

Longitudinal trajectories of depression symptoms in adolescence: Psychosocial risk factors and outcomes

Rachel Ellis^{1, 3, 4}, Marc L. Seal^{2,3}, Julian G. Simmons^{1,5}, Sarah Whittle^{1,5}, Orli Schwartz^{1,4}, Michelle Byrne⁶, Nicholas B. Allen^{1,4,6}

1. Melbourne School of Psychological Sciences, University of Melbourne, Australia

2. Department of Paediatrics, University of Melbourne, Australia

3. Murdoch Childrens Research Institute, Royal Children's Hospital, Australia

4. Orygen, The National Centre of Excellence in Youth Mental Health, University of Melbourne, Australia

5. Melbourne Neuropsychiatry Centre, Department of Psychiatry, The University of Melbourne and Melbourne Health

6. Department of Psychology, University of Oregon, USA

Nicholas B. Allen (Corresponding author)

Department of Psychology, University of Oregon, Eugene OR 97403-1227, USA

T: 541 346 4075| F: 541 346 4911| E: nallen3@uoregon.edu

Abstract

Variations in symptom trajectories within a population may represent distinct groups with different etiologies and outcomes. This study aimed to identify subgroups of depression symptom trajectories in a sample of adolescents, and to describe psychosocial attributes of the different groups.

In a longitudinal study, 243 adolescents (121 males and 122 females), were assessed using a battery of measures of temperament, psychopathology, and psychological and behavioral functioning. Four phases of data collection over seven years spanned average ages of the participants from 12 – 18 years old. Depressive symptoms from each phase were used to model latent class growth trajectories.

A four-group solution was selected as the best-fitting model: (1) ongoing stable low levels of depression; (2) very high depressive symptoms initially, but a steep decrease in symptoms over time; (3) moderately high depressive symptoms initially, but symptoms decreased over time; and (4) initially low levels of symptoms that increased over time. Trajectory group membership was associated with a range of psychosocial variables including temperament, childhood maltreatment, and young adult quality of life.

Characterising these subgroups allows for a better understanding of how the interaction of risk factors increases the likelihood of depression and other poor outcomes, and highlights the importance of early interventions to prevent and treat adolescent depression.

Key Words: Depression; Adolescence; Growth Mixture Modeling; Risk Factors; Longitudinal Studies

Introduction

Adolescence is a critical period of development during which there is increased risk for depression [1]. This increased risk likely involves a complex interaction of biological, environmental, and social factors [2]. This is particularly consequential as adolescents who experience depression often continue to experience negative psychosocial ramifications, with earlier onset associated with greater harm [3, 4]. This is not surprising, as depression can interrupt the attainment of educational and occupational goals, and the development of social relationships during these important formative years [5].

Despite the population level increase in vulnerability to depression across adolescence, there is considerable individual variation in the rise and fall of depressive symptoms over this period [5-7]. Statistical modelling techniques such as latent class growth analysis (LCGA) and growth mixture modelling (GMM) [8] can detect homogeneous subgroups within the larger heterogeneous population. That is, individuals who share similar trajectories of depressive symptoms cluster into groups that are distinguishable from each other. The ability to model multiple latent growth curves is important because different patterns of change in symptom levels within a population may represent different subtypes of a disorder, different etiological processes, or different clusters of comorbidities. Importantly, different trajectory patterns may also have different prognoses and different psychosocial outcomes [9-11]. Being able to characterise these different groups may elucidate mechanisms and enable better targeting of prevention and treatment programs.

A number of longitudinal studies have used GMM or similar techniques to characterise trajectory subgroups of adolescent depressive symptoms (see Table 1). As

there are significant methodological differences between these studies, their results vary in terms of the number and shape of the trajectories modelled. However, some important commonalities emerge in their findings. Every study reviewed here found that multiple trajectories fit their data better than a single trajectory, which supports the presence of meaningful subgroups within the larger population. Also, every study reported one large subgroup that had consistently low depressive symptoms over time, which is to be expected given that the majority of adolescents do not suffer from clinical levels of depression [1]. Fourteen of the 18 studies identified at least one subgroup that had increasing levels of depressive symptoms over time, and 14 studies identified at least one subgroup that had symptoms that declined over time. Two studies that did not find a group with increasing levels of depressive symptoms included age ranges that extended into adulthood [12, 13], so the mean trajectories may have been altered by later decreases in depressive symptoms. Ten of the 18 studies concluded that a 4-group model best fit their data, 6 studies preferred a 3-group model, one study reported a 5-group model [14], and one study reported a 6-group model [15], although this study included children under ten years old.

These studies analyzed a range of variables to identify risk and protective factors amongst their subgroups. Factors that were often associated with histories of elevated depressive symptoms included female gender [13, 16-22], and poorer relationships with parents [17, 18, 22-24] or peers [13, 17, 18]. Other factors found to be associated with depression trajectory membership were alcohol or other drug use [18, 20], low self-esteem [18, 19, 25], poor academic achievement [12, 14, 15, 19], negative affectivity [21], and stress/adversity [12, 17, 19, 24]. Furthermore, some studies examined adult outcomes of the different trajectories. Outcomes associated with elevated depression

trajectories included social and emotional problems, and poorer self-esteem [25]. Elevated depression trajectories have been associated with higher self-reported depression ratings and other mental health problems [15, 26], and lower educational attainment in adulthood [15]. Wickrama and Wickrama [27] found that higher adolescent depression trajectories contributed to young adult risk behaviours, such as committing crime, excessive drinking, and smoking. Similarly, Reinke et al. [28] identified groups with elevated depression symptoms that were more likely to have disruptive behaviour, alcohol and drug problems in adulthood than a low-depression group. Finally, Sabiston et al. [29] reported that groups with elevated depression trajectories had lower levels of physical activity and team sport participation in young adulthood.

The aims of the present study were firstly to examine longitudinal trajectories of depression symptoms in a sample of Australian adolescents using growth mixture modelling, and secondly to identify psychosocial risk factors and outcomes associated with different trajectories using the most contemporary statistical techniques. Most previous studies have examined a narrow range of covariates measured at either the beginning or end of the trajectory period. The current study extends previous research by examining a wide range of both predictor and outcome variables, covering demographic, psychological, and environmental attributes in a single analysis. By including both early predictors and late outcomes across the whole range of adolescence, within a single cohort, we aim to characterise the timing and persistence of other psychosocial factors relevant to depression, and better understand patterns of risk and recovery.

Based on the findings of previous studies, we expected to find either three or four latent trajectory classes. We expected to find one group with consistently low levels of depressive symptoms, representing the majority of the sample. Given that the majority of the trajectory studies outlined (Table 1) found groups with increasing symptoms and groups with decreasing symptoms, we also expected to find at least one group with each of these patterns.

We analyzed a range of variables that were chosen to encompass different domains, e.g. demographic (gender, socioeconomic status), psychological (temperament profile), and environmental (childhood neglect and abuse). All have previously been shown to be associated with risk for depression [4, 5, 19, 30-32]. In doing so, we aimed to determine whether different domains of risk tend to relate more strongly to different depression trajectories. We expected to find that female gender, lower SES, and higher levels of childhood maltreatment would all be associated with high depression trajectories, relative to the low-symptom group. The temperament dimension of Negative Emotionality has been specifically associated with depression [30], so we expected to see higher scores on this dimension in high depression trajectory groups.

We also wanted to characterise outcomes at the end of adolescence, so we analyzed variables measured at the final wave of data collection including drug use (tobacco, marijuana, and alcohol), life-role stress and morale, social support, relationship quality, positive outlook, physical health, and lifetime diagnoses of depression, anxiety, and other disorders. Given research findings that depression is associated with ongoing functional impairment that persists after remission [3, 4, 33, 34], we expected to find that the low-depression group had the most favourable

outcomes on these measures, even relative to a group whose higher symptoms had decreased by the end of adolescence.

Finally, three additional variables were analyzed at every time point throughout the study, in order to track their change over time for each of the depression groups. These were anxiety symptoms, global functioning, and parental ratings of externalizing problems (i.e. behavior that conflicts with others, such as rule-breaking and aggression [35]). We expected to find that these fluctuated to some extent in concert with depressive symptoms, given that previous research has found strong correlations between depression and anxiety [36], and depressed individuals are likely to experience interference with their daily functioning [37]. Further, externalizing problems often co-occur with internalizing problems such as anxious, depressed, and withdrawn behavior [35, 38]. We were particularly interested to explore whether any of the trajectory groups had high ratings on these variables that exceeded, preceded or outlasted any elevations in their depressive symptoms.

Method

Design

This research took place as part of the Orygen Adolescent Development Study (ADS), which was conducted in conjunction with Orygen, The National Centre of Excellence in Youth Mental Health. The ADS is a prospective longitudinal study of Melbourne children, with the broader aim to examine biopsychosocial risk and resilience for mental health problems over the course of adolescence. Data were obtained from four phases of data collection over seven years (2004-2011).

Participants

A cohort of 2453 individuals was involved in the initial in-school screening phase of the ADS. This original cohort was a sample of Grade 6 school students (10 – 12 years old) from a random selection of schools across metropolitan Melbourne, in a sampling frame designed to produce proportions of Government, Catholic and Private schools representative of the broader metropolitan area. Informed consent was obtained from all participants and their parents or guardians.

An initial screening was conducted through in-class administration of the Early Adolescent Temperament Questionnaire- Revised [EATQ-R; 39, 40]. Based on the initial screening, a sub-sample of 415 participants was selected to encompass a wide range of risk for later emotional problems, as assessed by the EATQ-R. To maximise variability, we selected equal numbers of adolescents deemed to be at high, medium, and low risk for psychopathology, based on scores for the Negative Emotionality and Effortful Control scales (see Yap et al. [41] for further details on sampling procedure). Research has consistently demonstrated that negative emotionality and effortful control are important risk factors for internalizing problems including major depressive disorder (see Yap et al. [42] for a review).

From the selected sample, 245 adolescents and their parents/guardians consented to participate and did not meet any exclusion criteria: learning disability, obesity or growth failure, chronic medical or neurological illness, or history of significant head injury, or any evidence of current or prior depressive, substance-use, or eating disorder. The first wave of intensive data collection occurred a mean of 9.91 months ($SD = 3.10$) after the school screening, when the mean age of participants was 12.49 years (range 11.38-13.61). These 245 participants were invited to participate over four waves of data collection (T1 – T4) on a battery of measures. Interviewers met

with the adolescent in their home for administration of baseline and follow-up assessments. Of these participants, two had missing data for their depressive symptoms at all four time points, and were therefore excluded from the final analysis. The final sample for this analysis therefore consisted of 243 participants (121 males and 122 females). Figure 1 presents a flow chart showing the numbers of participants assessed and the variables measured at each time point. Adolescents who discontinued participation after the school screening phase did not differ from those who participated in the home assessment on Negative Emotionality ($t[407] = 0.16$, ns), Effortful Control ($t[413] = -0.54$, ns), proportion of males and females ($\chi^2[1, N = 415] = 0.34$, ns), or socioeconomic classification ($t[405] = -1.00$, ns)[43].

Measures

Self-reported depression and anxiety symptoms, parent-reported externalizing symptoms, and interviewer-rated global function were measured at each wave using the Center for Epidemiological Studies Depression Scale [CESD; 44], Beck Anxiety Inventory [BAI; 45], Child Behaviour Checklist, Parent Version (CBCL; Achenbach, 1991), and the Children's Global Assessment Scale [CGAS; 46], respectively. At T2, socioeconomic status was estimated using the ANU4 Scale (F. L. Jones & McMillan, 2001), and physical and emotional neglect and abuse were measured using the Child Trauma Questionnaire, short form (CTQ; Bernstein et al., 1994). At T4, outcomes including substance use and quality of life were measured using the Youth Risk Behaviour Survey [YRBS; 47], and the Young Adult Quality Of Life scale [YAQOL; 48]. Lifetime psychiatric diagnoses were assessed using the Kiddie - Schedule for Affective Disorders and Schizophrenia for School-Aged Children – Present and Lifetime Version

[K-SADS-PL; 49]. See supplementary material for further information and psychometric properties of all these measures.

Missing Data

Data were missing for the CESD scale at T1 (6.6%), T2 (15.2%), T3 (28.4%), and T4 (32.1%). All other variables, the waves at which they were collected and percentages of missing data for each are shown in Table 2. Analysis of the entire dataset revealed the pattern of missing data to be MCAR (missing completely at random), using Little's MCAR test [50], $\chi^2(3597) = 3625.742, p = .365$. There is widespread agreement among statisticians that estimation of missing data is a more principled response to the problem of attrition than case deletion [e.g.: 51, 52, 53], and is preferable for the purpose of preserving sample size and power. Growth mixture modelling was performed in Mplus version 7.11, which used the full information maximum likelihood (FIML) method to model latent class trajectories using incomplete data sets. Therefore the missing CESD data was accounted for using this method. As MPlus does not compute missing data for variables outside of the model, the other variables required imputation of missing data. Multiple imputation was used to produce a set of five complete datasets, and means and standard errors were calculated from these.

Statistical Analysis

CESD scores from each of the four time points were used to model latent class growth trajectories in Mplus version 7.11. The analysis was undertaken according to the procedure recommended by Jung and Wickrama [54], who advised that the optimal model be determined by factors including fit indices, parsimony, theoretical justification, and interpretability. As a first step, latent class growth analysis (LCGA)

models with no within-class variance were estimated, with class numbers ranging from one to six. Models were initially estimated with intercept, slope, and quadratic factors, to determine the shape of the average growth curve of each class. Models were selected based on low Bayesian Information Criteria [BIC; 55] and sample size adjusted BIC (SABIC) values, and sufficient class sizes (no less than 1% of the sample size per class, as per Jung and Wickrama [54]). Models were also checked for sufficiently high entropy (a measure of class separation) and high average posterior probabilities for individual class assignment.

The two best-fitting models from LCGA were analyzed further with GMM, which allows estimation of within-class variance. The final best-fitting model was then selected, again by a combination of the lowest BIC and SABIC values, and sufficient class sizes, entropy, and posterior probabilities.

Once the final model had been selected, auxiliary variables were tested for mean differences across the latent classes. The mean differences were tested using Lanza et al.'s [56] stepwise approach. Specifically, after the latent class model was estimated, auxiliary variables were used as latent class predictors within a multinomial logistic regression. Individuals' most likely class (obtained from the individual posterior probabilities) was used as the latent class indicator variable, incorporating the inherent uncertainty rates. For continuous auxiliary variables the mean parameters were estimated for each latent class, and for categorical variables the probabilities for each category were estimated for each class. An overall test of association (using Wald's test), as well as pairwise class comparisons, were then computed. The *p*-values from the significance tests were corrected for multiple comparisons using the False Discovery

Rate (FDR) method [57], which controls the expected proportion of false discoveries (q) amongst the rejected null hypotheses. The false-positive rate was set at $q = 0.05$.

Results

Description of sample

Participants' SES tended towards the higher end of the ANU4 scale, with a mean of 63.5 and standard deviation of 22.8 (the scale ranges from 0, low SES, to 100, high SES). Of 209 participants who reported ethnicity, 178 identified only as Australian, 6 identified Chinese heritage, 4 Italian, 3 Maltese, 2 Croatian, and one each of Danish, Indonesian, Swiss, American, Canadian, Dutch, El Salvadorian, British, Greek, Hungarian, Indian, Kurdish, New Zealander, Scottish, Vietnamese, and Welsh heritage. By T4, 112 adolescents reported a lifetime history of any psychiatric diagnosis, including 56 with any depressive disorder and 59 with any anxiety disorder. Twenty-seven reported both depressive and anxiety disorders.

Depression trajectory analysis

For the LCGA models the BIC and SABIC decreased with each added class, up until the addition of a sixth class, when the BIC increased. The BIC values therefore indicated that the 5-class model best fit the data. Although the SABIC decreased with the addition of the sixth class, one of the classes contained only one participant. The six-class solution was therefore discarded. The results of the LCGA are shown in Table 3.

The BIC values for the 4- and 5-class models were almost identical, so both models were selected for further analysis with GMM. For each of the 4- and 5-class models, results were compared when different growth parameters were allowed to vary within classes. In the first step of GMM, the within-class slope variance was unrestricted

but held equal across the classes (i.e. the variance was no longer necessarily zero, but it was equal for every class). If this model converged successfully, restrictions were loosened further, and the slope variance was freed to vary individually for each class. This process was repeated for the intercept and slope terms for the 4- and 5-class models. The results of these models are presented in Table 4.

As can be seen from these results, a 4-class model, with the intercept variance freely estimated for each class, had the lowest BIC and SABIC values. Non-convergence can be considered evidence of model misfit [58], so the 5-class models that failed to converge were discarded. It is unsurprising that the fit of the 4-class model exceeds that of the 5-class model in GMM, but not in LCGA. As the within-class variances are restricted to zero in LCGA, it tends to extract more classes than GMM, as each class contains a narrower range of trajectories [59]. It was noted that the best-fitting 4-class model did not also have the highest entropy value. However entropy values are not intended as an indicator for model selection, and the best-fitting model's entropy value of 0.79 can be classified as sufficiently high [60]. The average latent class probabilities for most likely class membership ranged from 85% to 96% for the four classes, indicating very high probability of individuals being accurately classified into their most likely class. Furthermore, this model had a larger minimum class size than the other models. While it was a concern that the smallest class still consisted of only eight individuals, this nevertheless met Jung and Wickrama's [54] recommendation that classes should contain no less than 1% of the sample size. Furthermore, the four classes were well separated according to visual plots, with the two decreasing trajectories distinguished from each other in both severity and chronicity of symptoms. Therefore, in order to retain this valuable information on symptom severity and chronicity, we

decided to retain the 4-class model over a 3-class model. As a final validation of model selection, the Lo-Mendell-Rubin adjusted likelihood ratio test suggested that there was little statistical advantage in fit beyond a four-class model; the test was significant for 3 vs. 4 classes ($LMR = 41.47, p = 0.0098$), but non-significant for 4 vs. 5 classes ($LMR = 17.98, p = 0.244$). Taking all these considerations into account, the 4-class model with intercepts freely estimated was selected as the final model.

The estimated mean and observed individual trajectories for this 4-class model are shown in Figure 2. The shapes of the four mean trajectories indicate that the majority of the participants (65.4%, 77 males and 82 females) fell into a low, stable trajectory of depressive symptoms. The second-largest group (20.2%, 28 males and 21 females) initially had moderately high depressive symptoms, but their symptoms decreased over time. The third-largest group (11.1%, 10 males and 17 females) had depressive symptoms that increased over time. The smallest group (3.3%, 6 males and 2 females) had very high depressive symptoms initially, but showed a steep decrease in their symptoms over time. These groups were labelled “Stable Low”, “Moderate Early Symptoms”, “Late Symptoms”, and “Severe Early Symptoms”, respectively. Individual trajectories for each group are shown in Figure 3.

Psychosocial variables

With the final model selected, the additional variables were analyzed to test for differences in means or probabilities across the four groups. The results of statistical tests for all variables are summarised in Tables 5 and 6 for continuous and categorical variables, respectively. All p -values reported for the overall tests have been corrected for multiple comparisons using FDR. The F -statistics and degrees of freedom are the

results of combining chi-square values from each of the five imputations of missing data, using methods described by Schafer [61] and Allison [62].

Risk factors. The four groups were not significantly different in their gender composition or average socioeconomic status. Compared to the *Low Stable* group, the other three groups all scored significantly lower on the temperament dimension of Effortful Control. Both of the *Early Symptoms* groups also scored lower on Surgency and higher on Negative Emotionality.

The *Late Symptoms* and *Moderate Early Symptoms* groups were both significantly higher than the *Low Stable* group on physical and emotional neglect, and emotional abuse. The *Late Symptoms* group was significantly higher than all other groups on physical abuse.

Outcome variables. The *Late Symptoms* and *Moderate Early Symptoms* groups scored significantly lower than the *Low Stable* group on quality of life measures of role morale, positive outlook, and physical health. The four groups did not differ significantly on binge drinking behaviour or cigarette smoking. However, the *Low Stable* group had lower levels of marijuana use than the *Late Symptoms* and *Moderate Early Symptoms* groups.

The *Low Stable* group was less likely than the *Late Symptoms* and *Moderate Early Symptoms* groups to have had any psychiatric diagnosis, and less likely than the *Late Symptoms* group to have reached criteria for Major Depressive Disorder (MDD). The same pattern was found for other depressive disorders. The *Low Stable* group was less likely than the *Late Symptoms* group to have experienced any anxiety disorders.

Concurrent variables. Anxiety levels differed across the four groups at every time point, in a pattern approximately matching that of depressive symptoms. The *Low Stable* group consistently had lower levels of parent-rated externalizing symptoms than the other groups, at times 1, 2 and 4. At T3, the overall test did not reach significance ($p = 0.085$). At T1 the *Low Stable* group rated higher on global functioning than every other group, and remained higher than the *Late Symptoms* and *Moderate Early Symptoms* groups at T2 and T4.

Discussion

This study aimed to characterise longitudinal trajectories of depressive symptoms in a sample of adolescents, and to describe the combinations of risk factors and outcomes that differentiated between groups. Four trajectory classes were identified: *Low Stable*, *Moderate Early Symptoms*, *Severe Early Symptoms*, and *Late Symptoms*. These four groups differed from each other on ratings of temperament, childhood maltreatment, anxiety, externalizing symptoms, global functioning, and young adult outcomes.

The finding of a four-group solution is in line with the previous trajectory studies, 10 of which also settled on a four-group model [12, 16-18, 22-24, 27, 28, 63]. The differences between these 10 studies and those that reported a three-group solution are likely to reflect sample characteristics and modelling methods (for example, Sabiston et al. [29] and Chaiton et al. [26] set a minimum group prevalence of 10%, disallowing smaller groups). We note that one of our four groups was very small, and therefore the findings relating to this group may be less reliable than for larger groups. The studies that reported a four-group solution share a number of common findings. All reported a group with low, stable symptoms over time. Nine studies found

groups with increasing symptoms. The one study that did not [12] covered an age range of 15-24, a slightly older starting age than the others, including this study. Otherwise, Stoolmiller et al.'s [12] four trajectories closely resemble our current findings ("Very low", "Moderate decreasing", "High decreasing"), however they detected a "High persistent" class rather than the *Late Symptoms* class detected here. As current findings revealed that the *Late Symptoms* group already had quite escalated symptoms by age 15, it may be that the earlier starting age in the current study captured more of the escalation of this group.

Nine of the abovementioned studies also reported groups with decreasing symptoms. The one that did not [17] covered a shorter age range of 11-14, which may not have been long enough to capture a pattern of decline.

We expected to find a group with consistently low levels of depression, comprising the majority of the sample. This proved to be accurate, as the *Low Stable* group comprised 65.4% of the sample. This closely matches Wickrama and Wickrama [27], whose *Low* group comprised 63% of their sample. We expected to find that female gender, lower SES, high levels of the temperament dimension Negative Emotionality, and higher levels of childhood maltreatment would be associated with high depression groups, relative to the low-symptom group. In fact, only temperament and childhood maltreatment were shown to have significant associations with group classification. This contrasts with previous depression trajectory studies that found higher proportions of females in high depression groups [13, 17-21]. Although there was a trend for the *Late Symptoms* group to contain more females than the *Early Symptoms* groups, the overall test did not reach significance in this sample. Previous research suggests that the gender difference in depression emerges from the ages of 12-14 [64-

66], and in the present study the group that showed increasing symptoms over this period had the highest number of girls. The previous trajectory studies that did find significant gender differences in their more depressed groups had older average ages of participants and larger sample sizes than the present study, and therefore may have been better powered to detect the gender difference.

Both of the *Early Symptoms* groups had lower mean scores on the temperament dimensions of Surgency and Effortful Control than the *Low Stable* group, and higher mean scores on Negative Emotionality. This is in line with previous research linking these temperament dimensions to depressive symptoms [30, 35, 40, 67]. To some extent, this finding may be due to a tendency towards correlation between depression and temperament questionnaire measures. It is plausible that current depression influences responses to other questionnaire measures to some degree, leading to exaggerated temperament scores during periods of depression. However, a recent study by Harding et al. [68] investigated this issue and reported a clear statistical distinction between trait positive and negative affectivity, as measured by the EATQ-R, and depressive symptoms. They suggested that the EATQ-R ensured distinct construct measurement by separating items referencing depression, sadness, happiness, and pleasure as a distinct scale labelled Depressed Mood, which does not load onto the subscales used as measures of temperament in this study.

In terms of childhood maltreatment, the *Moderate Early Symptoms* and *Late Symptoms* groups scored higher than the *Low Stable* group on most measures of physical and emotional abuse and neglect. This is consistent with previous findings that abuse and poor family relationships are associated with adolescent depression and dysthymia [4, 31, 69]. Previous depression trajectory studies have also reported that

high depression trajectories were associated with poorer relationships with parents [17, 18, 24]. The *Severe Early Symptoms* group however was not significantly different to the *Low Stable* group on these measures. As childhood maltreatment was measured at Time 2 when the three high-depression groups had similar depression scores, it is unlikely that depression was driving the differences in their self-reported levels of childhood maltreatment.

In terms of outcomes in young adulthood, we expected the *Low Stable* group to have the most favourable quality of life outcomes, and lowest levels of risk behaviours. The results broadly supported this hypothesis. The *Low Stable* group had the lowest levels of marijuana use. They scored higher than the *Late Symptoms* or *Moderate Early Symptoms* groups on Role Morale, Positive Outlook, and Physical Health. Again, these results probably reflect concurrent depression levels to some extent. These results are consistent with those of Wickrama and Wickrama [27], who examined risky lifestyle factors in adolescent depression trajectory groups, and found that the increasing group showed the highest levels of risky lifestyle factors. They also found increased risk of binge drinking and smoking in this group, however these factors didn't reach significance in the present study.

We also expected the low depression group to have lower probability of a psychiatric diagnosis by Time 4, and this was found to be the case. It was the *Late Symptoms* group that had the highest probability of any psychiatric diagnosis, and this group had significantly higher rates of MDD, any depressive disorder, and any anxiety disorder compared to the *Low Stable* group. This pattern of depressive symptoms may therefore represent a particular vulnerability to comorbid disorders.

For the concurrent variables, we found that levels of anxiety, externalizing symptoms, and global functioning fluctuated in concert with depressive symptoms over time. This was especially true of anxiety, unsurprisingly given the high degree of correlation between depression and anxiety symptoms [36]. However, there were some interesting exceptions; the *Severe Early Symptoms* group still had higher parental ratings of externalizing symptoms than the *Low Stable* group at Time 4, despite their depressive symptoms having reduced to normative levels. Furthermore, the *Late Symptoms* group rated higher than the *Low Stable* group on anxiety and externalizing symptoms, and lower on interviewer rated global functioning, even at Time 1, prior to the escalation of their depressive symptoms. This suggests that the *Late Symptoms* group were experiencing measurable difficulties in other domains in early adolescence, before their depressive symptoms became pronounced. This pattern in the *Late Symptoms* group is consistent with epidemiological findings [70-72] indicating that onset of anxiety disorders typically precedes onset of depression within individuals, with the onset of anxiety disorders often occurring in childhood and early adolescence, and depression emerging in mid- to late-adolescence. Several studies have noted comorbidities between depressive disorders and anxiety and externalizing disorders [e.g.: 70, 72, 73, 74]. Adolescence represents a population-wide increase in vulnerability to depression, often precipitated by social rejection or loss of status during this phase [75]. There are a number of biological, psychological, and social factors that contribute to risk for depression during this period of life, for example puberty, peer-group changes, academic pressure, romantic relationships (see Lau [2] for a review). The presence of elevated anxiety and externalizing behaviours in this group in early adolescence may represent vulnerability factors that led to depression being triggered by any of the above-mentioned factors in later adolescence.

We specifically hypothesised that the group with the highest level of early depression symptoms would have the least favourable outcomes in late adolescence, as research has suggested that earlier onset of depression may result in greater harm to later psychosocial outcomes [3, 4]. This however was not supported by our results, as the *Severe Early Symptoms* group was similar to the *Low Stable* group on all of the young adult quality of life measures. The only evidence of longer-term harm in the *Severe Early Symptoms* group was their higher score on externalizing symptoms at Time 4. It may be that the harm associated with early onset of depression applies when those high depressive symptoms are maintained over time, rather than declining to normative levels. The timing of recovery may be important – this group’s symptoms may have declined early enough to avoid interruption of social, educational and occupational milestones. Indeed, the *Moderate Early Symptoms* group evidenced poorer outcomes in young adulthood, despite their depressive symptoms also having declined somewhat, and this was most likely because their depressive symptoms had remained higher than the norm up to and including Time 4. Therefore they were affected by depression for the majority of these important formative years. A similar conclusion was reached by Wickrama and Wickrama [27], whose decreasing group showed the fewest differences relative to their normative group in young adult risky lifestyle factors. They reasoned that early experiences of depression might not exert continuing influences on lifestyle factors if the depressive symptoms resolved. Rohde et al.’s [3] conclusion of psychosocial ramifications following an early episode of depression was based on a one-year follow-up of previously-depressed adolescents, so this shorter time period may not have been long enough to capture the degree of psychosocial recovery found by late adolescence in the present study. Given the high degree of correlation between depressive symptoms and other psychopathological symptoms such as anxiety, we

cannot conclude with certainty that these outcomes are specific to depression, rather than to broader dimensions of psychopathology [76].

A potential benefit of latent class analyses such as this is the identification of groups that may have different aetiologies and prognoses with respect to depression. The results of this study suggest that the latent classes identified here are subject to different combinations of risk factors. Specifically, it appears that the *Severe Early Symptoms* group had more temperament risk factors (i.e., higher ratings of Negative Emotionality and lower ratings of Effortful Control), while the *Late Symptoms* group had more environmental risk factors (i.e., higher ratings of childhood maltreatment). The *Moderate Early Symptoms* group had a combination of both. This has implications for possible interventions for these groups. For the *Late Symptoms* group, social and parenting interventions may be more relevant. That is, programs that provide social support to families and adolescents, and training in parenting skills, targeted to at-risk families, may help to reduce rates of childhood adversity. This may in turn help to reduce rates of depression in later adolescence. As this group was exhibiting higher levels of externalizing behaviours and anxiety in early adolescence, intervention may be triggered before depression symptoms escalate. For the *Early Symptoms* groups, psychological support may be more beneficial. Individuals in these groups appeared to be more sensitive and vulnerable to emotional difficulties due to temperament factors. These children may be less resilient to stress and require more emotional support.

This trajectory analysis may also have implications for prognosis. The *Late Symptoms* group had the highest levels of late-adolescent depression, and the poorest psychosocial outcomes at T4. Costello et al. [18] found a similar pattern of trajectories to this study, but they followed their sample to the age of 25. They found that by the age

of 25, the low and declining groups had merged into one pathway, while the group with increasing symptoms had consistently high levels of depression. This suggests that our *Late Symptoms* group may be most at risk of continuing to suffer from depression in the future.

This study had a number of strengths. It used a demographically representative sample of boys and girls from Melbourne, in a true within-participants longitudinal design, and the most contemporary statistical techniques to analyze the association between covariates and trajectory patterns. The longitudinal design and the use of an extensive battery of measures allowed for a rich characterisation of change in psychosocial factors over time, and the contextualisation of depression within a biopsychosocial framework. The use of growth mixture modelling allowed the identification of heterogeneous subgroups, with variation around the mean of each of those subgroups. Statistical tests of differences between these groups accounted for the uncertainty in the estimation of group membership. Nonetheless, a number of limitations are noteworthy. In particular, this study had a relatively small sample compared to many of the trajectory studies reviewed. This resulted in small trajectory classes and may have reduced statistical power. In particular, the *Severe Early Symptoms* group contained only eight individuals. The large standard errors may have obscured meaningful differences in this group, and results involving this group should be viewed with caution. The small sample size also meant that we could not test boys and girls separately, so potential gender differences were not fully explored.

Additionally, the outcome measures for psychosocial functioning were measured only at T4, and may to some degree reflect correlation with concurrent depression. We don't know whether a history of adolescent depression would continue to affect these

outcomes after remission of depressive symptoms. In other words, we don't know whether the *Late Symptoms* and *Moderate Early Symptoms* groups would continue to score poorly on these measures if their depression scores fell to normative levels at a later time.

The CTQ was administered at T2, so we only measured childhood maltreatment up to the age of approximately 15. Further traumatic experiences after this point may have continued to influence depression trajectories in ways not accounted for by this study. For example, the *Late Symptoms* groups may have experienced more ongoing adversity than the *Moderate Early Symptoms* group, contributing to the increasing symptoms in the former.

Previous research has suggested that depressive symptoms tend to increase over the course of adolescence, particularly among girls [e.g.: 1, 6, 64, 77]. However, this study found more predominant patterns of decrease than increase. This effect may be partly an artefact of the longitudinal measurement of the depression scores. Some research has suggested that repeated administration of a questionnaire in longitudinal studies might result in a bias towards decreasing scores over time [78]. Furthermore, some of the decline in symptoms of the groups that had high initial symptoms may be accounted for by regression to the mean. The differences in psychosocial factors for these groups relative to the normative group suggest, however, that their depression trajectories reflect real-world effects rather than measurement artefacts. Another issue with the measurement of depression was that we constructed the trajectories based on only one measurement of depression symptoms per timepoint. This may not have adequately captured the degree of fluctuation in adolescent depressive symptoms (the

CESD assesses symptoms in the past week). Future research may consider the use of alternative depression scales that capture symptoms over a longer time period.

The sampling procedure for this study involved selecting a risk-enriched sample based on temperament scores. Therefore, the proportions of individuals contained in each trajectory may differ in this sample compared to the proportions in the general population. However, this should not affect the interpretation of the effects of the various psychosocial variables on the development of depression. The observations regarding the relationships between depression and other psychosocial variables remain relevant.

Summary

Depression is a heterogeneous disorder, arising from a complex interaction of biological, psychological, and social factors. Different combinations of these factors may result in different patterns of depressive symptoms. This project sought to identify coherent patterns of longitudinal depressive symptoms within a sample of adolescents, and examine a range of variables associated with different trajectories of depressive symptoms. We collected a battery of measures of temperament, family processes, and psychopathology over seven years (covering the ages of 12 to 18 years old), for a sample of 243 adolescents (121 males and 122 females). Depressive symptoms were measured at four waves of data collection. These data were used in a growth mixture modelling analysis to extract homogenous subgroups from the larger heterogeneous group on the basis of longitudinal trajectories of depressive symptoms. This resulted in four groups: a large, normative group with ongoing stable low levels of depression, two groups with declining depressive symptoms and one group with increasing symptoms across adolescence.

The best-fitting four-group model was validated by the findings that trajectory class was predictive of a range of other psychosocial variables, and that all four classes had distinctive features that differentiated them from each other. The results suggested that stable internal characteristics such as temperament, which is thought to have a genetic basis, cannot alone account for depressive risk. In fact, environmental factors may play an even more important role. By the end of adolescence, it was the group with a relatively normal temperament profile but significant environmental risk factors that had the highest mean depression score and the poorest outcomes on a range of quality of life measures. These results reinforce the need for social and psychological support for at-risk families and adolescents.

This study was not able to show that psychosocial outcomes in young adulthood were attributable to depression itself. The *Late Symptoms* group, which had the lowest scores on quality of life measures at T4, also had the highest scores on childhood maltreatment variables. Their poorer outcomes at T4 may be due to depression, or to the same risk factors that caused the depression, or to a combination of both. The direction of effects is not clear. Factors such as low role morale and poor physical health may be contributing to high depression scores, and vice versa. Furthermore, it may be that temperament is a mechanism that increases either risk or resilience in the face of adversity. The *Late Symptoms* group demonstrated both higher scores on adversity measures, and lower scores on Effortful Control than the normative group. Reduced Effortful Control may be a mechanism through which early adversity translated into depression and poorer general wellbeing. In summary, this study provides an insight into the factors that contribute to longitudinal patterns of depression during adolescence, and to wellbeing in young adulthood. Future research will help to further

elucidate the interactions between depression, temperament, and environmental factors, and their contributions to psychosocial outcomes.

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Table 1: Studies of Depression Trajectories in Adolescence

Authors	N	Sample	Age range	Data collection waves ^a	Design	Classes	Trajectory descriptions (&
Brendgen et al. [17]	414	Boys & girls from Canada (over 90% Caucasian)	11-14	4	Longitudinal	4	Consistently low (47.7%) Consistently moderately depressed (12.7%) Increasingly depressed (12.7%) Consistently highly depressed (26.9%)
Briere et al. [14]	6910	Boys and girls from disadvantaged areas of Quebec, Canada	12-16	5	Longitudinal	5	Stable-low (68.1%) Increasing (12.1%) Decreasing (8.7%) Transient (8.7%) Stable-high (2.4%)
Chaiton et al. [26]	1293	The Nicotine Dependence in Teens (NDIT) Study of girls and boys in Montreal, Canada	13-17	20	Longitudinal	3	Boys: High (14%) Moderate (36%) Low (50%)
Costello et al. [18]	11,559	National Longitudinal Study of Adolescent Health (nationally representative sample of American adolescents)	12-25	3	Cohort-sequential	4	No depressed mood (28.7%) Stable low depressed mood (28.7%) Early high declining depressed mood (28.7%) Late escalating depressed mood (13.9%)
Cumsille et al. [22]	1072	Representative sample of Chilean adolescents	14-17	4	Longitudinal	4	Low stable (56%) Persistent high (12%) Low increasing (17%) High decreasing (15%)
Dekker et al. [15]	2076	The Zuid-Holland longitudinal study, random sample of Dutch boys & girls	4-18	6	Multiple birth-cohorts	6	Boys: Very low decreasing (1.9%) Low stable (39.8%) Moderate increasing (14.7%) High decreasing (2.3%) High childhood peak (1.6%) Increasing high (1.9%).
Diamantopoulou et al. [25]	1423	The Zuid-Holland longitudinal study, random sample of Dutch boys & girls	11-18	3	Multiple birth-cohorts	3	Boys: Low (92%) Decreasing (3%) Increasing (3%).
Duchesne and Ratelle [23]	416	Representative sample of French-speaking students attending public school in Quebec, Canada	11-16	6	Longitudinal	4	Moderate stable (54.6%) Low stable (27.2%) Moderate increasing (11.3%) High declining (7%)
Fernandez Castela and	3902	Random sample of German children and adolescents	11-14	4	Longitudinal	4	Low-increasing (62.5%) Moderate-slightly increasing (37.5%)

Kröner-Herwig [16]							High-decreasing (8.1%) Very high-stable (1.1%)
Mezulis et al. [21]	382	Wisconsin Study of Families and Work (Boys and girls, over 90% Caucasian)	11-18	4	Longitudinal	3	Stable Low (51%) Increasing (37%) Early High (12%)
Reinke et al. [28]	361	Boys and girls at public schools in at risk neighbourhoods in Pacific Northwest USA	10-16	6	Longitudinal	4	Increasing symptoms (5.1%) High levels of depressive syn (15.9%) Decreasing symptoms (8.9%) Low levels of depressive syn (21.2%)
Repetto et al. [61]	579	African American boys and girls at risk of school dropout	Four years, from 9th grade	4	Longitudinal	4	Consistently high (41.8%) Consistently low (21.2%) Increasing (21.2%) Decreasing (21%)
Rodriguez et al. [20]	925	Boys & girls in northern Virginia, USA	14-18	4	Longitudinal	3	High symptoms (23%) Moderate symptoms (44%) Low symptoms (33%)
Sabiston et al. [29]	860	The Nicotine Dependence in Teens study, of boys & girls in Montreal, Canada	12-18	21	Longitudinal	3	Low and declining (37%) Moderate with small increases (21%) High and increasing (21%)
Sallinen et al. [24]	112	Boys & girls in Finland	13-16	3	Longitudinal	4	Medium symptoms (25%) Minor symptoms (63%) Decreasing symptoms (5.5%) Escalating symptoms (6.5%)
Stoolmiller et al. [12]	206	Boys in the Oregon Youth Study (recruited from high crime areas)	15-24	10	Longitudinal	4	Very low (5.8%) Moderate decreasing (34%) High decreasing (35.9%) High persistent (24.3%)
Wickrama and Wickrama [27]	11,500	National Longitudinal Study of Adolescent Health	13-23	3	Accelerated sequential cohort	4	Low (63%) Decreasing (8%) Escalating (3%) Chronically moderate-high (24.3%)
Yaroslavsky et al. [13]	719	Boys & Girls in the Oregon Adolescent Depression Project	14-30	10	Longitudinal	3	High stable (32%) Moderate decreasing (44%) Low decreasing (24%)

^a Number of data collection waves during the period of trajectory analysis

Table 2: Measurement Tools and Missing Data

Data Collection Wave	Measure	Variable	Percent Missing Data
All	BAI	Anxiety	3.3% (T1), 15.6% (T2), 28.8% (T3), 32.9% (T4)
All	CGAS	Global functioning	1.2% (T1), 15.2% (T2), 29.6% (T3), 34.2% (T4)
All	CBCL	Externalizing symptoms	5.8% (T1), 15.2% (T2), 33.7% (T3), 40.7% (T4)
T1	EATQ-R	Surgency	6.2%
T1	EATQ-R	Affiliation	2.9%
T1	EATQ-R	Effortful Control	6.2%
T1	EATQ-R	Negative Emotionality	6.6%
T2	CTQ	Physical Neglect	15.2%
T2	CTQ	Emotional Neglect	16.9%
T2	CTQ	Physical Abuse	16.5%
T2	CTQ	Emotional Abuse	15.6%
T2	ANU4	Socioeconomic status	13.2%
T4	YAQOL	Role Stress	37.4%
T4	YAQOL	Role Morale	37.4%

T4	YAQOL	Relationship Quality	39.5%
T4	YAQOL	Social Support	37.4%
T4	YAQOL	Positive Outlook	37.9%
T4	YAQOL	Physical Health	39.5%
T4	YRBS	Cigarette use	33.3%
T4	YRBS	Marijuana use	33.7%
T4	YRBS	Binge drinking	34.2%
T4	K-SADS-PL	Lifetime any psychiatric disorder	21.8%
T4	K-SADS-PL	Lifetime MDD	21.8%
T4	K-SADS-PL	Lifetime any depressive disorder	21.8%
T4	K-SADS-PL	Lifetime any anxiety disorder	21.8%

Table 3: Fit Statistics and Class Sizes for Latent Class Growth Analysis Models

	1 Class	2 Classes	3 Classes	4 Classes	5 Classes	6 Classes
BIC	5570.422	5423.447	5392.831	5383.531	5382.739	5384.180
SABIC	5548.233	5388.579	5345.283	5323.304	5309.832	5298.594
Entropy		0.84	0.863	0.876	0.858	0.876
Class 1		193	23	184	15	39
Class 2		53	30	35	40	21
Class 3			190	20	21	4
Class 4				4	163	163
Class 5					4	15
Class 6						1

Table 4: Fit Statistics and Class Sizes for Growth Mixture Models of 4 and 5 Classes

	4 Classes: Intercept held across classes	4 Classes: Intercept freely estimated	4 Classes: Slope held across classes	4 Classes: Slope freely estimated
BIC	5335.393	5331.311	5342.833	5345.336
SABIC	5271.996	5258.404	5279.435	5272.429
Entropy	0.843	0.79	0.867	0.769
Class 1	5 (2.0%)	8 (3.3%)	23 (9.5%)	35 (14.4%)
Class 2	34 (14.0%)	159 (65.4%)	4 (1.6%)	163 (67.1%)
Class 3	24 (9.9%)	49 (20.2%)	175 (72.0%)	4 (1.6%)

Class 4	180 (74.1%)	27 (11.1%)	41 (16.9%)	41 (16.9%)
	5 classes: Intercept held across classes	5 classes: Intercept freely estimated	5 classes: Slope held across classes	5 classes: Slope freely estimated
BIC	Did not converge	5373.317	5341.007	Did not converge
SABIC		5284.561	5264.931	
Entropy		0.823	0.861	
Class 1		8 (3.3%)	38 (15.6%)	
Class 2		163 (67.1%)	4 (1.6%)	
Class 3		27 (11.1%)	23 (9.5%)	
Class 4		42 (17.3%)	14 (5.8%)	
Class 5		3 (1.2%)	164 (67.5%)	

Note. The best-fitting model is shown in bold text. Class counts are shown with the proportions in brackets.

Table 5: Tests of Mean Differences Between the Four Groups on Risk/Outcome Variables

	Variable	Overall <i>F</i> (ndf, ddf)	Corrected <i>p</i>	Pairwise comparisons
Temperament	Surgency	12.86 (3, 331)	0.000	SE, ME < N ME < L
	Affiliativeness	0.98 (3, 77)	0.445	
	Effortful control	46.64 (3, 48)	0.000	SE < ME < L < N
	Negative emotionality	33.24 (3, 1492)	0.000	N, L < SE, ME
Childhood maltreatment	Physical neglect	8.87 (3, 139)	0.000	SE, N < ME, L
	Emotional neglect	16.94 (3, 126)	0.000	SE, N < ME, L
	Physical abuse	3.94 (3, 329)	0.017	SE, N, ME < L
	Emotional abuse	15.82 (3, 242)	0.000	SE, N < ME, L ME < L
Adult quality of life	Role stress	2.88 (3, 8)	0.134	
	Role morale	4.91 (3, 11)	0.037	ME, L < N L < SE
	Relationship quality	0.60 (3, 4)	0.668	
	Social support	2.71 (3, 3)	0.244	
	Positive outlook	10.80 (3, 6)	0.015	ME, L < SE, N
	Physical health	5.75 (3, 6)	0.047	ME, L < N L < SE
Adult risky behaviour	Cigarette use	1.80 (3, 12)	0.244	
	Binge drinking	0.63 (3, 22)	0.642	
	Marijuana use	3.54 (3, 35)	0.039	N < ME, L
Socioeconomic status		1.14 (3, 40)	0.388	
T1 Anxiety		54.64 (3, 193)	0.000	N < L < ME < SE
T2 Anxiety		17.51 (3, 116)	0.000	SE, N < ME, L
T3 Anxiety		12.55 (3, 461)	0.000	N < ME, L
T4 Anxiety		11.56 (3, 4)	0.039	SE, N, ME < L N < ME
T1 Externalizing		34.99 (3, 8171)	0.000	N < SE, ME, L L < ME
T2 Externalizing		15.44 (3, 138)	0.000	N < SE, ME, L
T3 Externalizing		4.63 (3, 5)	0.085	
T4 Externalizing		6.37 (3, 12)	0.016	N < SE, ME, L

T1 Global function	14.03 (3, 16674)	0.000	SE, ME, L < N
T2 Global function	26.43 (3, 551)	0.000	ME, L < SE, N
T3 Global function	0.11 (3, 10)	0.953	
T4 Global function	12.29 (3, 4)	0.031	L < SE, N, ME ME < N

Note. Groups: N = Normative (Low Stable), SE = Severe Early, ME = Moderate Early, L = Late

Table 6: Tests of Mean Differences Between the Four Groups on Categorical Variables

Variable	Overall <i>F</i> (ndf, ddf)	Corrected <i>p</i>	Pairwise comparisons
Any psychiatric diagnosis	12.92 (3, 27)	0.000	N < L, ME
MDD	4.31 (3, 21)	0.030	SE, N < L
Any depressive disorder	4.64 (3, 746)	0.007	SE, N < L
Any anxiety disorder	3.13 (3, 34)	0.053	N < L

Note. Groups: N = Normative (Low Stable), SE = Severe Early, ME = Moderate Early, L = Late

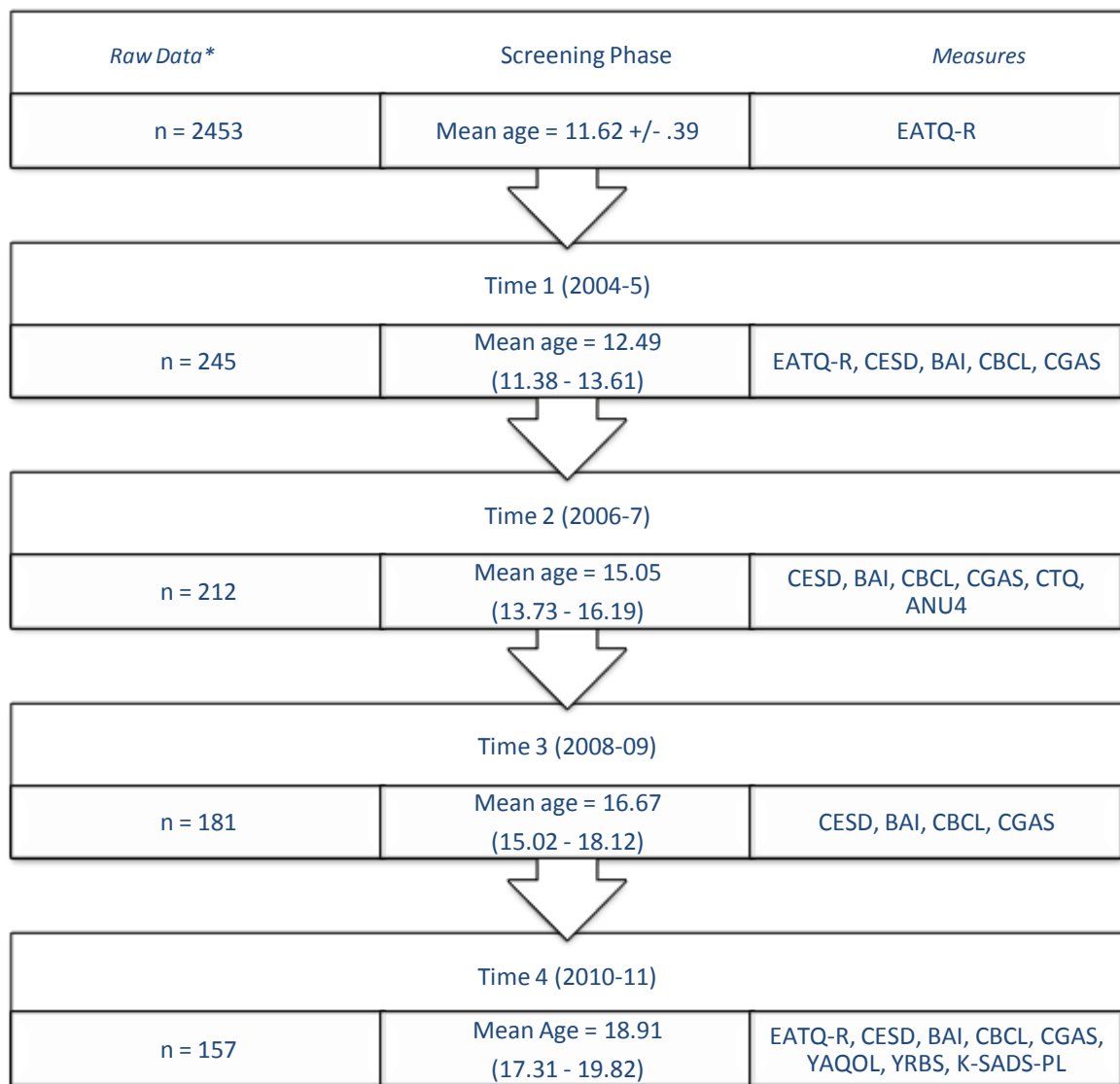
Figure 1: Flowchart of Orygen ADS data collection waves

Figure 2: Graphs of individual trajectories, and means for the four classes.

- a) All individual growth curves, with means of the four trajectory classes shown in bold colour.
- b) Mean growth curves for the four trajectory classes. Legend shows percentage of participants in each class.

Figure 3: Individual trajectories for each of the four classes, group means shown in red.

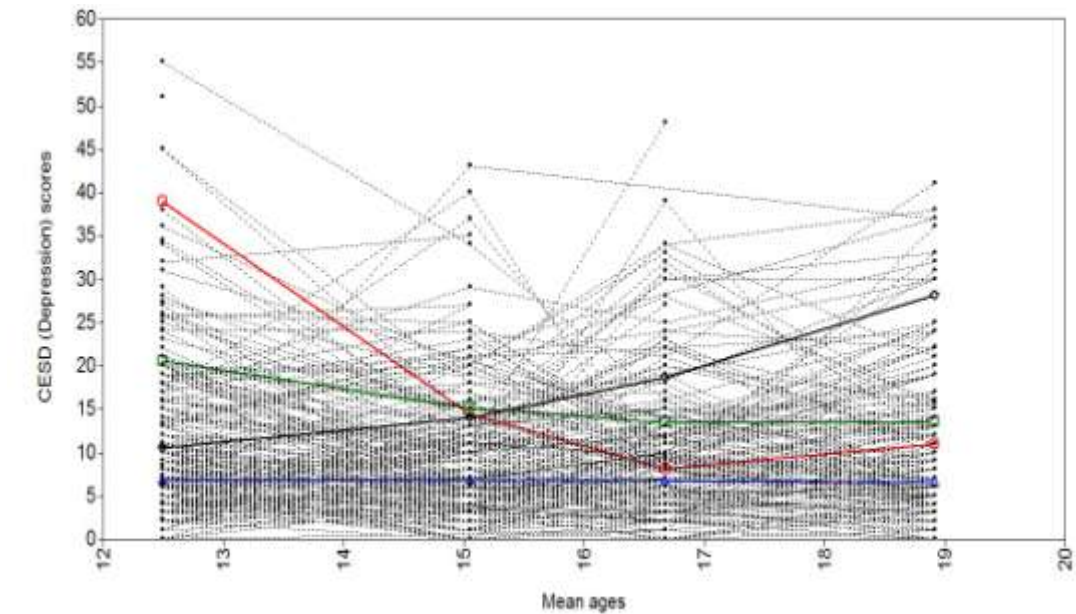
- a) *Low Stable* group
- b) *Moderate Early Symptoms* group
- c) *Severe early symptoms* group
- d) *Late symptoms* group



* Raw numbers prior to imputation of missing data

Figure 1: Flowchart of Orygen ADS data collection waves

a)



b)

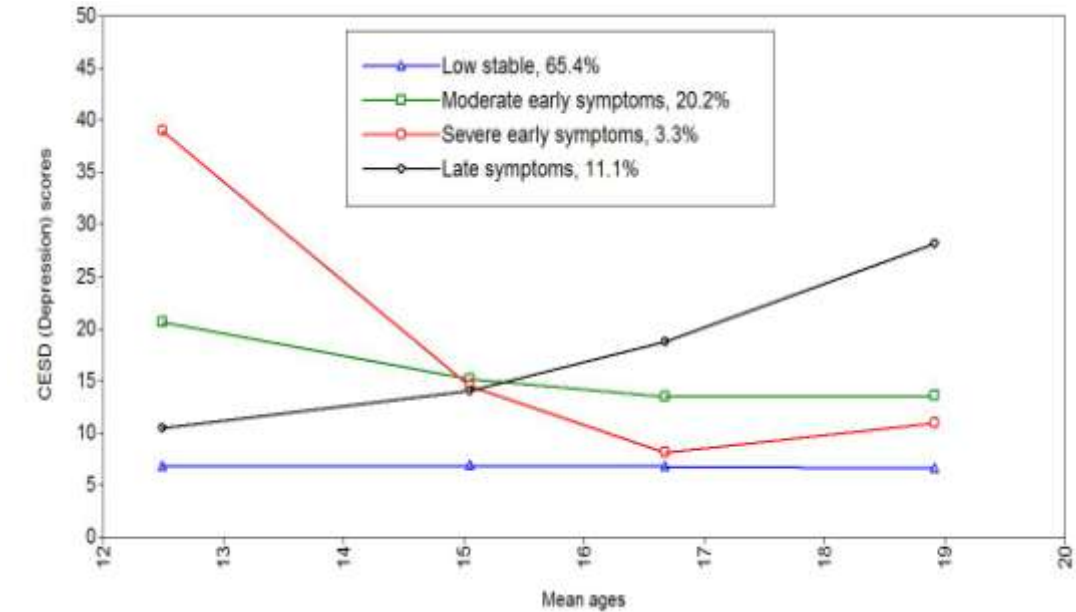
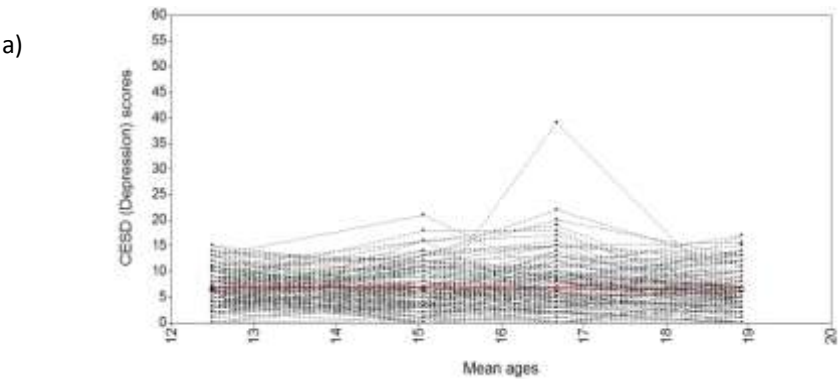


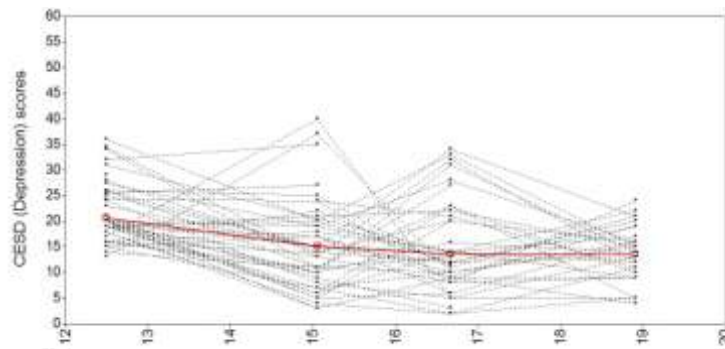
Figure 2: Graphs of individual trajectories, and means for the four classes.

- c) All individual growth curves, with means of the four trajectory classes shown in bold colour.
- d) Mean growth curves for the four trajectory classes. Legend shows percentage of participants in each class.

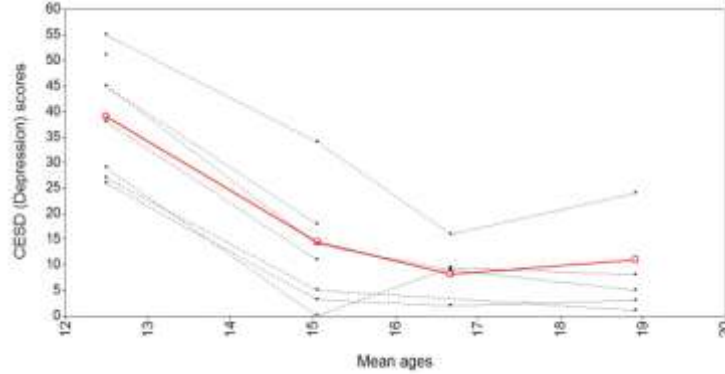
a)



b)



c)



d)

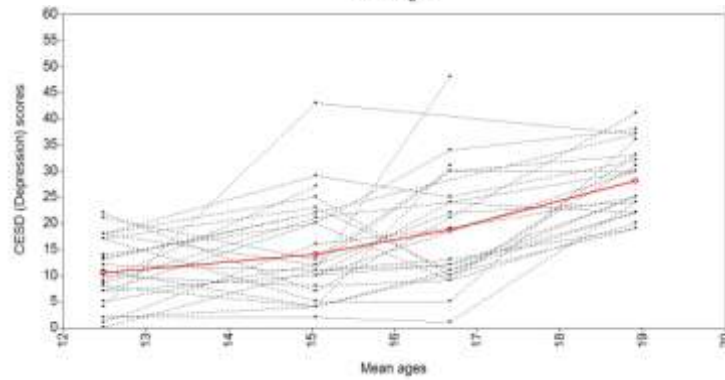


Figure 3: Individual trajectories for each of the four classes, group means shown in red.

e) *Low Stable* group

f) *Moderate Early Symptoms* group

g) *Severe early symptoms* group

h) *Late symptoms* group



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Author/s:

Ellis, RER; Seal, ML; Simmons, JG; Whittle, S; Schwartz, OS; Byrne, ML; Allen, NB

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