a multiplicity of processes and outcomes of individuals at a person-oriented level within existing longitudinal data (Cicchetti & Rogosch, 1996; Rutter & Sroufe, 2000). To understand these dynamic processes, studies linking childhood individual, and environmental, including family and social-contextual, risk-factors with variations in problem behaviors have identified numerous risks for internalizing and externalizing problems in childhood and adolescence, and suggest that children following different trajectories of internalizing and externalizing problems may also differ in these risk-factors (Gilliom & Shaw, 2004; Keiley et al., 2003; Leve et al., 2005; Oland & Shaw, 2005). In terms of age, earlier longitudinal studies assessing internalizing and externalizing problems from childhood to adolescence suggest that, in general, internalizing behavior trajectory is relatively stable during childhood and increases during adolescence (Bongers et al., 2003). However, Achenbach et al. (1991) provided evidence that internalizing problems (somatic complaints, withdrawal, anxiety, and depression) increased with age among clinically referred children aged 4 to 16 years. Evidence also shows that internalizing trajectories vary by sex, and being female is a risk factor for internalizing problems (Achenbach et al., 1991; Keiley et al., 2003; Leve et al., 2005), with girls showing higher level of internalizing problems with steeper increases from childhood to adolescence than boys (Angold et al., 2002; Keiley et al., 2003). However, a meta-analysis of 310 samples of children aged 8 to 16 years using Children's Depression Inventory found that girls' depression scores are slightly lower than boys' during childhood, but increase during adolescence between ages 12 and 16 surpassing boys' scores (Twenge & Nolen-Hoeksema, 2002). Additionally, studies on childhood internalizing problems show that environmental risk factors such as low SES, exposure to a negative familial context, and maternal depression are associated with internalizing problems (Duggal et al., 2001; Fanti & Henrich, 2010; Keiley et al., 2000; Leve et al., 2005), and child temperamental unadaptability and female gender are predictors of higher internalizing symptoms (Keiley et al., 2003).

There are variations in findings regarding externalizing problems from childhood to adolescence. While some longitudinal studies find decreasing externalizing behaviors for both sexes over time from childhood to adolescence (Bongers et al., 2003, 2004;

Leve et al., 2005; Shi & Ettekal, 2020; Shi et al., 2020), others show that externalizing behavior such as status violations increases over time, although aggression, opposition, and property violations decrease on average (Bongers et al., 2004). In an epidemiological study, Barker et al. (2010) found three trajectories of conduct problems across ages 4 to 13 years. Among the "early-onset persistent" group, problems persisted over the whole period, while behavior problems decreased and prosocial behaviors increased among the "childhood-limited" group, and adjustment problems (internalizing as well as externalizing) increased while prosocial behaviors decreased after about 10 years of age among the "adolescent-onset" group (Barker et al., 2010). Several studies suggest that, in general, males develop higher externalizing difficulties than females (Achenbach et al., 1991; Bongers et al., 2004; Keiley et al., 2000, 2003). Some studies have found that early deficiencies in cognitive functioning, and difficult temperament, are related to chronic externalizing problems (Fanti & Henrich, 2010; Miner & Clarke-Stewart, 2008). Furthermore, family adversity, maternal depression, low socioeconomic status (SES), single-parent status, and child temperament have been found as the strongest predictors of externalizing problems (Ackerman et al., 2001; Brennan et al., 2003; Fanti & Henrich, 2010; Keiley et al., 2003; Leve et al., 2005). For example, Leve et al. (2005) provided evidence of childhood temperament, family environment, and interaction of these variables as predictors of changes in externalizing behaviors of children across the ages of 5 to 17 years, showing sex differences, with maternal depression predicting increases in boys' externalizing behavior when impulsivity was low, and harsh discipline predicting increases in girls' externalizing behavior when impulsivity was high or when fear/shyness was low.

Additionally, risk factors that predict co-occurring problems may be distinct from those that predict single-problem behaviors (Chen & Simons-Morton, 2009; Duprey et al., 2020; Fanti & Henrich, 2010; Keiley et al., 2003; Shi et al., 2020), although there is a concept of common and unique risk-factors. A common risk factor predicts multiple trajectory subtypes, so the same childhood factor can lead to developing different forms of problem behaviors (Cicchetti & Rogosch, 1996), whereas a unique factor predicts only one specific trajectory (Keiley et al., 2003). The concept of a common risk factor aligns with the theory of multifinality, which specifies that a single vulnerability factor, any one component, or a single starting point, may result in diverse developmental outcomes (Cicchetti & Rogosch, 1996). This concept of multifinality pertains to the question to what extent the early childhood risk factors predict differential trajectories of pure vs. co-occurring behaviors (Fanti & Henrich, 2010). For example, as evidence of multifinality, Fanti & Henrich (2010) found that medical risk, difficult temperament, or maternal depression were risk factors for the co-occurring trajectory as well as pure externalizing trajectory.

Furthermore, risk factors for problem behaviors act in a cumulative manner (Atzaba-Poria et al., 2004), and empirical studies have examined additive effects of multiple individual risk factors including child's sex, ethnicity, temperament, and personality (Fanti & Henrich, 2010; Leve et al., 2005; Shi et al., 2020; Wang et al., 2016); and, cognitive and language problems (Bornstein et al., 2013; Fanti & Henrich, 2010; Flouri et al., 2014; Petersen et al., 2013; Shi et al., 2020). There are also family environmental risk factors that appear to have additional effects, such as maternal depression, family adversity, maternal education, peer rejection, low support home environment (Fanti & Henrich, 2010; Shi et al., 2020), harsh parenting (Wiggins et al., 2015), maltreatment (Duprey et al., 2020), maternal substance use, low income, and

parental status (Picoito et al., 2020). Evidence shows that child's temperament and maternal depression are commonly associated with primary externalizing and co-occurring trajectories (e.g., Fanti & Henrich, 2010). Further, a combination of more adverse childhood individual and family environmental factors has been associated with more severe co-occurring trajectories (e.g., Fanti & Henrich, 2010; Shi et al., 2020).

In understanding the etiology of psychopathology, extensive research has conceptualized early childhood temperament traits as a core feature in explaining childhood or adolescent psychopathology. Although some suggest that genetic factors also have an important role (Wang et al., 2020), evidence is limited. Studies focusing on temperament suggest that early childhood temperament traits can be broadly defined in three domains: reactivity (which encompasses irritability, and negative affect, i.e., behaviors responding to frustration, anger, fear, and sadness); sociability; and attention (Rothbart, 2007). These traits influence concurrent and prospective internalizing and externalizing problems throughout childhood and adolescence (Fanti & Henrich, 2010; Forbes et al., 2017; Keiley et al., 2003; Shi et al., 2020; Wang et al., 2016). Among these domains, high levels of childhood reactivity, i.e., negative affect or negative emotionality, which also encompass temper-tantrums, are found as risk factors for subsequent psychopathology (Davis et al., 2015; Forbes et al., 2017; Hoyniak et al., 2022; Leve et al., 2005; Potegal & Davidson, 2003; Roy et al., 2013; Van den Akker et al., 2022; Wang et al., 2016). Forbes and colleagues (2017) showed that high levels of preschool emotional reactivity predicted higher symptom trajectories of depression, anxiety, conduct disorder, and attention-deficit hyperactivity disorder from childhood to early adolescence (Forbes et al., 2017). Temper-tantrums are behavioral displays largely due to frustration (Wakschlag et al., 2015) and emotion dysregulation (Vogel et al., 2019; Wakschlag et al., 2012), and are characterized in parental narratives as: crying, screaming, shouting, falling to the floor, kicking, hitting, pulling/pushing, running away, freezing, stamping, whining, throwing something, and clinging to someone (Potegal & Davidson, 2003; Van den Akker et al., 2022). These are common early childhood behaviors, but existing research, while limited, suggests that persistent and severe temper-tantrums are clinically significant (Carlson et al., 2009) and demonstrate risk for later psychopathology (Hoyniak et al., 2022; Roy et al., 2013; Van den Akker et al., 2022) and poorer outcomes in adulthood, e.g., poorer occupational and marital functioning (Caspi et al., 1987). Low childhood self-regulation (including temper-tantrums) is associated with negative adolescent academic, health, and mental wellbeing outcomes (Howard & Williams, 2018). However, the common and unique associations of temper-tantrums in differentiating the development of primary and co-occurring internalizing and externalizing problems remain unclear. Similarly, research shows that poor early language skills are associated with both internalizing and externalizing problems (Chow & Wehby, 2018 for review and meta-analysis); however, evidence is limited on how childhood language ability predicts subsequent co-occurring internalizing and externalizing problems (e.g., Shi et al., 2020).

Thus, there is limited evidence on how childhood individual and family environmental factors differentiate longitudinal psychopathology trajectory subtypes, particularly co-occurring trajectories, with multifinality an open question (Cicchetti & Rogosch, 1996). Additionally, the findings of extant studies are inconsistent, due to methodological differences and because most studies in this area are based on clinical, at-risk, or single-gender samples. In sum, there is very limited methodologically strong

research using large longitudinal community samples including all sexes and a broad range of childhood risk-factors, allowing greater understanding of joint development of internalizing and externalizing problems from childhood to adolescence.

The present study adds to the literature by focusing on examining heterogeneity in the co-development of internalizing and externalizing problems from childhood through mid-adolescence using a person-centered approach (parallel-process LCGA) and determining a broad range of childhood risk factors including child's individual factors (sex, temper-tantrum, and language ability), maternal factors (age, ethnicity, mental health, education) and family factors (marital problems, father living with family, family income, parental smoking, parental substance use) for heterogenous trajectories in a large longitudinal representative community sample. Although the present study takes a developmental psychopathology perspective, embedded in an ecological framework (Bronfenbrenner, 1977), this is a data-driven study and therefore does not aim to test hypotheses arising from theoretical aspects of developmental psychopathology. However, we seek to provide evidence for the concepts of multifinality of developmental psychopathology, i.e., common factors associated with varied trajectories, as well as unique factors predicting a particular trajectory, by including individual, maternal, and family factors, based on the prior evidence of association of these factors with internalizing, externalizing and co-occurring problems, and based also on the availability of the data.

Our specific aims are to investigate empirically derived joint developmental trajectories of primary and co-occurring internalizing and externalizing problems from ages 5 to 17 years, and to determine how individual, maternal, and family risk-factors are associated with those trajectory subtypes.

Methods

Design

The analysis uses deidentified data from Generation 2 (Gen2) participants of The Raine Study, an intergenerational prospective cohort study. Gen2 were the children born (live births, $n = 2868$; female $= 1414$ (49%)) from women (Generation 1 (Gen1); $n = 2900$), recruited from a tertiary maternity hospital and nearby clinics in Perth, Western Australia from May 1989 to November 1991. Gen2 questionnaire data include follow-ups in the perinatal period and years 1, 2, 3, 5, 8, 10, 14, 17, 18, 20, 22, and 27 years: these follow-up years are approximately the mean age at each survey. In addition to data from Gen1 at giving birth, this study included follow-ups at 2, 3, 5, 8, 10, 14, and 17 years. Detailed information on the Gen2 cohort profile is published elsewhere (McKnight et al., 2012; Straker et al., 2015, 2017). Previous comparisons of the Raine Study cohort at six timepoints including four used in this study (birth, year 8, year 14, and year 17) and two in adulthood (years 20 and 22) with the contemporaneous Western Australian population found that the study cohort remained broadly representative (Straker et al., 2017). The Raine Study and each follow-up received institutional ethics approval. These now have overarching approval from the University of Western Australia (RA/4/20/5722). This specific project was approved by Curtin University (HRE2019-0774).

Participants

We analyzed data from the 2393 Gen2 participants (83.4% of the total cohort; 1236 (51.7%) male sex at birth) with child

internalizing and externalizing scores for at least one follow-up at 5, 8, 10, 14, or 17 years. Participants missing these data at all follow-ups ($n = 475$) were excluded. We examined whether the included and excluded participants were different in terms of their characteristics using variables with no missing data (i.e., child's (Gen2) sex at birth, mother's age at child's birth, mother's ethnicity, and father's ethnicity). This analysis showed that the included and excluded participants were significantly different in terms of these demographic variables. Excluded participants were more likely to be girls (54.1% vs 48.4% among included participants, $p = 0.0219$); to have younger mothers at child's birth (mean age $= 25.7$ years vs. 28.5 years among included participants, $p < .0001$); non-White mothers (18.3% vs 11.3% among included participants, $p < .0001$); and non-White fathers (20.6% vs 11.0% among included participants, $p < .0001$). To reduce the bias caused by these differences, we controlled for these variables in the predictive models for the subsequent analysis.

Measures

Outcome variables

Internalizing and externalizing T-scores were the outcome variables for the trajectory analysis, assessed at years 5, 8, 10, 14, and 17 follow-ups using Child Behavior Checklist (CBCL/4–18 questionnaire with 118 items reported by parents at all ages (Achenbach, 1991a), a widely used, reliable tool for psychological categorization (Warnick et al., 2008). A different version of the questionnaire (CBCL/2–3), designed for 2–3-year-olds, was used for the year 2 follow-up. In CBCL/2–3, only 59 of the items have counterparts in CBCL/4–18, while 40 items were specifically designed for the younger age group (Achenbach, 1991b). Therefore, we excluded age 2 from our trajectory analysis. Further, to ensure continuity across follow-ups, parent report was used for all ages even when youth self-report data were available (years 14 and 17).

The internalizing problems composite scale includes symptoms of mood disturbance, including anxiety, depression, and social withdrawal. The externalizing problems composite scale includes symptoms of impulsivity, hyperactivity, conflict with others, and violation of social norms (Achenbach, 2001). Each CBCL item has a 3-point scale: 0 (not true), 1 (somewhat or sometimes true), and 2 (very true or often true). Raw internalizing and externalizing composite scale scores were converted to T-scores using age- and gender-standardized normative data included in the manual (Achenbach, 1991a, 2001). T-scores are continuous age- and gender-standardized scores with a normal distribution (mean $= 50$, standard deviation $= 10$), allowing comparisons across groups or trajectories from school-age childhood to adolescence. Higher internalizing and externalizing composite scale T-scores indicate greater problems, with T-scores ≤ 59 considered as non-clinical/low-problems/normal, 60-63 as sub-clinical or borderline, and >63 as clinically significant.

Unlike T-scores for the CBCL individual syndrome ("narrow-band") scales (e.g., aggressive behavior), T-scores for the internalizing and externalizing composite ("broadband") scales are not truncated at lower values. Therefore, using T-scores for the internalizing and externalizing composite scales for the statistical analyses yields the results similar to those using the raw scores, without losing any differentiation by truncation. Furthermore, for analyses that include both sexes and different age ranges, using T-scores for internalizing and externalizing problems takes into account the sex/age differences in scores and limits confounding

(Achenbach, 1991a, 2001). See Supplementary Appendix 1 for more information on using T-scores.

Predictors

We used a broad range of childhood individual and family environment variables as predictors of joint trajectories. Childhood individual characteristics included: sex recorded at birth (male/female); language ability indicator measured by a single question, 'Is child's speech clear/Child difficult to understand' (reported at year 3 follow-up and dichotomized as: No/clear <75% of time vs Clear ≥75% time/all time); and 'Temper-tantrum', one item from CBCL-2/3 (a version administered to children at ages 2/3, (Achenbach, 1992)) reported at year 2 follow-up (dichotomized as: Not true/Somewhat or sometimes true vs Very or often true). Although temper-tantrum is one of the internalizing/externalizing problem items of the CBCL questionnaire, we used this variable measured at year 2 follow-up as a predictor and, therefore, does not overlap with the same item of internalizing/externalizing problems used for the trajectory analysis (i.e., age 5 and onwards).

Maternal variables included: mother's age at child's birth (referred as 'mother's age' hereafter); mother's ethnicity (dichotomized: White/non-White); mother's highest level of education (reported at year 8 follow-up, categorized as: 1 no qualifications/ did not complete high school; 2 high school/trade/technical education; and 3 university degree); and mother's lifetime mental/ emotional problems (reported at year 8 follow-up: yes/no).

Family variables included: father's ethnicity (dichotomized: White/non-White); father's highest level of education (reported at year 8 follow-up, categorized as: 1 no qualifications/did not complete high school; 2 high school/trade/technical education; and, 3 university degree); family income (reported at year 5 follow-up and dichotomized: ≤ $40,000 vs >$40,000 per year)(in 1995/96 the median income in Australia was $28,494); father living with family (reported at year 5 follow-up: yes/no); parental marital problems in previous year (reported at year 5 follow-up: yes/no); either parent smoking cigarettes daily (reported at year 3 follow-up and dichotomized: yes/no); and, family member smoking other substances (e.g., cigars/pipe/cannabis/cocaine) (reported at year 3 follow-up and dichotomized: yes/no).

For reasons of data availability, we used two variables measured at the year 8 follow-up: mother's highest level of education and lifetime mental health problems, as risk factors in the predictive models. Our justification is that the date of highest qualification was likely to precede the follow-up and that lifetime mental health problems, by design, includes problems at earlier ages. We did not use father's mental health problems and father's highest qualifications in the predictive model due to relatively strong (medium-high to high) associations with some other variables and potential multicollinearity problems. Also, there may be an accuracy issue for father's mental health problems because the questionnaire including this variable was answered by mothers as the primary caregivers in most cases, although there was a small proportion of the cases evaluated by fathers or other close caregivers. See Table S1 for the bivariate associations among characteristic variables, and Table S2 for the multicollinearity check in Supplementary Appendix 1.

Statistical analysis

We used SAS Studio 3.8 to conduct descriptive analysis. Trajectory analyses using latent class growth analysis (LCGA) were performed in Mplus Version 8.8 using a full information maximum likelihood approach with robust standard errors (Enders, 2010), which handles missing data in internalizing (INT) and externalizing (EXT) problems. In assessing the development trajectories of children's internalizing and externalizing problems at five follow-ups (years 5, 8, 10, 14, and 17), prior to specifying latent classes, we specified unconditional single-class linear, quadratic, and cubic latent growth models as the initial examination of the means and growth patterns of observed internalizing and externalizing variables over time. The model fit results and graphs indicated the quadratic model for this data. The cubic models for both internalizing and externalizing data had nonconvergence and nonidentification problems. Five time points are enough for quadratic growth models, but not to detect the cubic trend (Whittaker & Khojasteh, 2017) (See Supplementary Appendix 2 for more detail on choosing the quadratic model).

We, then, estimated unconditional LCGA models (Nagin & Nagin, 2005) separately for each internalizing and externalizing process with varying numbers of classes (i.e., one to six classes) specifying linear and quadratic slopes to assess the shape of the trajectories and number of classes. This preliminary analysis suggested quadratic slopes for both internalizing and externalizing processes. Then, to identify the joint developmental trajectories, we performed unconditional quadratic parallel-process LCGA with varying numbers of classes (i.e., two to six classes) allowing means of intercept and slope growth factors to vary across classes.

To select an optimal parallel-process LCGA model, model fit was assessed using a combination of criteria: Akaike Information Criterion (AIC), Bayesian Information Criterion (BIC), sample-adjusted BIC (saBIC), number of parameters, and Vuong-Lo-Mendell-Rubin Likelihood Ratio Test (VLMR LRT), and Bootstrapped Likelihood Ratio Test (BLRT) (for the contender models only). Lower absolute values of AIC, BIC, and saBIC indicate better model fit, and significant VLMR LRT and BLRT p-values (<0.05) suggest the current model with an additional class (k) significantly improves model fit compared to the previous model with one less class (k-1) (Nylund et al., 2007). Additionally, a combination of other selection criteria was also considered: entropy and class-specific average posterior probability of assignment (APPA) for classification quality, sample size (>5%), substantive importance, and interpretability of each trajectory class (van der Nest et al., 2020). Entropy close to 0.8 or greater indicates adequate classification precision, and APPA values close to 1 (ideally>0.8) indicate a good fit and greater precision of the members' assignment to the class (Muthén & Muthén, 2000; Nagin & Nagin, 2005; Nagin, 1999; Weller et al., 2020; van der Nest et al., 2020). See Appendix 2 for a brief review of the cutoff values of entropy and APPA.

Then, we applied a manual three-step BCH (short form of Bolck, Croon, and Hagenaars (Bolck et al., 2004)) method (Asparouhov & Muthén, 2021) for the LCGA models which were the candidates for the selection. This method saved BCH weights and predicter variables for the further analyses in the next step. The BCH weights account for the measurement error of latent class variables (See Supplementary Appendix 2 for more description of BCH method).

In the next step, multinomial logistic regression using BCH weights was performed to identify predictors of the trajectory classes. This multinomial logistic regression model was specified using all predictors (child, maternal, and family variables) simultaneously so that estimates for each predictor are adjusted for effects of other predictors, i.e., controlling for potential confounding effects. Prior to this, we examined bivariate

Table 1. Model fit comparison of models with an increasing number of trajectory classes

Model fit criteria	Models with varying number of classes				
	2-Class	3-Class	4-Class	5-Class	6-Class
Akaike Information Criterion (AIC)	134328.22	133156.33	132122.39	**131682.59**	131239.82
Bayesian Information Criterion (BIC)	134490.07	133358.64	132359.38	**131960.05**	131557.74
Sample-size adjusted BIC (SaBIC)	134401.10	133247.43	132229.11	**131807.54**	131382.99
Vuong-Lo-Mendell-Rubin LRT (VMLR-LRT) P-value	<.001	<.001	0.0016	**0.0365**	0.2382
Bootstrapped Likelihood Ratio Test (BLRT) P-value	NA	NA	0.000	**<0.0001**	0.6667
Number of parameters	28	35	41	**48**	55
Entropy	0.798	0.789	0.767	**0.760**	0.762
Average posterior probability of assignment	0.95/0.93	0.91/0.92/0.88	0.89/0.83/0.90/ 0.84	**0.81/0.88/0.81/ 0.89/0.83**	0.80/0.88/0.81/ 0.83/0.81/87
Sample size per class based on the estimated model (%)	0.60/98	15.9/41/43.1	16.8/23.1/34.9/ 25.2	**17.5/29/17/ 10/26.5**	18.2/5.9/15.6/ 10.2/24.7/25.3

Note. LRT, Likelihood Ratio Test.

associations among categorical variables using Chi-squared tests for Phi Coefficients (2x2 contingency tables) and Cramer's V tests for larger contingency tables to check the potential multicollinearity problems. We also performed Variance Inflation Factor and Tolerance to examine the multicollinearity problems among the variables included in the predictive models (See Table S2 for the results of these tests in Supplementary Appendix 1). Missing data in the predictors were imputed before performing multinomial logistic regressions using multiple imputations method (using 100 datasets) which is a part of the BCH method in Mplus (Asparouhov & Muthén, 2021). See Supplementary Appendix 2 for more on the multiple imputation methods applied here.

Results

Optimal class joint trajectory model

Based on the model fit indices and other selection criteria (Table 1), we selected a five-class parallel-process LCGA model which included: *Low-problems* (Low-INT/Low-EXT, 29%, $n = 695$), *Moderate Externalizing* (Moderate-EXT/Low-INT, 26.5%, $n = 634$), *Primary Internalizing* (Moderate High-INT/Low-EXT, 17.5%, $n = 420$), *Co-occurring* (High-INT/High-EXT, 17%, $n = 406$), *High Co-occurring* (Very High-EXT/High-INT, 10%, $n = 238$) trajectory classes (Figure 1). See Supplementary Appendix 3 for more on selection of the five-class model. We also performed Wald chi-squared tests and z-tests using MODEL TEST and MODEL CONSTRAINTS commands in Mplus to test whether the identified classes were significantly different in terms of mean intercept and mean slope growth factors (each test conducted separately for internalizing trajectories and externalizing trajectories from the parallel-process model). These tests showed that the identified trajectory classes were significantly different ($p < .01$) in intercepts as well as slopes of internalizing problem trajectories as well as externalizing problem trajectories. See Table S3 in Supplementary Appendix 3 for estimated means of intercept, slope, and quadratic slope growth factors of the five-class model.

Descriptive characteristics of overall sample and trajectory classes

Table 2 presents descriptive statistics of outcome variables. Both mean internalizing and externalizing T-scores gradually declined during the adolescent period. At each timepoint, correlations
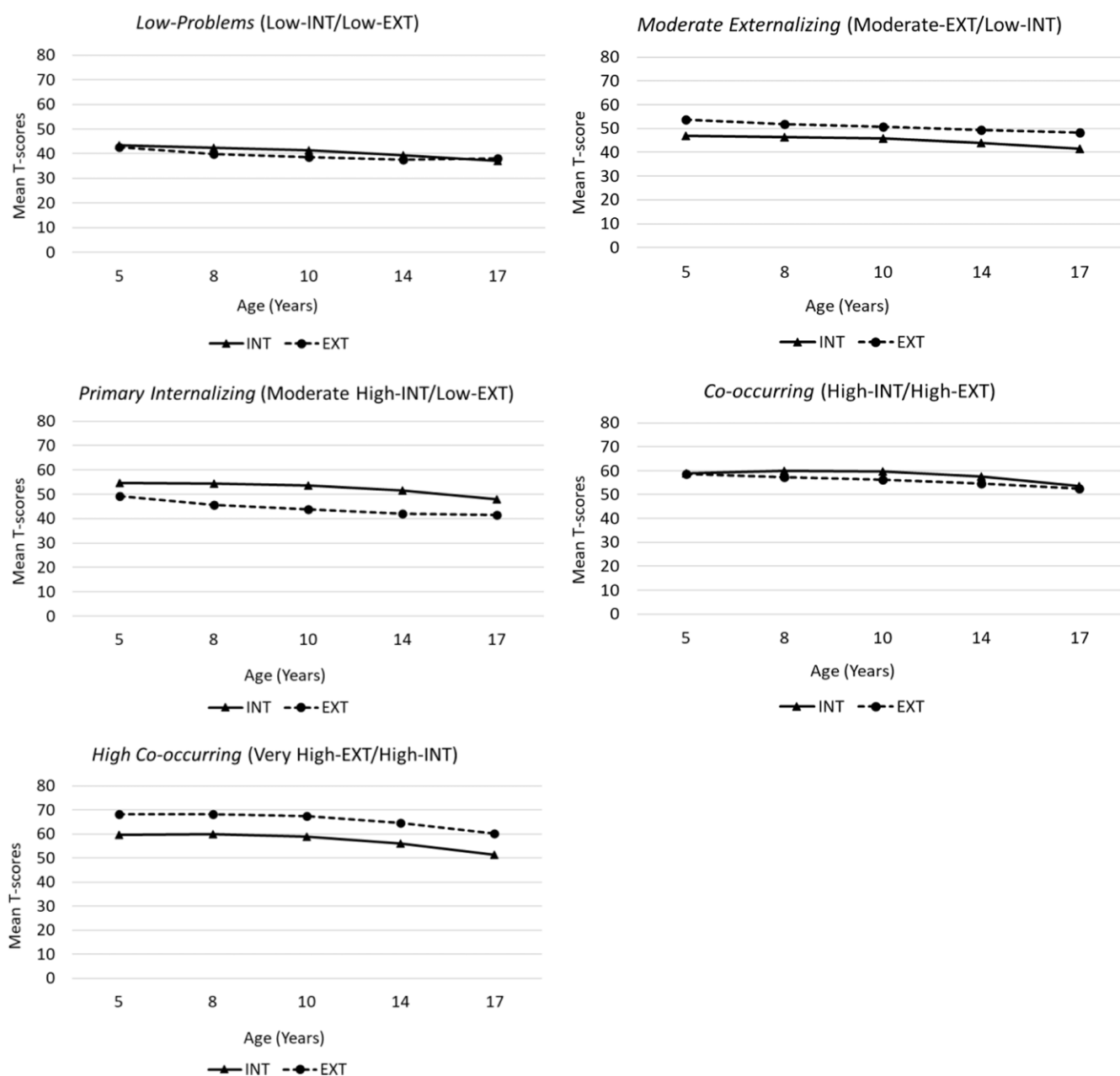
between internalizing (INT) and externalizing (EXT) T-scores were moderately high, ranging from 0.57 to 0.62.

Table 3 presents descriptive characteristics of the sample ($n = 2393$; 52% boys, 48% girls) and each trajectory class. Characteristics were measured at years 3 to 8 follow-ups. The sample was characterized by larger proportions of children who had mother older than 28 years (mean age = 28.5 years) at child's birth (54%), White parents (89%), parents with qualification of high school/trade/technical education (mothers: 55% and fathers: 57%), lower family income ($\leq$\$40,000/year, 57%), mother with no mental health problems (78%), father living with family (74%), parents reporting no marital problems (84%), parents not smoking cigarettes (73%), and none in the family smoking other substances (e.g., cannabis) (88%).

Descriptive characteristics of each trajectory class in Table 3 showed that the *Low-problems* class was characterized by larger proportions of children with older mothers, White fathers, both parents with university degrees, both parents without mental health conditions, fathers living with the family, higher family income (>\$40,000/year), parents who were nonsmokers, and no one in the family smoking other substances. The *Moderate Externalizing* class had larger proportions of children who had White mothers, mothers with no mental health conditions, and parents reporting no marital problems. The *Primary Internalizing* class was characterized by larger proportions of children whose mothers were older, non-White, with mental health problems, both parents with university degree, father living in the home, and higher family income. Larger proportions of children in the two high-problem co-occurring classes, *Co-occurring,* and *High Co-occurring*, had mothers who were younger (15–20 years) at child's birth, had no educational qualifications and had mental health problems, had fathers not living with family, had parents reporting marital problems, had parent(s) who smoked and family members smoking other substances, and lower family income. Furthermore, in the *High Co-occurring* class, larger proportions of participants were boys and had fathers with no qualification.

Multinomial logistic regression of trajectory classes: Association with childhood individual and family predictors

After selecting the five-class model, multinomial logistic regression was performed to determine the factors that predicted class

Figure 1. Joint trajectories of internalizing (INT) and externalizing (EXT) T-scores from age 5 to 17 years for each class of five-class parallel-process LCGA model.

membership in each joint trajectory class of internalizing and externalizing problems, controlling for the effects of other childhood predictors. Table 4 presents the odds ratios (ORs) and 95% confidence intervals (CIs) for predictors in each class, considering the *Low-problems* class as the reference group.

Compared with the *Low-problems* class (Table 4), those in the *Moderate Externalizing* class were more likely to have persistent temper-tantrums, younger mothers, and parent(s) who smoked cigarettes. Children in the *Primary Internalizing* class were more likely to have persistent temper-tantrums, speech difficulties (less/ not clear), non-White mothers, and mothers with mental health problems. In the *Co-occurring* class, children were more likely to have persistent temper-tantrums, mothers with mental health problems, parents with marital problems, family members smoking other substances, lower family income, and father not living at home. In the *High Co-occurring* class, children were more

likely to be male, and have persistent temper-tantrums, younger mothers, mothers with mental health problems, parents with marital problems, lower family income, and parent(s) who smoked cigarettes (Table 4).

Further multinomial logistic regression analyses were performed to compare trajectory classes with each other, other than the reference class. See Table S4 in Supplementary Appendix 4 for the results. These results showed that, compared with *High Co-occurring* group, children in the *Co-occurring* group were more likely to be girls. Compared with the *Primary Internalizing* group, the *Co-occurring* group had children with persistent temper-tantrums, White mothers, and low family income, and children in the *High Co-occurring* group were boys, who had persistent temper-tantrums, had younger mothers, White mothers, parents with marital problems, low family income, and mothers less likely to be university educated. Compared with the *Moderate*

Table 2. Descriptive statistics and correlations for internalizing (INT) and externalizing (EXT) T-scores

Age	N	Internalizing T-Score					Externalizing T-Score			
		Mean	Std dev	Minimum	Maximum		Mean	Std Dev	Minimum	Maximum
5	2170	50.33	10.13	33	88		51.98	10.23	30	86
8	2075	50.64	10.49	33	85		49.98	10.76	30	91
10	2017	49.40	10.55	33	85		47.38	10.73	30	90
14	1784	46.62	10.80	31	85		48.03	11.03	32	86
17	1355	44.37	10.41	31	80		44.93	10.47	32	88

Correlations* between internalizing (INT) and externalizing (EXT) T-scores

	INT Age 5	INT Age 8	INT Age 10	INT Age 14	INT Age 17	EXT Age 5	EXT Age 8	EXT Age 10	EXT Age 14	EXT Age 17
INT Age 5	1.00									
INT Age 8	0.64	1.00								
INT Age 10	0.54	0.63	1.00							
INT Age 14	0.45	0.52	0.58	1.00						
INT Age 17	0.41	0.47	0.49	0.62	1.00					
EXT Age 5	**0.60**	0.48	0.44	0.40	0.36	1.00				
EXT Age 8	0.45	**0.62**	0.47	0.42	0.37	0.74	1.00			
EXT Age 10	0.41	0.46	**0.62**	0.44	0.38	0.66	0.73	1.00		
EXT Age 14	0.36	0.40	0.43	**0.57**	0.41	0.58	0.66	0.71	1.00	
EXT Age 17	0.28	0.34	0.35	0.42	**0.59**	0.49	0.55	0.59	0.68	1.00

Note. *All correlation values were statistically significant with $p < .001$. Age is the approximate mean age at the respective follow-up year. Std Dev = standard deviation.

Externalizing group, children in the *Co-occurring* group were likely to have persistent temper-tantrums, non-White mothers, parents with marital problems and maternal mental health problems, and children in the *High Co-occurring* group were boys, had persistent temper-tantrums, had not clear/less clear speech, had parents with marital problems, had mothers with mental health problems, and had low family income.

Discussion

The present study contributes by investigating the development of co-occurring and distinct trajectories of internalizing and externalizing problems from childhood to mid-adolescence in a large general population cohort sample using parallel-process LCGA (i.e., a person-centered approach) and a broad range of childhood individual, maternal, and family factors predicting membership in these trajectories. We identified five joint trajectories of internalizing and externalizing problems, including two distinct and clinically significant high co-occurring trajectories, a moderately high internalizing trajectory, and two different trajectories exhibiting lower levels of both internalizing and externalizing problem behaviors. We identified a mix of unique and common risk factors predicting these trajectories and found multiple unique and common, but more adverse childhood individual, maternal, and family factors associated with the two high co-occurring trajectories compared to the lower problem trajectories.

Trajectory classes

We found some differences in the joint trajectory classes identified in the current study to those identified previously using parallel-process latent growth mixture modeling (e.g., Duprey et al., 2020;

Flouri et al., 2018; Hinnant & Mona, 2013; Oerlemans et al., 2020; Picoito et al., 2020; Shi et al., 2020; Wiggins et al., 2015), although some findings resembled their findings. Discrepant to other studies, the identification of a *High Co-occurring* class, in addition to a *Co-occurring* class, was a novel finding of this study. These two high-severity co-occurring classes revealed the existence of heterogeneity in the severity of co-occurring problems. Notably, around a third of the sample (27%) fell into these two higher-severity classes (10% belonging to *High Co-occurring* and 17% to *Co-occurring*) exhibiting clinically significant co-occurring problems. Children in the *High Co-occurring* class showed clinically elevated externalizing scores (mean T-scores >63) with sub-clinical (i.e., at-risk) internalizing problems (mean T-scores between 60 and 63), and those in the *Co-occurring* class had both internalizing and externalizing problems at sub-clinical levels (mean T-scores between 60 and 63). In contrast, children in the other three non-co-occurring trajectory groups, with primary internalizing (*Primary Internalizing*) or low internalizing and externalizing problems (*Low-problems* and *Moderate Externalizing* classes), showed non-clinical behavioral problems (mean T-scores ≤59). Thus, these findings support the notion that co-occurrence of high-problem behaviors should be considered as a distinct syndrome or symptomology (Angold & Costello, 1992; Lilienfeld, 2003; O'Connor et al., 1998). Importantly, children who show high co-occurring problem behaviors are at significantly elevated risk for more severe psychopathology in the future than children with primary internalizing or externalizing problems (Oerlemans et al., 2020; Papachristou & Flouri, 2020).

While we did not find a primary high internalizing trajectory class (high internalizing with low externalizing problems) as found in some other studies (e.g., Chen & Simons-Morton, 2009; Fanti & Henrich, 2010; Hinnant & Mona, 2013), we identified a class with

Table 3. Descriptive characteristics of the sample (*n* = 2393) and five joint trajectory classes based on the most likely class membership*

Characteristics (assessed at follow-up years 3–8)	Total sample (*N* = 2393)	Five trajectory classes				
		Low-problems (29%; *n* = 695)	Moderate externalizing (27%; *n* = 634)	Primary internalizing (18%; *n* = 420)	Co-occurring (17%; *n* = 406)	High co-occurring (10%, *n* = 238)
	n (%)	*n* (%)	*n* (%)	*n* (%)	*n* (%)	*n* (%)
Sex (*n* = 2393)						
Male	1236 (51.7)	350 (28.3)	337 (27.3)	205 (16.6)	205 (16.6)	139 (11.2)
Female	1157 (48.3)	349 (30.2)	313 (27.1)	202 (17.5)	199 (17.2)	94 (8.1)
Mother's age at child's birth (*n* = 2393)						
15–20 years	262 (10.9)	45 (17.2)	73 (27.9)	33 (12.6)	59 (22.2)	52 (19.8)
21–27 years	829 (34.6)	207 (25.0)	234 (28.2)	137 (16.5)	159 (19.2)	92 (11.1)
≥28 Years	1302 (54.4)	447 (34.3)	343 (26.3)	237 (18.2)	186 (14.3)	89 (6.8)
Mother's race (*n* = 2392)						
White	2145 (89.7)	631 (29.4)	600 (28.0)	342 (15.9)	360 (16.8)	212 (9.9)
Non-White	247 (10.3)	67 (27.1)	50 (20.2)	65 (26.3)	44 (17.8)	21 (8.5)
Father's race (*n* = 2392)						
White	2130 (89.0)	633 (29.7)	584 (27.4)	351 (16.5)	356 (16.7)	206 (9.7)
Non-White	262 (11.0)	65 (24.8)	66 (25.2)	56 (21.4)	48 (18.3)	27 (10.3)
Mother's highest qual[b] (Y[a]8; *n* = 2058)						
No qualification	521 (23.3)	120 (23.0)	145 (27.8)	81 (15.5)	105 (20.2)	70 (13.4)
High school/Trade/Technical	1136 (55.2)	349 (30.7)	311 (27.4)	187 (16.5)	187 (16.5)	102 (9.0)
University degree	401 (19.5)	141 (35.2)	105 (26.2)	88 (21.9)	54 (13.5)	13 (3.2)
Father's highest qual[b] (Y8; *n* = 1795)						
No qualification	329 (18.3)	83 (25.2)	104 (31.6)	45 (13.7)	52 (15.8)	45 (13.7)
High school/Trade/Technical	1022 (56.9)	304 (29.7)	289 (28.3)	179 (17.5)	159 (15.6)	91 (8.9)
University degree	444 (24.7)	177 (39.9)	105 (23.6)	94 (21.2)	59 (13.3)	9 (2.0)
Family income/year[d] (Y5; *n* = 2102)						
≤ $40, 000	1198 (57.0)	291 (24.3)	332 (27.7)	182 (15.2)	235 (19.6)	158 (13.2)
> $40,000	904 (43.0)	328 (36.3)	245 (27.1)	176 (19.5)	115 (12.7)	40 (4.4)
Mother's MH problem (Y8; *n* = 2080)						
No	1623 (78.0)	537 (33.1)	475 (29.3)	265 (16.3)	238 (14.7)	108 (6.7)
Yes	457 (22.0)	78 (17.1)	88 (19.3)	96 (21.0)	113 (24.7)	82 (17.9)
Father's MH[c] problem (Y8; *n* = 1792)						
No	1613 (90.0)	518 (32.1)	445 (27.6)	284 (17.6)	246 (15.3)	120 (7.4)
Yes	179 (10.0)	40 (22.3)	51 (28.5)	33 (18.4)	32 (17.9)	23 (12.8)
Father living with family (Y5; *n* = 2185)						
No	565 (25.9)	105 (18.6)	160 (28.3)	77 (13.6)	127 (22.5)	96 (17.0)
Yes	1620 (74.1)	536 (33.1)	434 (26.8)	299 (18.5)	235 (14.5)	116 (7.2)
Marital problems last year (Y5; *n* = 2140)						
No	1805 (84.3)	574 (31.8)	513 (28.4)	311 (17.2)	266 (14.7)	141 (7.8)
Yes	335 (15.7)	60 (17.9)	72 (21.5)	53 (15.8)	87 (26.0)	63 (18.8)
Either parent smoking tobacco (Y3; *n* = 2105)						
No	1532 (72.8)	508 (33.2)	407 (26.6)	267 (17.4)	242 (15.8)	108 (7.0)
Yes	573 (27.2)	117 (20.4)	175 (30.5)	91 (15.9)	109 (19.0)	81 (14.1)
Anyone smoking other substances (Y3; *n* = 2100)						
No	1856 (88.4)	580 (31.2)	512 (27.6)	317 (17.1)	288 (15.5)	159 (8.6)
Yes	244 (11.6)	47 (19.3)	67 (27.5)	39 (16.0)	62 (25.4)	29 (11.9)

(*Continued*)

Table 3. (Continued)

Characteristics (assessed at follow-up years 3–8)	Total sample (N = 2393)	Five trajectory classes				
		Low-problems (29%; n = 695)	Moderate externalizing (27%; n = 634)	Primary internalizing (18%; n = 420)	Co-occurring (17%; n = 406)	High co-occurring (10%, n = 238)
Child's temper tantrum (Y2; n = 1755)						
Not/sometimes/somewhat true	1474 (84.0)	499 (33.9)	400 (27.1)	257 (17.4)	215 (14.6)	103 (7.0)
Very/often true	281 (16.0)	33 (11.7)	75 (26.7)	42 (14.9)	77 (27.4)	54 (19.2)
Speech ability (Y3; n = 2106)						
Clear >75% of time/all time	1903 (90.4)	571 (30.0)	539 (28.3)	312 (16.4)	316 (16.6)	165 (8.7)
Not clear/clear <75% of time	203 (9.6)	55 (27.1)	41 (20.2)	47 (23.2)	35 (17.2)	25 (12.3)

*Note: Proportions of the classes estimated by the model and the proportions of the most likely class membership are slightly different in Mplus results.
[a]Y = follow-up year which approximately equates to mean age of child at that year.
[b]qual. = qualification.
[c]MH = mental health.
[d]For comparative purposes, $40,000 in 1995 adjusted for inflation would be $73,492 in 2021 (Source: Reserve Bank of Australia. (2022). *Inflation Calculator*. Accessed 14 Sept 2022; Available from: https://www.rba.gov.au/calculator/annualDecimal.html).

moderately elevated internalizing and low externalizing problems (i.e., *Primary Internalizing* class). Although non-clinical, children in this group showed moderately high internalizing problems with mean T-scores above average (i.e., >50 and <59) at most of the follow-ups. A possible explanation for not identifying high internalizing with low externalizing problems could be that, in general, children who have high internalizing problems (clinical or sub-clinical) also demonstrate high externalizing problems (Lee & Stone, 2012), as we have found in our two co-occurring groups. We also speculate that one reason this class (*Primary Internalizing*) does not reach clinical thresholds for 'pure internalizing' may be that parents did not sufficiently observe high internalizing problems among children who had low externalizing problems. Similarly, we did not identify a pure externalizing trajectory (high externalizing with low internalizing problems), as found in some studies (Chen & Simons-Morton, 2009; Fanti & Henrich, 2010; Nivard et al., 2017; Shi et al., 2020). The reason for this is unclear. However, it could be due to using exclusively parent-reported data. As observed in the previous work in this cohort, by mid-adolescence, when youth report their own symptoms (self-report), a greater proportion of self-reports than parent-reports reach clinical thresholds (Robinson et al., 2019). Nevertheless, Oerlemans et al. (2020) used self-report measures and found lower T-scores in the final follow-up (age 19) than in earlier waves for most of their trajectory classes, and Leve et al. (2005) reported decreasing externalizing scores over time for both boys and girls, although internalizing behaviors increased over time for girls.

Interestingly, we found that both internalizing and externalizing trajectories in the *High Co-occurring* class (where boys were more likely to be in this class) decreased slightly during adolescence. Some previous studies (e.g., Leve et al., 2005; Shi & Ettekal, 2020; Shi et al., 2020) support our finding; however, the reasons are unclear. Some suggest that externalizing behaviors are more likely to be overt during early childhood but more covert during later years (Bongers et al., 2003), and therefore, parents may not know the full range of externalizing problem behaviors in which adolescents engage (Leve et al., 2005), as shown in a separate analysis of the Raine Study comparing parent report to youth self-report CBCL (Robinson et al., 2019). Another possible explanation for not finding evidence of adolescent-onset behavioral problems in this study could be a limitation of the CBCL, which does not measure all adolescent-onset

problem behaviors, such as robbery and physical assault. As suggested by the previous studies (Leve et al., 2005; Robinson et al., 2019), adolescents might be better reporters than parents. Furthermore, there is also evidence showing a modest positive association between changes in externalizing problems and changes in internalizing problems (i.e., decrease (or increase) in one domain follows a decrease (or increase) in the other) among children assessed in kindergarten through seventh grade (Keiley et al., 2000), and among female adolescents (Lee & Stone, 2012; Measelle et al., 2006), indicating externalizing problems can precipitate internalizing problems (and vice versa) as well as reciprocal effects across the two domains (Lee & Stone, 2012). This evidence is consistent with our findings of declining co-occurrence of internalizing and externalizing problems in the *High Co-occurring* class during adolescence.

Risk factors

The analysis of risk factors associated with identified trajectories revealed that persistent temper-tantrum, maternal mental health problems, younger mother, lower family income, parental marital problems, and father not living with family were relevant in explaining more severe trajectories (*High Co-occurring, Co-occurring*, or *Primary internalizing*), compared to *Low-problems* group. In examining how these risk-factors differentiated the co-occurring groups (*Co-occurring* and *High Co-occurring*) from other trajectory groups, we found that children in both co-occurring trajectories displayed a more severe profile of childhood risk factors. Child's persistent temper-tantrum, maternal mental health problems, low family income, parental marital problems, and father not living with family were associated with both *Co-occurring* and *High Co-occurring* groups, compared with *Low-problems* group. Younger mother and parental cigarette smoking predicted membership in the *High Co-occurring* group. Family member's substance smoking (other than cigarettes) was uniquely associated with the *Co-occurring* group, and male sex was uniquely associated with the *High Co-occurring* trajectory. These findings are consistent with previous studies (e.g., Fanti & Henrich, 2010; Leve et al., 2005; Oerlemans et al., 2020; Shi et al., 2020; Wiggins et al., 2015; Willner et al., 2016) supporting the notion that a combination of multiple biological (e.g., sex), individual (e.g.,

Table 4. Multinomial logistic regression: Predictors of joint trajectory classes of internalizing and externalizing problems from childhood to mid-adolescence, considering *Low-Problems* as a reference class (N = 2393)

Childhood factors (assessed at follow-up years 2–8)	Moderate Externalizing vs low-problems OR (95% CI)	Primary internalizing vs low-problems OR (95% CI)	Co-occurring vs low-problems OR (95% CI)	High co-occur-ring vs low-problems OR (95% CI)
Sex				
Female (vs Male)	0.86 (0.66–1.14)	0.99 (0.71–1.40)	0.93 (0.67–1.29)	**0.56 (0.38–0.83)**
Mother's age at child's birth (unit/SD)[a]	**0.85 (0.73–0.99)**	0.90 (0.75–1.09)	0.86 (0.72–1.03)	**0.69 (0.55–0.86)**
Mother's race				
Non-White (vs White)	0.81 (0.47–1.38)	**2.66 (1.62–4.38)**	1.49 (0.88–2.54)	1.26 (0.64–2.48)
Mother's highest qualification (Y[b]8)				
No qualification (vs High school/Trade/Technical)	1.14 (0.79–1.66)	1.13 (0.70–1.82)	1.35 (0.89–2.04)	1.56 (0.97–2.51)
University degree (vs High school/Trade/Technical)	1.02 (0.69–1.76)	1.25 (0.80–1.94)	0.90 (0.56–1.45)	0.45 (0.19–1.05)
Mother's mental health problem (Y8)				
Yes (vs No)	1.10 (0.69–1.50)	**3.17 (2.00–5.02)**	**3.32 (2.15–5.13)**	**4.77 (2.92–7.80)**
Family income per year (Y5)				
>$40,000 (vs ≤$40,000)	0.83 (0.60–1.15)	1.14 (0.77–1.70)	**0.62 (0.42–0.92)**	**0.40 (0.23–0.67)**
Marital problem last year (Y5)				
Yes (vs No)	1.05 (0.64–1.73)	1.51 (0.87–2.64)	**2.47 (1.54–3.96)**	**2.91 (1.74–4.87)**
Father living at home with family (Y5)				
Yes (vs No)	0.70 (0.47–1.04)	0.96 (0.59–1.58)	**0.60 (0.40–0.92)**	**0.61 (0.38–0.99)**
Parent's tobacco-smoking (Y3)				
Yes (vs No)	**1.60 (1.10–2.31)**	1.48 (0.93–2.35)	1.09 (0.71–1.68)	**1.73 (1.07–2.81)**
Parent's smoking other substances (Y3)				
Yes (vs No)	1.22 (0.71–2.09)	1.30 (0.68–2.49)	**1.90 (1.10–3.31)**	0.98 (0.49–1.95)
Child's temper tantrum (Y2)				
Very/often true (vs Not/sometimes/somewhat true)	**3.07 (1.66–5.69)**	**2.83 (1.43–5.61)**	**6.07 (3.38–10.89)**	**8.95 (4.74–16.90)**
Speech ability (Y3)				
Not clear/clear <75% of time (vs Clear >75% time/all time)	0.71 (0.39–1.27)	**1.82 (1.04–3.18)**	1.09 (0.59–1.99)	1.41 (0.74–2.69)

Note: Significant (*p* < 0.05) estimates are bolded.
[a]Mean standardized. SD = standard deviation.
[b]Y = follow-up year which approximately equates to mean age of child at that year.

temperament, language ability), and contextual (e.g., family environment) variables is associated with the emergence and maintenance of co-occurrent problem behaviors through some additive or interactive mechanisms (Atzaba-Poria et al., 2004; Cicchetti & Toth, 1998).

Importantly, our results showed that two factors, maternal mental health problems and persistent temper-tantrum, were the common factors for all three more severe groups (*High Co-occurring, Co-occurring,* and *Primary Internalizing*). That is, children who had persistent temper-tantrum and whose mothers had mental health problems were at greater risk for developing either *Primary Internalizing or Co-occurring or High Co-occurring* problems. This result is the evidence of multifinality, i.e., children sharing similar characteristics may exhibit different patterns of later developmental outcomes. Due to the ongoing dynamic transaction of risk and protective processes experienced uniquely by individuals, varied outcomes will emerge (Cicchetti &

Rogosch, 1996, 2002). Similarly, low family income, marital problems, and father not living at home with family appeared as the common factors for the two co-occurring trajectories. Elucidating a developmental psychopathology approach, a previous study (Cicchetti & Toth, 1998) shows a conceptual framework suggesting that children of depressed mothers are at increased risk of behavioral problems, but maternal depression impacts child problem behavior via several contextual risk factors (e.g., social support, marital quality, and family conflict) as mediators. Other studies suggest a framework that socioeconomic disadvantage contributes to negative parenting practices impacting children's behavioral problems through higher levels of parental psychological distress and marital conflict (Conger et al., 2010; Roubinov & Boyce, 2017). We chose a different approach to examine direct association of childhood maternal mental health and several other maternal and family factors as predictors with each trajectory, consistent with other empirical

studies (Shi et al., 2020). Our findings (including substantially higher odds of maternal mental health problems in both co-occurring groups compared with *Low-problems* group) exhibit an additive effect and suggest that children who have mothers with mental health problems during their early childhood along with an accumulated profile of multiple other adverse individual and family factors have higher risk of adverse concurrent problem behavior trajectories through childhood to adolescence, concordant with previous studies (e.g., Fanti & Henrich, 2010; Wiggins et al., 2015).

Similarly, some studies have suggested that the association between child temperament characteristics and child internalizing and externalizing problem behaviors is moderated by family environmental factors (Leve et al., 2005; Morris et al., 2002). Although we did not formally test the moderating effects of family variables in the present study, our results accord with this finding. We found that persistent temper-tantrums were associated with all four trajectory classes, compared to *Low-problems* class, but the effect magnitudes were substantially higher for the two severe co-occurring classes than the other classes, i.e., children with persistent temper-tantrums were nine times more likely to be in *High Co-occurring* class and six times more likely to be in *Co-occurring*, as opposed to approximately three times more likely to be in the other two classes. This finding supports the previous research suggesting persistent temper-tantrums may be markers of subsequent psychiatric disorders (Belden et al., 2008). Also, in both co-occurring trajectories, the effect magnitudes for persistent temper-tantrums were greater whereas the effect magnitudes for maternal mental health problems and marital problems were also greater, along with other associated adverse risk factors suggesting an additive effect of accumulated adverse family factors, as shown in prior studies (Atzaba-Poria et al., 2004; Capaldi et al., 2012; Fanti & Henrich, 2010; Keiley et al., 2003; Leve et al., 2005; Oland & Shaw, 2005; Shi et al., 2020). This suggests that children with persistent temper-tantrums at 2 years of age who also experienced a severe profile of accumulated adverse family factors were at greater risk of exhibiting subsequent severe co-occurring internalizing and externalizing problems.

Although studies show that language deficit is associated with both internalizing and externalizing problems (Chow & Wehby, 2018), an interesting difference in our findings was that we found a unique association of speech difficulties with the *Primary Internalizing* group, which partially agrees with a study showing an association between language deficit and emotional disturbance among students (Nelson et al., 2005). These findings suggest that children with speech difficulties may have problems with communicating and interpreting social cues and are at risk of developing higher internalizing problems. Contrary to prior work (e.g., Leve et al., 2005), we did not find a significant association between female sex and membership in the *Primary Internalizing* class or the co-occurring problem classes, compared to *Low-problems* class. However, we found that children with speech difficulties and temper-tantrums, non-White mothers, and maternal mental health problems were at greater risk of having higher internalizing with low externalizing problems. On the other hand, our results showed that children who experienced fewer or less severe individual, maternal, and family risk factors, i.e., with a more positive and enhanced family environment (protective factors), were more likely to have low levels of internalizing and externalizing problems (i.e., *Low-problems* class).

Strengths

The analysis used a relatively large representative community sample with extended follow-up (birth to about 17 years) plus individual, maternal, and family factors, thus enabling the inclusion of a broader range of childhood predictors. The parallel-process LCGA approach was methodologically strong and allowed the analysis of two domains simultaneously to investigate co-occurrent conditions. This enabled the identification of distinct trajectory classes with varying severity of joint development including those at risk of severe co-occurrence.

Limitations

Although extensively used and validated, the CBCL uses survey data based on diagnostic criteria, rather than providing a clinical diagnosis (Warnick et al., 2008), with results reflecting a spectrum of mental wellbeing. Further, to ensure continuity across follow-ups, parent report was used even though youth self-report data were available at year 14- and 17 follow-up. Additionally, we used the term "predictor" but note that parental educational level and mental health problems were assessed at the year 8 follow-up and so cannot "predict" items measured at the year 5 follow-up, even though highest qualification is likely to pre-date that time. However, parental mental health problems were ascertained as "lifetime mental health problems", which are more likely to pre-date the analysis time course, and therefore mother's mental health problems, which have been used in the predictive model, can be considered as a risk-factor.

Also, questionnaires were completed by the primary caregiver, mostly but not always mothers. Consequently, "mother's mental health problems" may not be accurately reported for some cases. Further, parental mental health problems or stress may influence parental evaluation of children's emotional and behavioral problems. Furthermore, some risk factors (mother's mental health problems, temper-tantrum, and speech problems) used in the predictive analysis were measured by a single question, instead of a questionnaire measuring a construct related to each of these variables. While some suggest that a single item can sometimes be as effective and reliable as a multi-item questionnaire construct (Verster et al., 2021), measurement reliability could be an issue.

Implications

The identification of more than one-quarter of the sample with co-occurring internalizing and externalizing problems emphasizes the importance of considering co-occurrence of problem behaviors as a distinct syndrome and delivering interventions that simultaneously support these developmental vulnerabilities. Our findings indicate the additive effects of early childhood risk factors, including maternal mental health problems and persistent temper-tantrum, may set the stage for the development of elevated internalizing problems and co-occurring internalizing and externalizing problems. Those exhibiting co-occurring and high co-occurring problems had typically incurred multiple adverse childhood factors including persistent temper-tantrum and maternal mental health problems, supporting the theory of multifinality as well as additive effects of multiple family factors including low income, marital problems and father not living with family. This in turn suggests the importance of broad-based community interventions in earlier life and in childhood that promote child competence and support adaptive family

relationships to prevent children's developmental failures and thereby related disorders (Cicchetti & Toth, 1998). This is consistent with the recent emphasis on holistic early-life interventions occurring within the first 1000 and 2000 days of life (Darling et al., 2020; New South Wales Ministry of Health, 2019). Further, the association of maternal mental health problems associated with elevated internalizing trajectory and both co-occurring trajectories emphasizes the importance of identifying at-risk mothers and fostering social support and other specific interventions to alleviate parental mental health problems, particularly among mothers, which is important to enhance parent-child adaptive communication and interaction, and to reduce larger family stresses such as marital discord (Cicchetti & Toth, 1998). The finding of greater association of persistent temper-tantrums with high co-occurring psychopathologies and elevated internalizing trajectories indicates that persistent temper-tantrums may be markers of future psychiatric disorders. This association also indicates that children of mothers with mental health problems are at risk of development of a wide range of emotional and behavioral problems, which could be due to that these mothers may find difficulties in getting involved with positive and effective parenting (Mesman et al., 2009). Additionally, we found childhood-onset problem behaviors, but we did not find evidence of adolescent-onset problems, which could be due to using a community-based sample where there may not be a lot of adolescent-onset problem behaviors, as in the high-risk or clinical sample. Another explanation could be, as suggested by prior evidence, that childhood-onset problems and adolescent-onset problems (e.g., depressive disorders) may be differentially influenced by genetic and psychosocial factors (Cicchetti & Rogosch, 2002). However, psychosocial stressors including higher familial problems (such as higher rates of criminality, substance abuse in the family, or family discord) may have a more prominent role in childhood-onset problems than in the adolescent-onset problem behavior (Cicchetti & Rogosch, 2002). These findings underscore that interventions for child, mother, and family environment should, where possible, be undertaken early when problems are more remediable during early childhood.

Additionally, an association between children with speech difficulties and higher internalizing problems with low externalizing problems indicate that these children may have communication and social skill problems and are at risk of developing associated internalizing problems. Overall, these results suggest that if individual risk-factors such as temper-tantrums and speech difficulties are undiagnosed and untreated at early ages, children will be at greater risk of developing higher psychopathologies during their childhood and adolescence. Taken together, these findings highlight the importance of early identification of risk-factors as well as early mental health and preventive interventions including broad-based community interventions early in life before behavioral outcomes (e.g., antisocial behaviors) and emotional psychopathology become problematic, which will lead to more positive developmental outcomes for the whole family, a positive foundation for the child's physical, social-emotional and cognitive development, and significant benefits to the community (Forbes et al., 2017; Shonkoff & Fisher, 2013). These findings may also help design interventions and treatment strategies by providing information on unique and common risk-factors influencing different subtypes of trajectories including moderate externalizing, primary internalizing, and co-occurring and high co-occurring emotional and behavioral problem trajectories.

Conclusion

Around a third of the sample exhibited co-occurring and high co-occurring trajectories of internalizing and externalizing problems and displayed a more severe profile of individual, maternal, and family risk-factors, indicating the importance of considering co-occurrence when a child presents with high internalizing and high externalizing problems. Our findings emphasize the severe consequences of maternal mental health problems and persistent temper-tantrum as well as family factors including marital problems, father not living with family, and low income, on the development of internalizing and externalizing problems and their co-occurrence during childhood through to adolescence. Earliest possible targeted interventions and broad-based social support are emphasized to reduce modifiable risk-factors, e.g., persistent temper-tantrums, speech difficulties, maternal mental health problems, family discord, parental smoking, or substance use, and associated subsequent behavioral and mental health problems during late childhood and adolescence.

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