Adolescent Trajectories of Depressive Symptoms: Co-development of Behavioral and Academic Problems

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**Abbreviations.** Center for Epidemiologic Studies-Depression (CES-D); Growth Mixture Modeling (GMM); New Approaches, New Solutions (NANS); Maximum Likelihood with Robust estimator (MLR).
ABSTRACT

**Purpose.** Increasing evidence suggests the existence of heterogeneity in the development of depressive symptoms during adolescence, but little remains known regarding the implications of this heterogeneity for the development of commonly co-occurring problems. In this study, we derived trajectories of depressive symptoms in adolescents and examined the co-development of multiple behavioral and academic problems in these trajectories. **Methods.** Participants were 6910 students from secondary schools primarily located in disadvantaged areas of Quebec (Canada) who were assessed annually from age 12 to 16. Trajectories were identified using growth mixture modeling. The course of behavioral (delinquency, substance use) and academic adjustment (school liking, academic achievement) in trajectories was examined by deriving latent growth curves for each covariate conditional on trajectory membership. **Results.** We identified five trajectories of *stable-low* (68.1%), *increasing* (12.1%), *decreasing* (8.7%), *transient* (8.7%), and *stable-high* (2.4%) depressive symptoms. Examination of conditional latent growth curves revealed that the course of behavioral and academic problems closely mirrored the course of depressive symptoms in each trajectory. **Conclusions.** This pattern of results suggests that the course of depressive symptoms and other adjustment problems over time is likely to reflect an important contribution of shared underlying developmental process(es). **Keywords.** Depression, developmental trajectories, adolescence, delinquency, substance use, academic adjustment.
IMPLICATIONS AND CONTRIBUTION

We find five trajectories of depressive symptoms in adolescents and demonstrate that the course of behavioral and academic problems mirrors the course of symptoms in each trajectory. Mirror co-development likely reflects shared underlying processes and supports the relevance of systematically considering co-occurring problems in clinical assessment and intervention development.
Depression is a highly prevalent and disabling condition, which increases during adolescence. The risk factors which explain the global rise in depressive symptoms and the incidence of major depression during adolescence have been extensively documented. However, recent evidence suggests that the course of depressive symptoms is not identical for all adolescents, but is characterized by considerable heterogeneity. This evidence comes from a growing number of studies which have identified distinct developmental trajectories in subgroups of adolescents.

Despite disparities in samples and methods, several commonalities can be extracted from these studies. First, between three and six trajectories of depressive symptoms have been consistently documented. Second, a stable-low trajectory, comprising a majority of individuals who do not experience elevated symptoms during adolescence, was identified in virtually all investigations. Third, at least three other trajectories have been identified in a large proportion of studies: an increasing trajectory of adolescents who experience low symptoms in early adolescence that go up over time, a decreasing trajectory of adolescents with elevated symptoms in early adolescence that go down over time, and a stable-high trajectory of individuals with consistently elevated symptoms.

Despite this mounting evidence of developmental heterogeneity in depression, the theoretical and practical implications of trajectories remain largely unclear. A research gap is the implication of diverse pathways for the development of other adjustment problems which commonly co-occur with depression. Adolescent depressive symptoms have consistently been associated with behavioral difficulties, such as delinquency and substance abuse, as well as academic problems, such as lower academic achievement and performance and lower school liking, bonding or connectedness. The co-occurrence of depressive symptoms with other
problems is particularly prevalent during adolescence and increases the risk of long-term psychosocial impairments.\textsuperscript{21}

Several mechanisms may explain how depressive symptoms relate to co-occurring problems. First, depressive symptoms may influence behavioral and academic problems. For instance, depression has been argued to increase the risk of substance use via a self-medication mechanism\textsuperscript{22} and to influence academic adjustment by disrupting cognitive functioning and learning processes.\textsuperscript{23} Second, behavioral and academic problems may influence depressive symptoms. The Dual Failure model notably holds that conduct problems in childhood increase the risk of mood problems via a combination of academic and social failures.\textsuperscript{24} Third, co-occurrence may be explained by shared processes (or risk factors). For instance, Problem Behavior Theory suggests that multiple problems tend to cluster in the form of a ‘syndrome’ that proximally results from an overall proneness to problem behavior.\textsuperscript{25}

Although substantial research has focused on mechanisms of co-occurrence in adolescent depression (e.g.,\textsuperscript{26}), few studies have examined how heterogeneity in the course of depressive symptoms relates to the development of other problems over time. Previous trajectory studies have either examined behavioral and academic problems as predictors or outcomes of trajectories\textsuperscript{7,13,15,16} or derived joint trajectories of depressive symptoms with behavioral problems (e.g.,\textsuperscript{27,28}). These studies have produced mixed findings, except for the trajectory of \textit{stable-low} depressive symptoms, which was consistently associated with lower behavioral and academic problems compared to other trajectories.

An alternative strategy to investigate the development of co-occurring problems in trajectories is to use \textit{conditional growth curves}.\textsuperscript{29} In this approach, growth curves are derived to model the course of co-occurring problems in each trajectory (one curve per problem per
trajectory). The method offers several advantages. Compared to the predictor/outcome approach, this strategy takes advantage of information collected over time, offers a dynamic view of co-occurrence, and provides a descriptive insight regarding mechanisms of co-occurrence by revealing whether changes in depressive symptoms precede, follow or move together with changes in other problems. Compared to the joint trajectory approach, this approach allows to derive trajectory-specific patterns of co-development and is better suited for the simultaneous examination of multiple behavioral and academic problems. Despite these advantages, we are aware of no investigation that has used this approach to examine the development of co-occurring problems in trajectories of depressive symptoms.

In this study, we identified developmental trajectories of depressive symptoms in a large prospective sample of students followed throughout secondary school (age 12 to 16). We used growth mixture modeling\(^3^0\) to extract subgroups of participants characterized by different course of depressive symptoms during adolescence. Based on previous findings, we expected to identify four trajectory classes of stable-low, increasing, decreasing, and stable-high depressive symptoms. We then investigated the co-development of behavioral (delinquency, substance use) and academic adjustment (school liking, academic achievement) in trajectories using conditional growth curves. We expected to find consistently lower behavioral and academic problems in the trajectory of stable-low symptoms over time, but made no prediction regarding how other trajectories would relate to co-occurring problems given limited findings from previous studies.
METHODS

Participants

Participants from the two main cohorts of the New Approaches New Solutions (NANS) dropout prevention evaluation\textsuperscript{31} were assessed annually from grade 7 to grade 11. NANS cohorts 1 (2002-2007) and 2 (2003-2008) were merged (n=10 683). Three quarters of participants attended a secondary school in a disadvantaged area of Quebec (Canada) and were exposed to NANS. These schools were selected using stratified random sampling to be representative of all schools in disadvantaged areas of Quebec in terms of geographical location, size, and language. The remainder of participants attended a comparison school in an area of average SES and were not exposed to NANS. Data were obtained each Spring via self-reported questionnaires administered in class by teachers supervised by trained experimenters. Seventy-seven percent (77%) of eligible participants provided free and informed consent to participate in the study. All procedures were approved by the Institutional Review Board of the University of Montreal.

For this study, we selected the participants who were aged 12 at entry in grade 7 (roughly 80% of each cohort). We excluded participants who were older, moved to a school outside of a NANS school during the study or did not respond on the depressive symptoms measure at age 12 (or responded inappropriately by reporting the highest value on all items, including reverse-coded items). Excluded participants were more likely to be males and had poorer adjustment on all study variables at age 12. The final sample included 6910 participants. Participants were mostly female (56%) and Quebec-born Caucasians (91%). Other participants were from a diversity of origins. Rates of available data for depressive symptoms were 100% at age 12, 74% at age 13, 41% at age 14, 41% at age 15, and 54% at age 16. Rates were similar for behavioral
and academic covariates. Lower rates of available data at ages 14 and 15 were due to a restricted data collection by design given a teacher union strike in wave 4 of NANS (age 14 for cohort 1, age 15 for cohort 2).

Measures

**Depressive symptoms.** Depressive symptoms were assessed using the Center for Epidemiologic Studies-Depression (CES-D) questionnaire. The CES-D includes 20 items exploring how participants felt in the past week. The scale has been validated in French adolescents and showed good to excellent internal consistency across time points ($\alpha = .87-.91$).

**Delinquency.** Delinquency was assessed using a validated 16-item scale inquiring about involvement in various delinquent activities in the past 12 months. Items such as “in the past 12 months, have you intentionally destroyed things which were not yours” were dichotomized (0=no; 1=yes) and summed up. Internal consistency was good to excellent at all time points ($\alpha = .87-.94$).

**Substance use.** Substance use was measured using a 4-item scale, probing the frequency of past-year alcohol and drug use. The scale included items such as “did you get intoxicated with beer, wine or hard liquor?” (0=never; 3=very often). Internal consistency was acceptable at all time points ($\alpha = .74-.77$).

**School liking.** School liking was measured using a 4-item scale. The scale included items such as “I like school” (1=not at all; 7=absolutely). School liking is conceptually close to school bonding and connectedness and has little or no overlap with measures of behavioral adjustment. Internal consistency of this scale was good at all time points ($\alpha = .86-.88$).
**Academic achievement.** Academic achievement was measured using self-reported mean grades in Mathematics and Language arts. Participants reported their grades using the following item “To the best of your knowledge, what are your average grades in [mathematics or French] this year?” based on the 0-100% scale typically used in Quebec report cards. Internal consistency was acceptable at all time points ($\alpha=0.70$–0.72).

**Statistical Analyses**

All analyses were carried out using Mplus 6.21.\(^{35}\) We derived trajectories of depressive symptoms using growth mixture modeling (GMM).\(^{30}\) We defined time according to age and merged the two cohorts together. We estimated models with different numbers of trajectories (1 to 8) using the robust maximum likelihood estimator (MLR) to account for non-normality. In order to select the best model, we considered multiple criteria, including information criteria, likelihood ratio tests, and substantive interest. We tested various models in preliminary analyses, before focusing on solutions with four growth factors (intercept, linear growth, quadratic growth, cubic growth) and within-class variation allowed only around the intercept. We also tested separate trajectories by gender. We found similar solutions and thus took gender into account as a predictor of trajectories. All models were estimated with a large number of initial start values (5000, with 100 optimizations) to avoid selecting solutions at local maxima.

We examined the co-development of behavioral and academic problems in trajectories of depressive symptoms by deriving growth curves for each of the covariates conditional on trajectories using Mplus TRAINING option. Growth curves were defined by growth parameters (intercept, slope, quadratic and cubic trends). We tested whether trajectories differed in the course of co-occurring problems by comparing the fit of (a) models with the same course (identical growth parameters) for a covariate in two specific trajectories and (b) models with...
different growth parameters in the same two trajectories. This test of nested models was repeated for all pairwise comparisons between trajectories using the Mplus MODELTEST option. Missing values on depressive symptoms and covariates over the follow-up period tended to be higher in males and participants who had poorer emotional, behavioral, and academic adjustment at age 12 (Appendix A). Missing data were handled in all models using full-information maximum likelihood with the MLR estimator to preserve sample size and reduce potential missingness bias. We did not adjust for nesting in school because 26% of participants switched from one NANS school to another during the study. Sensitivity analyses indicated that adjustment for school clustering at age 12 (using the “type=complex” option) did not modify results, except for likelihood ratio tests, which did not discriminate between trajectory solutions (analyses available upon request).
RESULTS

Descriptive Statistics

Table 1 presents the means and standard deviations for depressive symptoms and behavioral and academic covariates from age 12 to 16. Depressive symptoms remained relatively stable throughout the secondary school period, with a slight decline at age 16. Delinquency also remained relatively stable. Substance use and academic adjustment respectively increased and declined from age 12 to 16.

Selection of Trajectory Model

Figure 1 compares the information criteria for different trajectory solutions. Fit was better (lower values) in models with a larger number of trajectories, but fit improvements became gradually smaller (especially beyond a 4-class model). Likelihood ratio tests (Table 2) suggested that there was little statistical advantage in fit beyond a 5-class model (except for the BLRT which failed to discriminate between solutions). Whereas qualitatively different trajectories emerged in models from 2 to 5 trajectories, additional trajectories in models with 6 classes appeared to represent quantitative variations around these trajectories. We thus selected the 5-class model, which was composed of five clearly-distinguished trajectories and included a small yet important trajectory of individuals with stable-high symptoms.

Description of Trajectory Model

Figure 2 presents the five trajectories of depressive symptoms. The trajectory labeled \textit{stable-low} depressive symptoms included the majority of adolescents (68.1\%) and was characterized by low scores on the CES-D (below 10) between ages 12 and 16. The trajectory labeled \textit{increasing} depressive symptoms was the second largest class (12.1\%) and was
characterized by moderate depressive symptoms at age 12, which steadily increased during secondary school to reach high levels by age 16. The trajectory labeled decreasing symptoms (8.7%) included participants who reported high symptoms at age 12, followed by a rapid and stable decline in symptoms. The trajectory labeled transient comprised a similar proportion of adolescents (8.7%) and was characterized by moderate symptoms at age 12, which increased to high levels at ages 13 and 14, before leveling down to moderate levels by ages 15 and 16. Finally, the trajectory labeled stable-high symptoms included a minority of adolescents (2.4%) who reported consistently elevated symptoms.

**Gender as a Predictor of Trajectories**

We examined whether gender predicted trajectory membership. Relative to the stable-low trajectory class, females emerged as significantly more likely than males to be found in the stable-high (odds ratio[OR] = 3.5, p < .001), decreasing (OR = 2.6, p < .001), and transient (OR = 1.9, p < .001) classes, but not the increasing class (OR = 1.1, p > .05). Females were also more likely to be members of stable-high (OR = 3.1, p < .001), decreasing (OR = 2.3, p < .001), and transient (OR = 1.7, p < .01) classes relative to the increasing class, as well as the stable-high (OR = 1.8, p < .05) and decreasing (OR = 1.4, p < .05) classes relative to the transient class.

**Course of Behavioral and Academic Problems Conditional on Trajectories of Depressive Symptoms**

We next examined the co-development of behavioral and academic problems in trajectories by deriving conditional growth curves. Comparison of nested models (not shown) indicated that growth curves for all co-occurring problems were significantly different in the five trajectory classes. A remarkably similar pattern of results emerged for all covariates (Figure 3).
closely follow the course of depressive symptoms in each trajectory. However, The precise course of covariates in trajectory classes varied in relation to the general course in the full sample for the same covariate. For instance, the course of substance use and academic achievement in all five trajectories were tilted counter-clockwise reflecting the general trend for these covariates to increase over time.

Visual inspection suggests specificities beyond this general pattern. The three non-stable trajectories (decreasing, transient, increasing) reached higher levels of behavioral than academic problems relative to the stable-low and stable-high trajectories. Trajectory peaks in the non-stable trajectories reached higher or equal levels of behavioral problems than the stable-high trajectory, which was not the case for trajectories of depressive symptoms (rank order differences). Co-development between depressive symptoms and academic covariates was more similar in the stable high and stable-low classes than the three non-stable trajectories. Finally, between-class variability in delinquency tended to increase over time, while between-class variability in achievement tended to decrease.

Ancillary Analyses

We conducted a more traditional test of behavioral and academic problems as predictors and outcomes of trajectories (Appendices B and C). These analyses indicated that behavioral and academic predictors primarily distinguished trajectories on the basis of concurrent depressive symptoms at age 12 and that behavioral and academic outcomes distinguished trajectories on the basis of concurrent depressive symptoms at age 16. These results are consistent with our main findings and suggest that these findings do not represent an artefact of our analytical approach.
DISCUSSION

We identified five trajectories of depressive symptoms in a large sample of secondary school students followed from age 12 to 16. Consistent with most previous studies, we replicated four trajectories of stable-low, increasing, decreasing, and stable-high symptoms. Interestingly, we also identified a transient (rise-and-decline) trajectory which is more idiosyncratic to this study. Also consistent with previous studies,4,5,7,9,10 most participants with elevated depressive symptoms at a given age had non-stable, temporary elevated symptoms. However, participants in these trajectories (increasing, decreasing, transient) maintained higher symptoms than the stable-low trajectory at all time points, including outside trajectory peaks. Together, the stable-high, increasing, decreasing, and transient trajectories indicate that one adolescent out of three had symptoms that remained moderate and/or elevated across secondary school. This emphasizes the high prevalence and stability of adolescent depressive symptoms.2,37 Although we found similar trajectories in males and females, females to be more likely to be members of trajectories of early and stable symptoms (stable-high, decreasing, transient). This may reflect a variety of factors, including earlier pubertal timing and greater reactivity to life stressors related to entry into secondary school in females compared to males.38

The main contribution of this study was to examine the co-development of behavioral and academic adjustment problems in trajectories of depressive symptoms using a conditional growth curve approach. This innovative approach allowed us to identify a clear and consistent pattern of co-development over time: the course of each behavioral and academic problem closely mirrored the development of depressive symptoms in each trajectory. This statement should however be qualified in two ways. First, the course of each covariate in trajectories varied as a function of the course of this covariate in the full sample. Second, peak level academic difficulties tended to
remain lower than peak level behavioral difficulties in the trajectories of temporary symptoms
(increasing, decreasing, transient) relative to the two stable trajectories (stable-high, stable-low).
This is likely to reflect lower general lability of academic adjustment compared to behavioral and
emotional adjustment over the secondary school years.

Although previous studies reported a similar “wax and wane” pattern of conduct
problems with other difficulties,\(^29,39\) this generalized mirror pattern is a novel finding in
adolescent depression research. At a descriptive level, the fact that depressive symptoms tended
to co-develop together with, rather than to precede or follow behavioral and academic problems,
is not suggestive of causal or consequence models. Our results are generally more consistent
with a common process model, in which underlying developmental processes give rise to
simultaneous trends in depressive symptoms and other problems over time. This model appears
to provide a primary explanation for our results across covariates and trajectories, but does not
preclude the existence of direct influences between depressive symptoms and other problems,
which have been documented in our research and the larger literature.\(^26,40\)

Several underlying processes may explain co-development over time. A first possibility
is a time-varying individual vulnerability. A personality trait that is stable yet fluctuating over
time such as neuroticism has been suggested to explain the co-occurrence of conduct problems
and depressive symptoms.\(^39\) A second possibility is time-varying environmental influences.
Individuals in the stable-high trajectory may be exposed to chronic stress (e.g., family
dysfunction, etc.), while individuals in transient, increasing, and decreasing trajectories may
react to temporary negative life events (e.g., secondary school entry in the decreasing trajectory).
A third possibility is a combination of individual and environmental influences. Problem
Behavior Theory holds that individual and environmental risk factors contribute to a general
proneness to deviance, which leads to the clustering of emotional, academic, and behavioral
difficulties. In line with diathesis-stress models of depression, individual and environmental
factors are likely to interact in a complex fashion. Genetic, biological, or psychological
vulnerability to depressive symptoms in some individuals may only be activated when these
individuals are confronted with high stress. Adolescents in the stable-high, transient, increasing,
and decreasing classes may all share a common vulnerability that gets “switched on” at a
different timing and for a different duration by chronic stress (stable-high) or acute stress
(transient, increasing, decreasing).

This study is not without limitations. First, all study variables were self-reported,
including depressive symptoms. Shared method variance may have contributed to the
identification of mirror patterns of co-development. Second, rates of missing data were high,
though a good portion resulted from missingness by design given a teachers union strike in one
year. Full information maximum likelihood should also have reduced attrition biases, but no
statistical solution is a panacea. Third, we could not perfectly adjust for nesting within school
because several participants switched school during the study. Fourth, adolescents in the NANS
sample attended schools primarily located in disadvantaged areas. It is unclear whether the
trajectories and relations found here generalize to students who attend school in an advantaged
area (e.g., private schools). The nature of the sample may have influenced the trajectory solution
(e.g., identification of a unique transient trajectory) or patterns of co-development, since
participants in high-risk samples may be more likely to develop multiple problem behaviors.

Future research is needed to determine the nature of the underlying developmental
process(es) that give rise to the mirror co-development of depressive symptoms and associated
behavioral and academic problems. Trajectory studies that examine multiple individual and
environmental time-varying influences such as pubertal timing, genetic vulnerability, personality factors, and stressful life events would be particularly informative and would allow undertaking formal tests of competing explanations. An intriguing question which could be addressed by these studies is whether there are distinct underlying developmental processes of co-development or a single underlying process shared by all trajectories.

In terms of clinical implications, our findings suggest that depressive symptoms co-develop together with behavioral and academic adjustment problems in a relatively systematic manner. This reinforces the notion that clinical assessment of adolescents with depressive symptoms should always consider potential co-occurring problems. Depression prevention and treatment approaches may benefit from a focus on multiple co-occurring problems rather than depression only and from devoting greater attention to non-specific risk factors which are known to exert an influence on multiple adjustment problems.\textsuperscript{42}
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**FIGURE LEGENDS**

**Figure 1.** Comparison of information criteria for models with 1 to 8 trajectories

**Figure 2.** Trajectories of depressive symptoms in NANS secondary school adolescents

**Figure 3.** Development of behavioral and academic problems conditional on trajectories of depressive symptoms: (a) delinquency, (b) substance use, (c) school liking (reversed), (d) academic achievement (reversed)
Table 1

Mean and Standard Deviations for Depressive Symptoms and Behavioral and Academic Covariates from age 12 to 16

<table>
<thead>
<tr>
<th></th>
<th>Mean (SD)</th>
<th>age 12</th>
<th>age 13</th>
<th>age 14</th>
<th>age 15</th>
<th>age 16</th>
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<tr>
<td>Depressive Symptoms</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>12.27 (10.15)</td>
<td>12.53 (10.38)</td>
<td>12.13 (9.90)</td>
<td>12.37 (9.97)</td>
<td>11.59 (10.18)</td>
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<tr>
<td>Delinquency</td>
<td></td>
<td>1.60 (2.70)</td>
<td>1.82 (3.06)</td>
<td>1.81 (3.32)</td>
<td>1.70 (3.09)</td>
<td>1.74 (3.23)</td>
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<tr>
<td>Substance Use</td>
<td></td>
<td>.19 (.43)</td>
<td>.34 (.54)</td>
<td>.49 (.60)</td>
<td>.58 (.61)</td>
<td>.65 (.64)</td>
</tr>
<tr>
<td>School Liking</td>
<td></td>
<td>4.18 (1.37)</td>
<td>4.01 (1.26)</td>
<td>3.99 (1.25)</td>
<td>3.97 (1.23)</td>
<td>4.03 (1.24)</td>
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<tr>
<td>Academic Achievement</td>
<td></td>
<td>76.79 (10.18)</td>
<td>76.40 (10.25)</td>
<td>75.28 (10.41)</td>
<td>73.08 (9.38)</td>
<td>72.48 (9.80)</td>
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Table 2.

Likelihood Ratio Tests Comparing Different Trajectory Solutions

<table>
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<th></th>
<th>VLMR</th>
<th>Adjusted LMR</th>
<th>BLRT</th>
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<tr>
<td>1 Class</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>2 Classes</td>
<td>1672.98 (5)</td>
<td>1635.97 (5)</td>
<td>1672.98 (5)***</td>
</tr>
<tr>
<td>3 Classes</td>
<td>1050.15 (5)</td>
<td>1026.92 (5)</td>
<td>1050.15 (5)***</td>
</tr>
<tr>
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<td>734.98 (5)</td>
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<td>734.98 (5)***</td>
</tr>
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</tr>
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<td>407.77 (5)</td>
<td>419.04 (5)***</td>
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<td>7 Classes</td>
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<td>334.72 (5)</td>
<td>342.29 (5)***</td>
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<tr>
<td>8 Classes</td>
<td>298.18 (5)</td>
<td>291.60 (5)</td>
<td>298.18 (5)***</td>
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</table>

Note. Adjusted LMR = Lo-Mendell-Rubin adjusted likelihood ratio test; BLRT = Bootstrapped Likelihood Ratio Test.

*** p < .001; ** p < .01; * p < .05.
CAPTION

*Figure 1.* Comparison of information criteria for models with 1 to 8 trajectories
Note. AIC = Akaike Information Criterion; BIC = Bayesian Information Criterion; ABIC = Sample-Size Adjusted Bayesian Information Criterion
Figure 2. Trajectories of depressive symptoms in NANS secondary school adolescents
Transient (8.7%)
Decreasing (8.7%)
Increasing (12.1%)
Stable-high (2.4%)
Stable-low (68.1%)
Sample mean
Figure 3. Development of behavioral and academic problems conditional on trajectories of depressive symptoms: (a) delinquency, (b) substance use, (c) school liking (reversed), (d) academic achievement (reversed)
(a) Delinquency

(b) Substance Use

(c) School liking (reversed)

(d) Achievement (reversed)

- Transient
- Decreasing
- Increasing
- Stable-High
- Stable-Low
- Sample mean
Appendix A.

Non parametric correlations between study variables at age 12 and number of missing values on depressive symptoms and covariates over the follow-up period (ages 13 to 16)

<table>
<thead>
<tr>
<th>Predictors (age 12)</th>
<th>Depressive symptoms</th>
<th>Delinquency</th>
<th>Substance Use</th>
<th>Academic achievement</th>
<th>School liking</th>
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<tbody>
<tr>
<td>Gender (1=male)</td>
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<td>.15**</td>
<td>.13**</td>
<td>.12**</td>
<td>.12**</td>
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<tr>
<td>Depressive symptoms</td>
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<td>.07**</td>
<td>.07**</td>
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<td>.07**</td>
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<td>.11**</td>
<td>.10**</td>
<td>.10**</td>
<td>.10**</td>
</tr>
<tr>
<td>Substance use</td>
<td>.09**</td>
<td>.10**</td>
<td>.09**</td>
<td>.09**</td>
<td>.09**</td>
</tr>
<tr>
<td>School liking</td>
<td>-.08**</td>
<td>-.08**</td>
<td>-.08**</td>
<td>-.07**</td>
<td>-.07**</td>
</tr>
<tr>
<td>Academic achievement</td>
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<td>-.15**</td>
<td>-.15**</td>
<td>-.14**</td>
<td>-.14**</td>
</tr>
</tbody>
</table>

** = p < .01
Appendix B

Associations between academic and behavioral predictors at age 12 and trajectory class membership

<table>
<thead>
<tr>
<th>Trajectory Class Membership, Odds Ratios ¹</th>
<th>Reference = Stable-low</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Transient</td>
</tr>
<tr>
<td><strong>Behavioral predictors</strong></td>
<td></td>
</tr>
<tr>
<td>Delinquency (1 SD unit)</td>
<td>2.0 ***</td>
</tr>
<tr>
<td>Substance use (1 SD unit)</td>
<td>1.6 ***</td>
</tr>
<tr>
<td><strong>Academic predictors</strong></td>
<td></td>
</tr>
<tr>
<td>School liking (1 SD unit)</td>
<td>0.8 ***</td>
</tr>
<tr>
<td>Academic Achievement (1 SD unit)</td>
<td>0.7 ***</td>
</tr>
</tbody>
</table>

¹ Odds ratios derived from multinomial regression using the Mplus R3STEP option

*** p < .001; ** p < .01; * p < .05
Appendix B (Continued)

**Associations between academic and behavioral predictors at age 12 and trajectory class membership**

<table>
<thead>
<tr>
<th>Trajectory Class Membership, Odds Ratios</th>
<th>Reference = Increasing</th>
<th>Reference = Transient</th>
<th>Reference = Decreasing</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image" alt="" /></td>
<td>Transient</td>
<td>Decreasing</td>
<td>Stable high</td>
</tr>
<tr>
<td><strong>Behavioral predictors</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Delinquency (1 SD unit)</td>
<td>1.0</td>
<td>1.4 ***</td>
<td>1.3 **</td>
</tr>
<tr>
<td>Substance use (1 SD unit)</td>
<td>1.0</td>
<td>1.6 ***</td>
<td>1.2 *</td>
</tr>
<tr>
<td><strong>Academic predictors</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>School liking (1 SD unit)</td>
<td>1.1</td>
<td>0.9</td>
<td>1.0</td>
</tr>
<tr>
<td>Academic achievement (1 SD unit)</td>
<td>1.1</td>
<td>0.9</td>
<td>0.7</td>
</tr>
</tbody>
</table>

1 Odds ratios derived from multinomial regression using the Mplus R3STEP option

*** p < .001; ** p < .01; * p < .05
Appendix C

Mean academic and behavioral outcomes at age 16 of trajectories of depressive symptoms

<table>
<thead>
<tr>
<th>Behavioral outcomes</th>
<th>Estimated mean $^1$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Stable-low</td>
</tr>
<tr>
<td>Delinquency</td>
<td>1.0 $^c$</td>
</tr>
<tr>
<td>Substance use</td>
<td>-0.04 $^c$</td>
</tr>
<tr>
<td>Academic outcomes</td>
<td></td>
</tr>
<tr>
<td>School liking</td>
<td>4.2 $^c$</td>
</tr>
<tr>
<td>Academic achievement</td>
<td>74.1 $^c$</td>
</tr>
</tbody>
</table>

$^1$ Estimated means and statistical tests are derived from equality tests of means across classes using posterior probability-based multiple imputations with the Mplus Auxiliary (e) option.

Note. Groups with the same superscripts do not differ statistically.
Modified Table 2.

Fit and Likelihood Ratio Tests for Different Trajectory Solutions (taking nesting into account with the Mplus “type = complex” option)

<table>
<thead>
<tr>
<th></th>
<th>Information Criteria</th>
<th>Likelihood Ratio Tests</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>BIC</td>
<td>ABIC</td>
</tr>
<tr>
<td>1 Class</td>
<td>156948</td>
<td>156916</td>
</tr>
<tr>
<td>2 Classes</td>
<td>155319</td>
<td>155272</td>
</tr>
<tr>
<td>3 Classes</td>
<td>154313</td>
<td>154250</td>
</tr>
<tr>
<td>4 Classes</td>
<td>153623</td>
<td>153543</td>
</tr>
<tr>
<td>5 Classes</td>
<td>153210</td>
<td>153114</td>
</tr>
<tr>
<td>6 Classes</td>
<td>152835</td>
<td>152723</td>
</tr>
<tr>
<td>7 Classes</td>
<td>152537</td>
<td>152410</td>
</tr>
<tr>
<td>8 Classes</td>
<td>152283</td>
<td>152140</td>
</tr>
</tbody>
</table>

Note. BIC = Bayesian Information Criterion; ABIC = Sample size adjusted Baryesian Information Criterion; AIC = Aikaike Information Criterion; VLMR = Vuong-Lo-Mendell-Rubin Likelihood ratio test; Adjusted LMR = Lo-Mendell-Rubin adjusted likelihood ratio test; BLRT = Bootstrapped Likelihood Ratio Test.

*** \( p < .001 \); ** \( p < .01 \); * \( p < .05 \).
Modified Figure 2. Trajectories of depressive symptoms in NANS secondary school adolescents (taking nesting into account)
Transient (8.7%)
Decreasing (8.7%)
Increasing (12.1%)
Stable high (2.4%)
Stable low (68.1%)
Sample mean
Modified Figure 3. Development of behavioral and academic problems conditional on trajectories of depressive symptoms (taking nesting into account): (a) delinquency, (b) substance use, (c) school liking (reversed), (d) academic achievement (reversed)
Highlights

- Evidence suggests multiple trajectories of depressive symptoms in adolescents
- Implications of these trajectories for commonly co-occurring problems are unclear
- We identified five trajectories in adolescents followed from age 12 to 16
- Behavioral and academic problems mirrored the course of symptoms in trajectories
- Co-occurring problems should always be considered in assessment and intervention