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Explaining trajectories of adolescent drunkenness, drug use, and criminality: A latent transition analysis with socio-ecological covariates



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HIGHLIGHTS

- There are different trajectories in adolescent substance use and criminal behaviour.
- Trajectories are largely stable in early to mid-adolescence.
- The different trajectories are likely to have different causal mechanisms.
- Family cohesion and criminal peers was linked to an entrenched group.
- Implications for theory, policy and practice are discussed.

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ABSTRACT

Background: Although there are diverse trajectories in adolescent substance use and criminality, it is less clear why some adolescents follow one pathway and not another. In this study, we examine how different domains in a young person's life, such as temperament, peer, and family factors, are linked to different trajectories and whether some domains are more strongly associated with specific patterns of these behaviours.

Methods: Data comes from the Longitudinal Research on Development in Adolescence (LoRDIA) study in Sweden. Adolescents were surveyed at baseline (n = 755, age 13, grade 7) and followed up at grades 8 and 9. Latent transition analysis and multinomial logistic regression were conducted.

Results: Four distinct statuses were found, showing heterogeneity in adolescent substance use and criminal behaviours. These statuses were however highly stable. Individual, peer and family domains were all relevant in distinguishing between the statuses. A key finding is that the relative importance of these domains differed between statuses, suggesting differential effects of the domains on the different trajectories. The pre-teen family environment, as well as criminal peers, was most strongly associated with a more entrenched group. This was not the case for a 'Dabblers' group, where novelty-seeking was weakly linked. For the 'Occasional Law Breakers', criminal peers was more strongly associated.

Conclusions: Our results suggest that substance use and criminality in early to mid-adolescence is more diverse than current theories allow. Moreover, the different trajectories in these behaviours are likely to have different causal mechanisms, which has important implications for theory, policy and practice.

1. Introduction

Developmental trajectories of adolescent substance use and/or criminality¹ have been studied using latent transition analysis (e.g. Monahan, Rhew, Hawkins, & Brown, 2013; Bright et al., 2017), which being a person-centred method (see Lanza, Patrick, & Maggs, 2010) allows a theoretical account of *how* behaviours cluster differently in

young people as they develop. What is less clear from existing studies is *why* some adolescents' behaviours follow one trajectory and not another. There is a substantive need to understand not just the different trajectories, but the mechanisms that may be driving these patterns (Bhaskar, 1975; Hedström, 2005); such knowledge could inform policy and practice to be more sensitive to sub-group differences (Pawson, 2013). In particular, being able to model which factors in early

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¹ We use the word 'criminality', rather than 'delinquency', to reflect both a substantive interest in law-breaking behaviour, but also to be coherent with the measure used in our study, which only looks at criminal acts.

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adolescence are indicative of which developmental patterns help to better tailor preventative efforts. Moffitt (2018), in reviewing the history of her original dual taxonomy of adolescent criminal behaviour (see Moffitt, 1993), outlines how a better understanding of heterogeneity in adolescent criminal behaviour has led to important developments in prevention policy and practice.

Where studies of transitions in adolescent substance use and criminality exist, they often however have a univariate or 'uni-domainal' perspective, e.g. looking at individual or peer-level factors. This means that potential explanatory accounts become mono-causal, neglecting the complexity of adolescent lives (Sercombe, 2014), which in turn hampers translation into 'real world' policy and practice. The socio-ecological perspective (e.g. Sameroff, 2010) provides a more comprehensive model where adolescent development is viewed as the product of different domains in a young person's life, such as individual, family, and peers. Studies adopting this perspective (e.g. Goldstein, Davis-Kean, & Eccles, 2005) confirm the explanatory relevance of including variables from different domains. Few studies to date however have used a socio-ecological model to look at heterogeneity, that is, different trajectories in the development of substance use and criminality in adolescence.

While latent transition analysis (LTA; see Lanza et al., 2010) is a robust method of studying heterogeneity, it is rare that LTA studies of adolescent substance use and criminality use a range of socio-ecological explanatory covariates. Existing studies have identified differential trajectories and in some cases linked in single-domain covariates, such as pubertal timing (Chung, Park, & Lanza, 2005), gender (Jackson & Schulenberg, 2013), socio-demographics (Bright et al., 2017) and peer factors (Monahan et al., 2013). Additionally, many such LTA studies examine alcohol or drug use or criminal behaviours separately. Where studies do look at how substance use and criminal behaviours cluster (e.g. Bright et al., 2017), a more complex, socio-ecological explanatory model is lacking. The link between substance use and criminality in adolescence is complex with studies showing only weak longitudinal, reciprocal associations (see Turner, Daneback, & Skårner, 2018), and then only for early criminality leading to later substance use. Yet for those adolescents who do show early criminal behaviour, there is often considerable overlap with substance use (see Moffitt, Caspi, Harrington, & Milne, 2002). This suggests that it is important to examine how both substance use and criminal behaviours cluster during adolescence and progress, in terms of temporal order, but also how these trajectories might be explained within a socio-ecological model.

1.1. Previous literature on trajectories of adolescent substance use and criminal behaviour

Latent class and latent transition studies of adolescent substance use and criminal behaviour often find three to four classes, comprising one larger 'normative' class, one to two classes where substance use or criminal behaviour feature to some degree, and one small 'severe' class where these behaviours are predominant (see Monahan et al., 2013; Vaughn, Salas-Wright, DeLisi, & Maynard, 2014; and Bright et al., 2017). Monahan et al. (2013) investigated patterns of substance use and delinquency in a sample of US adolescents and found four latent classes: abstainers, delinquent-only, substance-use-only, and co-occurring. The most common transition to co-occurring behaviour was abstinence to delinquent-only then to co-occurring. The delinquent-only group comprised 26% of the sample and was stable over time, compared to the substance-use-only group which grew from 2 to 8%. Transitions from substance-use-only thus reflected very small numbers of youth and they were as likely to transition to abstinence as they were to co-occurring behaviour. The question arises of which youth maintain, escalate, or de-escalate their behaviour. Bright et al. (2017), also in a US sample, found three classes: low risk (81%), delinquent-only (18%), and co-occurring (1%). Using gender, ethnicity, and caregiver

education and income as explanatory variables, only gender had an effect, and only in late adolescence (15–18 years) with males being more likely than females to transition from delinquency-only to co-occurring behaviour. Studies looking solely at the development of substance use (e.g. Choi, Lu, Schulte, & Temple, 2018) also found that males were more likely than females to progress to poly-substance use. In general, when looking just at substance use behaviours, studies have shown that latent statuses are fairly stable in adolescence, i.e. teenagers tend to remain in the same class over time, and the proportion engaged in poly-substance use is low (Baggio et al., 2014; Choi et al., 2018).

1.2. Previous literature on the role of peer, family, and individual factors in the development of adolescent substance use and criminal behaviour

In a US sample, Goldstein et al. (2005) examined the role of parental and peer factors on a measure of 'problem behaviour', which included substance use, criminality, but also sexual activity. They found that adolescents' perceptions of parental intrusiveness in 7th grade were linked (0.15 standardised effect) to extreme peer orientation (see Fuligni & Eccles, 1993) in 8th grade, which in turn was more strongly linked (0.23) to problem behaviour in 11th grade. Family income also had a weak effect (−0.15), as did positive family climate (−0.07), on parental perceptions of negative peers, which in turn was also linked, albeit weakly, (0.09) to later problem behaviour. Their model did not however test for cross-lagged or auto-regressive effects on all measures, nor did it investigate sub-groupings of adolescents via a latent class approach. Monahan et al. (2013) looked at peer influence alone on transitions, but separated peer influence by different behavioural domains, e.g. perceived peer drug use and peer crime. They found that the influence of peers' behaviour was domain-specific when transitioning from abstinence to a single-behaviour, with effects in the 0.16–26 range, but both behaviours were more strongly linked to the transition to co-occurring behaviour (range 0.19–36). This suggests a peer effect for some youth with some behavioural transitions, but by no means all.

In the family domain, Abar, Jackson, and Wood (2014) found parent-teen relationship quality moderates the well-known link between perceived parental knowledge and substance use and criminality (see Stattin & Kerr, 2000); the arising point being that parents who have better quality relationships with their teens either have less need for knowledge of their charges' activity, or that the teens themselves in such positive relationships do not escalate in their substance-using or criminal behaviour. In a systematic review of longitudinal studies on parenting factors that reduce adolescent alcohol use, parental modelling, monitoring, and parent-child relationship quality had strong support (Ryan, Jorm, & Lubman, 2010). Another important family-level factor is family income. Studies have shown that even transient financial difficulties can have an effect on later adolescent behaviours (Ramanathan, Balasubramanian, & Faraone, 2017) and the effect remains even when controlling for parenting style and neighbourhood variables (Rekker, Pardini, Keijsers, Branje, & Loeber, 2015).

In terms of the individual-level domain, temperament has been linked to substance use (see Hartman, Hopfer, Corley, Hewitt, & Stallings, 2013), particularly in those youth high in novelty-seeking. Other studies have also demonstrated a link between individual factors such as emotional adjustment (Farrell & Danish, 1993), childhood aggression (Brook, Whiteman, Finch, & Cohen, 1996), internalising problems (Loeber, Stouthamer-Loeber, & White, 1999), low constraint and aggressive undercontrol (Samek et al., 2018), and later substance use and/or criminality in adolescence. These effects are however weak, i.e. < 0.2 and do not examine heterogeneity for example by latent classes. Moreover, all of these studies examined the individual-level variables in isolation from at least one other socio-ecological domain, such as peers or family. In a study of the link between parenting practices and adolescent substance use, Kapetanovic, Skoog, Bohlin, and Gerdner (2019) found that not only did temperament moderate this

link, but more importantly that the moderation was stronger for a subgroup of ‘detached thrill-seekers’, suggesting differential effects for different sub-groups.

1.3. Study aim

Building on this work, we aim to examine the trajectories of adolescent alcohol and drug use and criminality using latent transition analysis with explanatory covariates from three socio-ecological domains: individual, peers, and family. In particular, we pose two preliminary research questions: 1) Do covariates from each domain significantly distinguish between the identified latent statuses? 2) Does the strength of association between a covariate and the latent status group differ by latent status group, i.e. a differential effects hypothesis? A further, exploratory but more important, research question is to what extent the strength of associations differ for each latent status group, which in turns connects to the substantive interest in why some adolescents follow one trajectory and not another.

2. Method

2.1. Design, procedure and ethics

The data in the current study comes from the Longitudinal Research on Development in Adolescence (LoRDIA) programme. LoRDIA is a prospective, general population, cohort study following over 2000 Swedish adolescents, examining psychosocial development, with a focus on mental health, substance use and criminality. The overall design, study context and procedure, along with ethical approval, has been described in more detail in Turner et al. (2018). Important to note is that no significant differences, between the LoRDIA sample and students in the study population that did not participate in LoRDIA, were found in terms of sex, school exam grades or school absence.

2.2. Participants

For this study, the baseline sample at grade 7 ($n = 755$) comprised 49.8% girls and 50.2% boys; the mean age was 12.8. This sample was selected based on having two or more completed questionnaires during grades 7, 8, or 9. This gave 93% participation at grade 7, 89% at grade 8, and 91% at grade 9.

2.3. Measures

2.3.1. Indicators of latent statuses

Substance use was conceptualised as intoxication through either alcohol or drug use. Alcohol intoxication (drunkenness) was chosen over alcohol use, as the latter measure may include only usage of negligible effect. Moreover, there is a growing literature suggesting that

Table 1

Prevalence of the indicators at each time point.

Indicator	Response	Grade 7	Grade 8	Grade 9
		($n = 700$) Valid/%	($n = 672$) Valid/%	($n = 686$) Valid/%
Drunkenness	None	677/97.1	624/93.3	561/82.6
	Infrequent	12/1.7	19/2.8	46/6.8
	Frequent	8/1.1	26/3.9	72/10.6
Drug use	None	684/98.8	650/97.5	647/95.1
	Infrequent	2/0.3	9/1.3	13/1.9
	Frequent	6/0.9	8/1.2	20/2.9
Criminality	None	598/86.9	525/81.1	509/78.7
	Infrequent	84/12.2	114/17.6	128/19.8
	Frequent	6/0.9	8/1.2	10/1.5

N.B. Some percentages may not total to 100 due to rounding. The proportion of missing data has been excluded from percentages.

early drunkenness, rather than alcohol use per se, is a better predictor of developmental problems (see Enstad, Pedersen, Nilsen, & von Soest, 2017). This study was also interested in how drunkenness and drug use may group together, alongside criminality, and thus they were retained as separate measures. The measures of drunkenness and drug use were adapted from the annual school survey conducted by The Swedish Council for Information on Alcohol and Drugs (CAN) (see Englund, 2016). The measure for criminality was adapted from the national school survey conducted by The Swedish National Council for Crime Prevention (see Ring, 2013). More information about these measures can be found in Turner et al. (2018). In order to avoid problems of overly sparse contingency tables in the LTA, three response categories were created for all three indicators: No, Infrequent (being less than monthly), Frequent (being monthly or more). It is important to note however that low or empty cell counts do not affect the model identification estimates in the LTA.

Baseline levels of the three indicators did not differ between participants with valid or missing data at grade 8. When comparing grade 9 participants with valid or missing data, baseline levels of the indicators did differ², but these differences were less than an equivalent 5% increase on the scale and viewed as negligible. Thus, missing indicator data due to internal attrition was viewed as Missing At Random (MAR).

Table 1 lists the prevalence of the indicators at each time point.

2.3.2. Socio-ecological covariates

All covariate data was available at grade 7 (baseline) only. Individual level covariates were sex (male/female) and temperament, as measured by the four scales in the Junior Temperament and Character Inventory (JTCI), validated in a Swedish context by Boson, Brandström, and Sigvardsson (2018): Novelty-seeking, harm avoidance, reward dependence and persistence. Up to 5% missing items were allowed per scale and alphas for each scale for the wider sample were 0.7, 0.8, 0.6, and 0.3 respectively. Previous research (e.g. Hartman et al., 2013) has shown that the four temperament scales of the JTCI can significantly predict early-onset substance use problems, and thus theoretically provide a good control of individual variation in temperament. Peer level covariates were measured by three separate questions designed for the LoRDIA study: participants were asked how many of their friends get drunk, have tried drugs, or sometimes commit crimes. Responses were canvassed using a 4-point ordinal scale from ‘None’ to ‘Most’. These questions were kept as separate covariates given that the effect of peers’ perceived behaviour may be behaviour-specific (see Monahan et al., 2013). Two family level covariates were used: family cohesion and family financial situation. Family cohesion was measured using Bloom’s (1985) scale, allowing only one missing item. Scale reliability (alpha) was 0.7. Perceived family finances was measured using a 3-point ordinal question designed for the LoRDIA study: Does your family have less/the same/more money than other families where you live? Analysis of internal missing data found that grade 9 levels of criminality were marginally higher for participants with missing baseline data only regarding peer drug use and peer criminality. These differences were < 3.5% equivalent increase on the scale and deemed negligible. Thus, the covariate data was also held to be MAR. Multicollinearity between the covariates was tested and VIFs > 2.5 were found only for peers’ perceived crime, which had a VIF of 2.8.

Table 2 gives descriptive statistics for the covariates, excluding sex, at baseline.

2.4. Analytic approach

All analyses were conducted in LatentGold 5.1.0 (see Vermunt & Magidson, 2005) with some post-hoc sensitivity analyses conducted in

² Mann-Whitney independent samples test. Test statistics available on request to the corresponding author.

Table 2
Descriptive statistics for the covariates (baseline).

Covariate	Mean	s.d.	Range
<i>Individual level</i>			
Novelty Seeking	6.96	3.47	0–17
Harm Avoidance	6.38	4.36	0–20
Reward Dependence	4.17	2.1	0–9
Persistence	3.37	1.45	0–6
<i>Family level</i>			
Family cohesion	3.54	0.46	1–4
Perceived family financial status	2.06	0.42	1–3
<i>Peer level</i>			
Peers who get drunk	1.21	0.55	1–4
Peers who take drugs	1.1	0.37	1–4
Peers who commit crime	1.27	0.57	1–4

Stata SE 15.1. We followed the three-step approach to identifying latent transitions models with covariates (see Collins & Lanza, 2010; Vermunt, 2010; Bakk, Tekle, & Vermunt, 2013). The number of classes was determined by a combination of conceptual and statistical consideration. Collins and Lanza (2010) note that LTA models due to their complexity often result in sparse contingency tables. This makes the probability values of absolute measures of model fit, such as chi-square, unreliable. To address this issue, following Collins and Lanza’s (2010) suggestions, we relied on measures of relative model fit, such as the likelihood-ratio goodness-of-fit (L2), Akaike Information Criterion (AIC), Bayesian Information Criterion (BIC) and the proportion of classification errors (CE). Smaller values of L², AIC, BIC, and CE indicated a preferable model statistically. In order to test the sensitivity of the absolute fit statistic, we also employed LatentGold’s bootstrapping of the L2 measure of absolute fit, using 500 iterations. Conceptual consideration was based on existing literature and interpretability of the meaning of the classes and item-response profiles.

Step 1 of the approach estimated the LTA model choosing the appropriate number of statuses. Time was then added as a covariate allowing transition probabilities to vary over time. This is to capture developmental changes. Measurement invariance over time was tested by running an unrestricted model with direct effects of time on the indicators, and the –2LL Diff likelihood statistic was calculated. In step 2, the final model was re-estimated and the posterior status probabilities were saved to a new data file. In step 3 the covariates were regressed in a multinomial logistic regression on the posterior classifications, in order to estimate the effect of the covariates on latent status (using LatentGold’s Step3 module; see Bakk & Vermunt, 2013). Robust estimators were used which minimise the risk of false positives arising from skew in the data. Missing data was handled using LatentGold’s multiple imputation, which under the assumption that the data is MAR, provides reliable estimates (see Little & Rubin, 2002).

The Step 3 regression analyses were conducted in two series: i) testing the regression with all covariates but excluding the smallest latent class. This was due to concerns that the smallest class did not contain enough events per variable (EPV) for the full multi-nomial regression to run reliably; ii) running a logistic regression with just the largest and the smallest latent class with only four covariates which the previous analysis and theoretical considerations suggested as most relevant. This was to determine estimates for a limited range of covariates, yet still in line with the socio-ecological perspective, in relation to the smallest group, and also to obtain sensitivity and specification statistics for this comparison, which assists in evaluating the reliability of the model. For this analysis, we employed the Firth method of Penalized Maximum Likelihood Estimation (PMLE). PMLE is designed for the analysis of small numbers of cases on the rarer of two outcomes in logistic regression. It allows for convergence when data are very sparse and prone to near or complete separation (see Firth, 1993). The

Table 3
Model fit statistics.

Model	Np*	L2	AIC	BIC	Classification error (CE)
1 status	6	1523.7	25.7	–3439.7	0
2 statuses	12	910.6	–575.4	–4013	0.04
3 statuses	20	791.5	–678.5	–4079.1	0.12
4 statuses	30	667.5	–782.5	–4136.9	0.07
4 statuses with time covarying with transitions	42	645.9	–780	–4078.9	0.07
4 statuses, with time covarying with response probabilities	45	627.5	–792.5	–4077.4	0.06

* Np = Number of parameters in the model.

PMLE analysis was conducted using the firthlogit module in Stata SE 15.1.

3. Results

3.1. Latent status model development

Model fit statistics are shown in table 3 for the tested LTA (Markov) models, with the chosen model shown in bold.

We selected the 4-status model with time affecting transitions only. This is in part based on the lowest AIC, BIC, and CE, which reflect a good balance between model parsimony and statistical measures of relative fit. In terms of absolute model fit, the bootstrapped L2 probability was > 0.05, suggesting the model did not differ significantly from the observed data. Conceptual interpretation also favoured this model in that it both allowed transitions to vary between grades, which is important to understand developmental patterns, but also as the four statuses captured the heterogeneity of response patterns and provided distinctly meaningful classes. The –2LL Diff test between the final two models (–2LL Diff = 18.4, p < 0.01) suggested that a time variant model was a better fit to the data. However, using AIC and BIC, the time-invariant model was preferred. Conceptually, the time-invariant model is also preferred, following Lanza et al. (2010), as measurement invariance implies that the meaning of latent statuses is comparable over grades.

The baseline prevalence and item response profile for the selected model is given in Table 4.

Each of the four statuses was labelled to reflect our interpretation of the profiles. The largest group at nearly 80% of the sample, dubbed “Abstainers”, had a low probability of engaging in any of the three behaviours. The next largest group at nearly 10% of the sample was

Table 4
Four-status model of drunkenness, drug use and criminality across grades 7–9, with time affecting transitions between statuses.

Status label	Abstainers	Occasional law-breakers	Dabblers	Regular-all
Baseline prevalence	79.6%	9.7%	9.1%	1.6%
Item response probabilities:				
<i>Drunkenness</i>				
None	0.99	0.89	0.26	0.08
Infrequent	0.01	0.09	0.28	0.2
Frequent	< 0.01	0.02	0.46	0.72
<i>Drug use</i>				
None	0.99	0.99	0.82	0.21
Infrequent	0.01	0.01	0.1	0.14
Frequent	0.00	0.00	0.08	0.65
<i>Criminality</i>				
None	0.95	0.06	0.54	0.00
Infrequent	0.05	0.93	0.46	0.16
Frequent	0.00	0.01	0.00	0.84

Table 5
Transition probabilities by grade.

Transitions to grade ...	from ...	Abstainers	Occasional Law-Breakers (OLB)	Dabblers	Regular-All
<i>Grade 7</i>					
8	Abstainer	0.90	0.05	0.04	0.01
8	OLB	0.05	0.82	0.09	0.04
8	Dabblers	0.02	0.005	0.97	0.005
8	Regular-all	0.01	0.005	0.005	0.98
<i>Grade 8</i>					
9	Abstainer	0.83	0.04	0.13	0.00
9	OLB	0.15	0.48	0.25	0.12
9	Dabblers	0.005	0.005	0.98	0.01
9	Regular-all	0.005	0.005	0.18	0.81

labelled “Occasional law-breakers”, as they had a high probability of committing crime on an infrequent basis but did not endorse the other two behaviours. The third group, comprising 9%, was called “Dabblers” to indicate partaking in the three behaviours but in a casual and/or occasional manner, e.g. this group had a 46% probability of frequent drunkenness, a 28% probability of infrequent drunkenness, alongside much lower probabilities of drug use (of any kind), and a 45% probability of infrequent crime. The final and smallest group, the “Regular-All” group at 1.6% of the sample, had high probabilities of engaging in all three behaviours on a regular basis. While this group is very small in terms of actual numbers of adolescents in just this study, it was deemed conceptually important as it captured a ‘small, but severe’ group, which corresponds closely to similar ‘severe’ groups found in other studies with larger samples (see Vaughn et al., 2014).

3.2. Modelling latent transitions

Table 5 shows the transition probabilities for each status by grade. Transition probabilities in bold indicate the probability of remaining in that status.

Transition probabilities across both grades show high stability of latent statuses with all but one probability being > 0.8. The exception is the probability of remaining in the Occasional Law-Breakers (OLB) group in grade 9 (0.48); there was also a 0.25 probability of moving into the Dabblers group. The probability of remaining an Abstainer changes between grades from 0.9 to 0.83, reflecting a shift in grade 8 towards more experimental behaviour. Interestingly, the probability of remaining in the Regular-All group changes from 0.98 to 0.81, indicating that some 8th graders have reduced the frequency of these behaviours by grade 9.

3.3. Explanatory covariates

Descriptive statistics of the covariates by each latent status are given in table 6. The Regular-All group, which we deemed to be of high conceptual importance, consistently had the most adverse mean values of the covariates compared to the three other latent statuses. This group was however too small to be included in the multi-nomial regression with all four groups. The parameter estimates (log odds) from the step 3 regression comparing the Abstainer, Occasional Law-breakers and the Dabblers are shown in Table 7, with Abstainers as the reference group. Statistically significant estimates are shown in bold.

All covariates significantly discriminate between the three main statuses, with the exception of perceived family financial status and the temperament dimension Reward Dependence. The covariates also show differentiation between the latent statuses. For example, the probability of being in the OLB group, compared to the Abstainers, is higher for males, for adolescents who perceive that their peers commit crime, and for those who perceive lower cohesion in their families. Whereas, for

Table 6
Descriptive statistics for the covariates by latent status.

Latent status	Variable	Mean	S.D.
<i>Abstainer</i> (n = 1893)	Sex (1 = female)	1.47	0.50
	Novelty Seeking	6.54	3.24
	Harm Avoidance	6.28	4.29
	Reward Dependence	4.27	2.09
	Persistence	3.45	1.43
	Perceived family financial status	2.06	0.41
	Family cohesion	3.59	0.42
	Peers who get drunk	1.14	0.43
	Peers who use drugs	1.05	0.23
	Peers who commit crime	1.18	0.44
	<i>Occasional law-breaker</i> (n = 183)	Sex (1 = female)	1.76
Novelty Seeking		8.78	3.97
Harm Avoidance		6.98	5.01
Reward Dependence		3.31	1.99
Persistence		2.78	1.26
Perceived family financial status		2.05	0.52
Family cohesion		3.36	0.49
Peers who get drunk		1.46	0.74
Peers who use drugs		1.28	0.45
Peers who commit crime		1.78	0.76
<i>Dabblers</i> (n = 156)		Sex (1 = female)	1.50
	Novelty Seeking	9.06	3.63
	Harm Avoidance	6.66	4.38
	Reward Dependence	4.10	2.14
	Persistence	3.30	1.51
	Perceived family financial status	2.04	0.45
	Family cohesion	3.33	0.53
	Peers who get drunk	1.49	0.86
	Peers who use drugs	1.23	0.52
	Peers who commit crime	1.59	0.74
	<i>Regular-All</i> (n = 33)	Sex (1 = female)	1.88
Novelty Seeking		11.22	3.07
Harm Avoidance		7.11	4.14
Reward Dependence		3.00	2.04
Persistence		2.00	1.36
Perceived family financial status		1.67	0.68
Family cohesion		2.78	0.85
Peers who get drunk		2.56	1.09
Peers who use drugs		2.67	1.07
Peers who commit crime		3.00	0.88

the Dabblers (compared to the Abstainers), peers who use drugs is important for distinguishing the groups, whereas gender is not. Although family cohesion is also relevant for the probability of being in the Dabblers status, this is less so than for the OLB status.

Based on a comparison of descriptive statistics concerning the Abstainers and the Regular-All group, as well as the results of the multi-nomial regression, we selected the following four covariates to be included in the PMLE logistic regression: sex, novelty-seeking, family cohesion, criminal peers. These covariates also represent different domains from the socio-ecological model, albeit with limited coverage. The PMLE logistic regression model was significant (Wald chi-square = 24.63, n = 1389, p < 0.01). Overall correct classification was 99.35% with 99.78% specificity and 66.7% sensitivity. The parameter estimates from the model are given in Table 8, with statistically significant estimates shown in bold.

All four covariates were significant in discriminating between the Regular-All status and the Abstainers. Being male, family cohesion, and peers who commit crime were most strongly associated. While the model correctly predicts the Abstainers, the sensitivity was judged only to be adequate concerning the correct prediction of the Regular-All group. Thus, some caution is needed in applying these results.

4. Discussion

Using Latent Transition Analysis on a Swedish general population sample, we found four statuses of adolescents’ drunkenness, drug use,

Table 7
Step 3 regression estimates (log odds) comparing three latent statuses on all covariates.

	Abstainers (ref.)	OLB	S.E.	Dabblers	S.E.	Wald	p.
Intercept	-0.00	-3.5*	1.1	-2.76*	1.19	31.22	< 0.01
Sex							
Female (ref.)	0.00	0.00	-	0.00	-	-	-
Male	0.00	1.53*	0.28	0.16	0.25	64.29	< 0.01
Novelty Seeking	0.00	0.15*	0.04	0.22*	0.04	37.11	< 0.01
Harm Avoidance	0.00	0.06*	0.03	0.02	0.03	1.12	0.57
Reward Dependence	0.00	0.06	0.07	0.12	0.06	22.26	< 0.01
Persistence	0.00	-0.16	0.09	0.05	0.09	13.65	< 0.01
Perceived family financial status	0.00	-0.09	0.25	-0.56*	0.26	2.23	0.33
Family cohesion	0.00	-0.9*	0.25	-0.69*	0.26	20.43	< 0.01
Peers who get drunk	0.00	0.2	0.21	-0.18	0.26	14.62	< 0.01
Peers who use drugs	0.00	0.44	0.31	1.31*	0.31	25.92	< 0.01
Peers who commit crime	0.00	1.07*	0.19	-0.08	0.26	37.96	< 0.01

S.E. = Standard error of the estimate.

* = $p < 0.05$.

Table 8
Step 3 PMLE regression estimates (log odds) comparing the Regular-All group with the Abstainers.

	Abstainers (ref.)	Regular-All	S.E.	p.
Sex				
Female (ref.)	0.00	0.00	-	-
Male	0.00	5.10*	1.83	< 0.01
Novelty Seeking	0.00	0.37*	0.15	< 0.01
Family cohesion	0.00	-4.10*	1.11	< 0.01
Peers who commit crime	0.00	3.07*	0.67	< 0.01

* = $p < 0.05$.

and criminal behaviour: “Abstainers” (80% of the sample), “Occasional law-breakers” (10%), “Dabblers” (9%), and a “Regular-All” group (1.6%). While the Regular-All status was very small in terms of actual numbers in this study, other latent class studies with much larger samples have also found a ‘small, but severe’ group (see Vaughn et al., 2014). The conceptual relevance for practice, that a low prevalence but highly-entrenched group exists, meant that this group was important to retain. The descriptive statistics of the explanatory covariates for this group point to an interesting trend in how the Regular-All group differs from the other three statuses. The PMLE regression confirmed, albeit on a limited set of covariates, the role of temperament, family cohesion and peer factors in distinguishing the Regular-All status, although caution is advised due to the low events per variable in the analysis.

The statuses tended to be very stable during early to mid-adolescence, with the exception of remaining in the Occasional Law-Breakers group in grade 9. These adolescents were as likely to remain in the status as they were to transition to one of the other statuses. We also examined the relationship between these four statuses and a set of socio-ecological covariates. We found that all covariates were significant in distinguishing between the three main statuses, with the exception of perceived family financial status and the temperament dimension Reward Dependence. In relation to the Regular-All status, all the four included covariates were significant; the most strongly associated being: male, low family cohesion and peers who commit crime.

The four identified statuses are in line with previous research from the U.S. (e.g. Monahan et al., 2013; Bright et al., 2017), despite the different socio-cultural context, although the prevalence of law-breaking groups was higher in the U.S. studies. Statuses were stable during our study, which is also consistent with previous research. These findings contribute towards and extend existing theories of adolescent risk behaviours, such as the Social Development Model (see Cambron, Catalano, & Hawkins, 2018), which foreground escalation in a homogenising model of adolescent development. Rather, this study suggests that there is considerable heterogeneity in how adolescents engage in

these behaviours. More importantly, trajectories of these behaviours are fairly static during early-mid adolescence and do not appear to escalate so rapidly. Moreover, that more entrenched or worrisome behaviours, e.g. the Regular-All status, are already in place prior to the teenage years, which has policy and prevention implications, such as *when* intervention measures *for this group* may be more relevant. An exception to the pattern of stability was the OLB group who had an approximately 50% chance of remaining in that status at grade 9 or transitioning to the other statuses, most likely the Dabblers group. This may be indicative of some adolescents ‘naturally’ maturing out of criminality, in line with Moffitt (1993) adolescent-limited offending theory. It also highlights how around half of this group do not *at this developmental stage* ‘mature out’ and may be in need of support. Again, this suggests a different policy and practice implication for this particular group of adolescents who may be more life-course-persistent (LCP) in their criminal behaviour (see Moffitt, 1993).

There are also some theoretical implications from this study for Moffitt’s (1993) dual taxonomy of the development of criminal behaviour (see also Moffitt, 2018 for a review) in that greater heterogeneity was found than the theory would allow. The Regular-All group in this study aligns well with Moffitt’s LCP group in terms of early debut with criminal behaviour and negative family environments. Our study suggests, however, that LCP adolescents are likely to have substance use issues involving alcohol intoxication as well as drug use. Given the aetiology of LCP adolescents, these behaviours are likely to be symptoms of a developmental pathway, rather than causal factors. Indeed, our study supports the idea that low family cohesion and criminal peers are *together* explanatory factors relevant for theorising the *mechanisms* of LCP pathways. Our findings also suggest that the adolescent-limited group may be better understood as two distinct groups: the OLB group who only present criminal behaviour and for whom criminal peers, family cohesion and being male were more strongly associated; and the Dabblers group who present lower levels of criminal behaviour alongside infrequent or experimental substance use. For this group, individual characteristics, such as novelty-seeking, as well as substance-using peers were more strongly associated. Further research in other samples would be needed to confirm these findings in other socio-cultural settings.

This study had two preliminary research questions concerning application of a socio-ecological model, that is, building explanations using individual, family, and peer domains. Our first question, that covariates from each domain would have explanatory value for distinguishing between statuses, was supported. Support was also found for the second question – a differential effects hypothesis – in that the strength of associations between a covariate and the latent status group differed by group. Taken together, these two results pave the way for the question of *why* some adolescents follow one trajectory and not

another; in line with our exploratory research question, the strength of associations between the explanatory covariates and the latent status differed *within* each status, but also *between* statuses. For example, within the OLB group, the criminal peers covariate was relatively stronger than all of the other covariates, in comparison to the reference group. These peer covariates were however relatively weaker in the Dabblers group. This supports the idea that peer influence may be behaviour-specific (see Monahan et al., 2013), but also suggests that this effect may be limited to specific sub-groups of adolescents (e.g. the OLB group), and less relevant for other teens. Unsurprisingly, the covariates had the largest effect in identifying the Regular-All group, in comparison to the Abstainers; yet for this group being male, experiencing low family cohesion, having peers who commit crime, were the most prominent explanatory factors. Given that the Regular-All was low in terms of actual numbers in this study, it is important to interpret the results concerning this group with some caution. It may also be the case the some of the untested covariates, such as perceived family finance, may also be associated with this group.

What is clearer from our study is thus not just that there are sub-groups of adolescents – in terms of their substance use and criminal behaviours – but moreover that these sub-groups have different socio-ecological mechanisms contributing to their behaviours. For example, for adolescents with more entrenched behaviour, any causal mechanisms are likely to occur in contexts of lower family cohesion, novelty-seeking temperaments, and criminal peers. This corresponds with large-scale cross-sectional studies, e.g. Baglivio, Wolff, Piquero, Delsi, and Vaughn (2017), that found that parental problems were linked to temperamental issues in their children, which in turn were related to adolescent criminal behaviour. Crucial for prevention policy and practice is that these family/parental contexts are likely to be in place *before* adolescence, and that this group's behaviour is fairly static in early to mid-adolescence. On the contrary, for teens 'dabbling' in these behaviours, causal mechanisms may be more to do with novelty-seeking and peer factors, which alongside the stability of these behaviours is important for practitioners to note. Furthermore, this study does not show which factors are causal, but rather which factors can help identify *who* may be in these sub-groups.

Consequently, a substantive contribution our study makes is through the value of examining heterogeneity using a socio-ecological model, i.e. explaining different trajectories for different sub-groups of adolescents. In particular, we found family-level effects, in terms of perceived cohesion and relative financial status, *alongside* the well-known peer effects (e.g. Monahan et al., 2013), whilst controlling for potential variations at the individual level in terms of sex and temperament. Family and peer effects were also comparable in relative size, suggesting the importance of the pre-teen family environment, alongside peer factors, particularly for those adolescents with more entrenched behaviours. The findings from this study can thus support theoretical work looking at *differential* causal processes in the development of adolescent substance use and/or criminality, e.g. within the Social Development Model, drawing on abductive theorising (Bhaskar, 1975) about the mechanisms driving these processes.

Whilst this study provides novel findings, some limitations need to be noted. The sample, albeit a general population of adolescents, is drawn from Sweden, where adolescent drug use is lower than in many other western countries (European Monitoring Centre for Drugs and Drug Addiction, 2017). This is reflected in the lower prevalence in this study of a drug-using group. This should not however overly affect the strength of the explanatory covariates. A problem with longitudinal school-based surveys is that adolescents with the most entrenched problems may be more likely to drop-out. Although attrition was low, some minor differences were found for those with missing data at grade 9; these differences were viewed as negligible and should not affect the overall analysis. The data is also self-report and some participants may have under-reported their behaviour. Similarly, it is possible that participants could over-report their drug use. Efforts to increase accurate

and honest reporting included reassuring participants about anonymity and confidentiality, such as verbal reiteration prior to data-collection of non-disclosure and explanation of how the data would be securely stored and handled, as well as the importance of 'real' answers for the research and the preference of a blank or missing answer over a made-up one. The time-varying model provided an equally good fit to the data as the time invariant model, but was rejected on conceptual grounds, in that the meaning of statuses becomes unstable. The theoretical upshot of this for studying development is that the findings of this study also need to be investigated using dynamic or latent growth mixture models, requiring more waves of data. The Regular-All group, being very small, could only be compared on limited number of the covariates. This means that the excluded covariates are unanalysed and may still play a role in theory. Future research should take in account the high conceptual relevance, but very low prevalence of this group, in order to design studies with sufficient power to test socio-ecological covariates. Finally, this study did not attempt to predict transitions between statuses, which is an important area for further study. Transition probabilities were mostly very low, which makes predicting transitions problematic. This study also suggested that more entrenched behaviours are already in place in early adolescence. Future research should look both at the genesis of these behaviours, pre-adolescence, but also at transitions in later adolescence.

5. Conclusions

Our analysis found four statuses based on adolescents' alcohol intoxication, drug use, and criminal behaviour, and that statuses were largely stable, with the exception of the Occasional Law-breakers group who were equally as likely to continue, as to decrease, their behaviour. The results also showed that there are different socio-ecological factors associated with these different behavioural trajectories, with e.g. family cohesion and criminal peers in the early teen environment being highly relevant for the most entrenched group, yet not for all the other groups. Our study thus contributes towards a better understanding of why some adolescents follow one behavioural trajectory and not another, although more theoretical and empirical work is needed. These findings have important implications for current theories of adolescent development and also for policy and practice concerning young people, substance use and crime, particularly in terms of which sub-groups of adolescents may need which kinds of intervention and at which developmental stages.

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Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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