

The developmental antecedents of illicit drug use: Evidence from a 25-year longitudinal study

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Abstract

Background: The present study examined the developmental antecedents of illicit drug use and abuse/dependence.

Methods: A 25-year prospective longitudinal study of the health, development, and adjustment of a birth cohort of 1265 New Zealand children. Measures included assessments of adolescent and young adult illicit drug use and abuse/dependence; cannabis use to age 25; measures of parental adjustment; measures of exposure to childhood sexual abuse, physical abuse, and interparental violence; novelty-seeking; childhood and early adolescent adjustment and substance use; and affiliation with substance-using peers.

Results: Illicit drug use and abuse/dependence from ages 16 to 25 were significantly associated (all p values $< .05$) with a range of parental adjustment measures; exposure to abuse in childhood; individual factors; and measures of childhood and early adolescent adjustment. Analyses using repeated measures logistic regression models suggested that parental illicit drug use, gender, novelty-seeking, and childhood conduct disorder predicted later illicit drug use and abuse/dependence. Further analyses revealed that these pathways to illicit drug use and abuse/dependence were mediated via cannabis use, affiliation with substance-using peers, and alcohol use during ages 16–25.

Conclusions: The current study suggested that the illicit drug use and abuse/dependence were associated with a range of early life circumstances and processes that put individuals at greater risk of illicit drug use and abuse/dependence. However, the use of cannabis in late adolescence and early adulthood emerged as the strongest risk factor for later involvement in other illicit drugs.

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1. Introduction

In recent decades, many developed societies have grappled with issues concerning the use and abuse of a range of illicit drugs, including hallucinogens (LSD, ecstasy, PCP), opiates (heroin, morphine), stimulants (methamphetamine), cocaine, barbiturates, solvents, prescription medications, and plant extracts such as mushrooms (Substance Use and Mental Health Services Administration, 2007; World Health Organization, 2000). The use of such drugs has raised issues about the risk factors and life processes that lead young people to experiment with, use and abuse these drugs. This topic has been the subject of a growing literature (for reviews see: Anderson, 2006;

Bloor, 2006; Compton et al., 2005; Galea et al., 2004; Hawkins et al., 1992; Mayes and Suchman, 2006; Rehm et al., 2006; Ripple and Luther, 1996) that has identified a range of factors associated with the increased usage of illicit drugs, including: family background factors, family support, and parental supervision; exposure to abuse during childhood and adolescence; individual factors such as temperament and gender; adjustment problems in childhood and early adolescence; and affiliation with substance-using peers. The purpose of the present investigation is to examine the extent to which both: (a) childhood factors and (b) adolescent adjustment and substance use; may be related to later illicit drug use. A review of representative findings in this area is given below.

1.1. Parental adjustment factors

Research suggests that parental adjustment problems, including substance use and criminality, may be related to adjustment

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problems in children, via genetic influences, social learning, or exposure to an unstable home environment (e.g. Bahr et al., 2005; Keyes et al., 2007; Pears et al., 2007; Stallings et al., 1997; van der Zwaluw et al., 2008). It could therefore be argued that parental adjustment factors may play a key role in the development of substance use in offspring.

A wide range of studies have examined family background factors and their relationship to risk of illicit drug use and abuse/dependence in adolescence and early adulthood. A number of studies have found that parental substance use may be related to substance use and abuse in adolescents (Johnson and Leff, 1999). For example, Kilpatrick and colleagues (Kilpatrick et al., 2000), using data from a national household survey, found that exposure to illicit drug abuse by parents increased the risk of substance abuse and dependence amongst adolescents. Similarly, Merikangas et al. (1998) found that individuals who had first-degree relatives who were diagnosed with substance use disorders were at an eight-fold risk of also being diagnosed with a substance use disorder. Pears et al. (2007), using prospective data, found evidence to suggest that patterns of substance use and abuse were transmitted across three generations.

Other factors such as lower levels of parental interest and monitoring, and higher levels of parental criminality may be related to higher levels of substance use and abuse/dependence. For example, Chilcoat and Anthony (1996) found that rates of illicit drug use were higher amongst adolescents who perceived lower levels of parental concern and involvement. Similarly, Duncan et al. (1998) reported that inept parental monitoring was related to increased levels of substance use in adolescents. Hayatbakhsh et al. (2007), using data from a prospective birth cohort, found that maternal partner criminality predicted cannabis use by age 21. Similarly, Felitti et al. (1998) found that parental criminality was associated with an increased risk of drug abuse amongst a large ($n > 10,000$) cross-sectional sample. In general, the evidence suggests that family dysfunction and parental adjustment problems may be associated with increased risk of illicit drug use.

1.2. *Exposure to abuse in childhood*

A second set of factors that has been linked to the risk of involvement with illicit drugs is exposure to abuse during childhood. It could be argued that exposure to abuse in childhood may lead to increased risk of substance use in adulthood, at least in part due to concomitant increases in risk of mental illness (e.g. Mulder, 2002). However, it should be noted that longitudinal data are critical to demonstrate links between childhood abuse and later outcomes (Putnam and Trickett, 1993).

A number of longitudinal studies have found that exposure to sexual abuse in childhood (CSA), exposure to physical abuse, and witnessing interparental violence may be linked to increased risk of substance use and abuse/dependence in adolescence and adulthood (Miller et al., 1997; Simpson and Miller, 2002). For example, Widom et al. (2006), using data from a prospective cohort study, found that those exposed to sexual and/or physical abuse in childhood were 1.5 times more likely to report using illicit drugs at age 40. Similarly, Kilpatrick et

al. (2000) found that adolescents who reported having been sexually or physically abused, or who witnessed interparental violence, were at increased risk for substance abuse/dependence. Also, Wilsnack et al. (1997) found that women who reported exposure to CSA were more likely to report using a range of illicit drugs than women who reported no CSA exposure. Felitti et al. (1998) found that one of the key risk factors for later substance abuse/dependence was exposure to interparental violence. Christoffersen and Sothill (2003), using data from over 80,000 children born in Denmark in 1966, found that violence between parents, stemming from alcohol abuse, increased risks of drug addiction in children aged 15–27. In addition, Dube et al. (2002), using a case–control design, found that exposure to interparental violence during childhood was associated with increased likelihood of illicit drug use, including intravenous drug use. The findings of these studies suggest that exposure to abuse during childhood increases the risk of illicit drug use and abuse/dependence in adulthood.

1.3. *Individual factors*

Research suggests that there are a range of individual factors that may predict illicit drug use and dependence. However, two of the strongest predictors of involvement in illicit drugs are gender and novelty-seeking. A range of studies has shown that males are more likely than females to report the illicit drug use and abuse/dependence (Bloor, 2006), and that those reporting higher levels of novelty-seeking (Acton, 2003; Staiger et al., 2007) demonstrate higher levels of illicit drug use and abuse/dependence. For example, Duncan et al. (1998), using growth curve modelling techniques, found that gender predicted adolescent substance use, with males more likely than females to report substance use. Also, Rodham et al. (2005), in a sample of English 15- and 16-year old adolescents, found that males were more likely to report illicit drug use. Similar findings were reported for an Australian secondary school sample ($n > 20,000$) by Lynskey et al. (1999). In terms of novelty-seeking, Evren et al. (2007) found that novelty-seeking predicted illicit drug dependence in a sample of Turkish adolescents. Also, Adams et al. (2003), using a case–control sample of adolescent substance users, found that those who were high in novelty-seeking reported using a wider range of substances than those low in novelty-seeking. Khan et al. (2005) reported that novelty-seeking had a modest positive association with externalizing disorders, including substance dependence. These findings suggest that males and those higher in novelty-seeking are at a greater risk of illicit drug use and abuse/dependence.

1.4. *Childhood and early adolescent conduct and attention problems*

An additional set of factors that may be linked to risks of illicit drug involvement are conduct and attention problems in childhood. A number of studies have suggested that individuals who display conduct and attention problems are at greater

risk of illicit drug use and abuse/dependence (Deas and Brown, 2006). For example, Khan et al. (2005), using twin-registry data, found associations between conduct problems and substance abuse problems. Also, Molina and Pelham (2003) found that conduct and attention disorder in early adolescence predicted later use and abuse of a range of substances in later adolescence in a prospective study. Flory et al. (2003) found an interactive relationship between conduct and attention problems and later substance use and dependence, such that individuals with high levels of both conduct and attention problems were at greatest risk of later illicit drug use and dependence. In addition, Fergusson et al. (2007) found that the associations between attention problems in childhood and later illicit drug use were mediated via conduct problems. The findings of these studies suggest that conduct and attention problems in childhood may be related to increased risks of later illicit drug involvement.

1.5. Adolescent substance use and social processes

A further set of factors that may be linked to increasing risks of illicit drug involvement are substance use and social processes in adolescence. A large number of studies have found evidence for “gateway” effects for cannabis use in illicit drug use and abuse/dependence, in which the use of cannabis may increase the risk of use of other illicit drugs (Kandel, 2003; MacCoun, 1998), while others have suggested that other drugs such as alcohol and tobacco may also be involved in the gateway to illicit drug involvement (Botvin et al., 2002; Center on Addiction and Substance Abuse, 1994). The nature of these “gateway” effects is a matter of some debate (Fergusson et al., 2006; Kandel et al., 2006; MacCoun, 1998, 2006; Morral et al., 2002), and there may be evidence of “reverse gateway” effects (Viveros et al., 2006) in which the use of cannabis may increase the risk of tobacco use. However, a range of studies has clearly shown that the use of cannabis is associated with increasing risks of other illicit drug use and abuse/dependence (Kandel, 2003; MacCoun, 1998). Furthermore, peer influence, and in particular affiliation with substance-using peers, may be associated with increased risks of illicit drug use and abuse/dependence (Bloor, 2006).

The gateway effects of cannabis and other substances have been examined in a number of studies. For example, Lynskey et al. (2003) using a discordant twin design, found that those who had used cannabis were 2.1–5.2 times more likely to use other illicit drugs. Also, Kandel et al. (1992) found that 80%–90% of individuals who reported using both cannabis and other illicit drugs used cannabis prior to using other illicit drugs. Further, Fergusson et al. (2006), using a prospective cohort design, found that frequency of cannabis use predicted risks of other illicit drug use, such that those who used cannabis more frequently were more likely to use other illicit drugs. Kandel and Yamaguchi (2002) found that both tobacco use and alcohol use tended to precede the use of cannabis and other illicit drugs in a large national data set.

Peer influence has also been examined in a number of studies. For example, Duncan et al. (1998) found that peer deviance

predicted substance use trajectories during adolescence. Jenkins (1996), using a large cross-sectional data set, found that peer drug use was the strongest predictor of illicit drug use during adolescence. Also, Wills et al. (1998) found that peer influence mediated the associations between early risk factors and later substance use.

Collectively, the findings of these studies suggest that involvement with substance use in early adolescence, and affiliation with substance-using peers, increase the risk of illicit drug involvement in adolescence and early adulthood.

1.6. Background to the present study

While there has been growing evidence on the risk and protective factors for illicit drug use, there have been relatively few studies that have reported longitudinal data on the role of a wide range of risk factors assessed over the period from childhood to adulthood. In this paper we report on the results of a longitudinal study of use and abuse of illicit drugs in a birth cohort of New Zealand young people studied from birth to the age of 25 years. The analyses reported examine a range of issues in the development of illicit drug use and abuse. These issues include:

1. The role of childhood and parental factors in predisposing young people to use illicit drugs;
2. The role of peer affiliation and substance (tobacco, alcohol, and cannabis) use in the development of illicit drug use and abuse.

The hypothesized relationships between childhood and parental factors, adolescent peer affiliation and substance use factors, and illicit drug use and abuse/dependence are presented in Fig. 1.

More generally, the aims of the paper are to develop a multivariate account of the ways in which a wide range of social, family, and individual factors combine over the life course to influence the use and abuse of illicit drugs.

2. Method

The data were gathered as part of the Christchurch Health and Development Study (CHDS). The CHDS is a longitudinal study of a birth cohort of 1265 children (635 males, 630 females) born in the Christchurch (New Zealand) urban region in mid-1977. The cohort has been studied at birth, 4 months, 1 year and at annual intervals to age 16 years, and again at ages 18, 21, and 25. The study has collected information from a variety of sources including: parental interviews, teacher reports, self-reports, psychometric assessments, medical, and other record data. All aspects of the study's design have been approved by the Canterbury Ethics Committee. An overview of the study design, methodology, and major findings can be found in Fergusson et al. (1989) and Fergusson and Horwood (2001).

All analyses were based on all cohort members assessed at each point of observation. Sample sizes were as follows: 18 years ($n=1025$); 21 years ($n=1011$); and 25 years ($n=1003$). These samples represented between 79% and 81% of the original cohort of 1265 participants. In addition, as a result of missing data on some covariates the sample number included in the covariate adjustment analyses was reduced to approximately 900. The present analysis used the following measures.

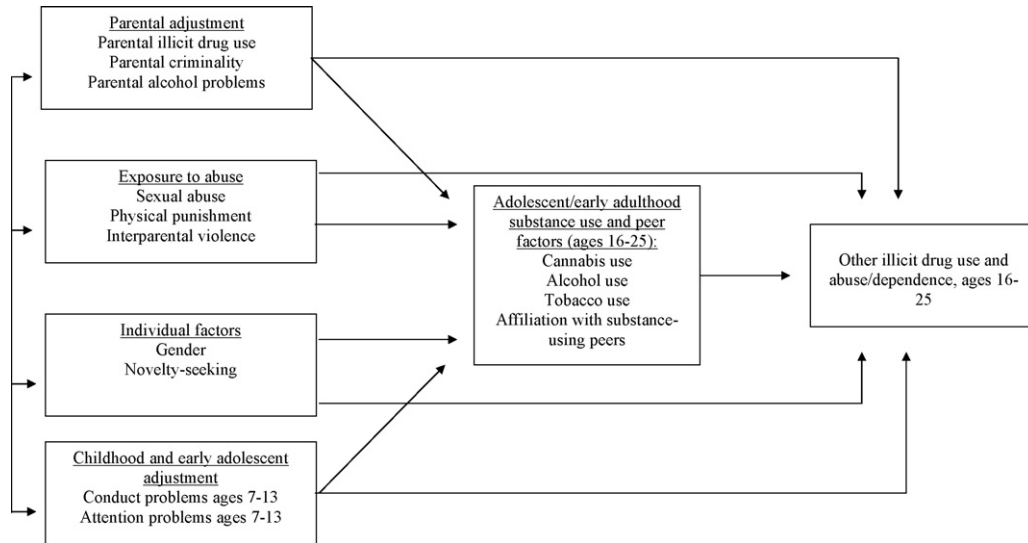


Fig. 1. Model of the hypothesized associations between fixed childhood factors, time-dynamic adolescent substance use and peer factors, and illicit drug use and abuse/dependence ages 16–25.

2.1. Illicit (non-cannabis) drug use and illicit drug abuse/dependence

As part of the interviews at ages 18, 21, and 25, cohort members were questioned about their use of illicit drugs other than cannabis since the previous assessment. Each assessment included questions about other illicit drug use for each year of the assessment period. The cohort members were questioned about their use of a range of illicit drugs, including solvents (glue, petrol, and paint); stimulants (including methamphetamine); barbiturates; other prescription medications that were illicitly obtained; opiates, including both heroin and morphine; cocaine (in any form); hallucinogens including ecstasy, LSD, and PCP; and any other substances (primarily plant extracts) including mushrooms and datura. In this way the data collection provided an account of the individual's reported frequency of use of a range of other illicit drugs for each year from ages 16–17 to 24–25. For the purposes of this analysis, participants were classified as having used other illicit drugs in a given year if they reported using any of the above classes of substances on at least one occasion, creating a dichotomous outcome measure. In addition, at each assessment, participants were questioned about problems associated with their use of drugs since the previous assessment with items from the Composite International Diagnostic Interview (CIDI: World Health Organization, 2000). This information was compared with DSM-IV criteria (American Psychiatric Association, 1994) to construct a diagnosis of illicit drug abuse/dependence during each year from ages 16–17 to 24–25, which was also a dichotomous outcome measure. The measure of illicit drug use and abuse/dependence has been reported to have adequate reliability and validity (Andrews and Peters, 1998). For the purposes of the present analyses, all participants classified as having a diagnosis of other illicit drug abuse/dependence were also classified as having used other illicit drugs.

2.2. Predictors of illicit drug use and illicit drug abuse/dependence

To examine the antecedents of illicit drug use and illicit drug abuse/dependence, a series of measures was chosen from the database of the study for inclusion in the analysis. These measures were selected on the basis of: (a) a review of the literature identifying factors which previously have been found to be associated with increased risks of illicit drug involvement (see above) and (b) previous analyses based on the Christchurch Health and Development Study cohort which have identified factors associated with illicit drug involvement (Boden et al., 2006; Fergusson et al., 2006). The factors chosen for inclusion in the analyses were as follows.

2.2.1. Measures of parental adjustment and substance use.

2.2.1.1. Parental illicit drug use. When the young person was aged 11, resident parents were questioned as to their history of illicit drug use. The young person was classified as having a parent history of illicit drug use if one of his/her parents was reported to have a history of illicit drug use.

2.2.1.2. Parental criminality. When the young person was aged 15, resident parents were questioned as to their history of criminal offending, including property and violent offending, and any official convictions. The young person was classified as having a parent history of criminality if one of his/her parents was reported to have a history of offending.

2.2.1.3. Parental alcohol problems. When the young person was aged 11, resident parents were questioned as to whether they had ever experienced either problems with alcohol, or alcoholism. These reports were used to form a dichotomous measure of whether or not the young person's parents reported experiencing alcoholism or problems with alcohol.

2.2.2. Measures of exposure to abuse in childhood.

2.2.2.1. Childhood sexual abuse. At ages 18 and 21 years sample members were questioned retrospectively about their experience of sexual abuse during childhood (<16 years) (Fergusson et al., 1996). Questioning spanned an array of abusive experiences from episodes involving non-contact abuse (e.g. indecent exposure) to episodes involving attempted or completed intercourse. Sample members who reported an abusive episode were then questioned further about the nature and context of the abuse. Using this information a 4-level scale was devised reflecting the most extreme form of sexual abuse reported by the young person at either age. This classification was: no sexual abuse; non-contact abuse only; contact sexual abuse not involving attempted or completed intercourse; attempted/completed oral, anal, or vaginal intercourse.

2.2.2.2. Parental use of physical punishment (childhood physical abuse). At ages 18 and 21 years sample members were asked (retrospectively) to describe the extent to which their parents used physical punishment during childhood (Fergusson and Lynskey, 1997). Separate questioning was conducted for mothers and fathers. This information was used to create a 4-level scale reflecting the most severe form of physical punishment reported for either parent: parents never used physical punishment; parents rarely used physical punishment; at least one parent used physical punishment on a regular basis; at least one parent

used physical punishment too often or too severely, or treated the respondent in a harsh or abusive manner. The interpretation of scale items was left to the discretion of respondents.

2.2.2.3. Interparental violence (0–16 years). At the age of 18 years, sample members were questioned concerning their (retrospective) experience of interparental violence during their childhood (prior to age 16 years). The questioning was based on a series of eight items derived from the Conflict Tactics Scale (CTS; Straus, 1979). Separate questioning was conducted for both father-initiated and mother-initiated interparental violence. An overall measure was created by summing the responses for both father- and mother-initiated violence.

2.2.3. Individual factors.

2.2.3.1. Gender. Recorded at birth.

2.2.3.2. Novelty-seeking. Novelty-seeking was assessed via self-report at age 16 years using the novelty-seeking items from the Tridimensional Personality Questionnaire (Cloninger, 1987), $\alpha = .76$. For the purposes of the present analyses, novelty-seeking scores were split into quartiles to create a four-level measure of novelty-seeking at age 16.

2.2.4. Childhood and adolescent adjustment.

2.2.4.1. Child conduct and attention problems (ages 7–13). At each assessment from age 7–13 years, information on child behavior problems related to conduct and attention issues was obtained from parental and teacher report using a behavior questionnaire that combined items from the Rutter et al. (1970), Conners (1970), and Conners (1969) parental and teacher questionnaires. For the purposes of the present analysis, the parent and teacher reports were summed and the resulting scores averaged over the 7-year period to produce scale score measures reflecting the extent of the child's tendencies to conduct and attention problems at ages 7–13 (Fergusson and Horwood, 1993; Fergusson et al., 1991). The alpha reliabilities of these scales were .97 and .93, respectively.

2.2.5. Time-dynamic measures of substance use and peer influence (ages 16–25). In all cases, the time-dynamic measures used in the analyses were re-scaled to categorical measures with four levels. The use of the four-level measures allowed direct effect-size comparisons with the other time-dynamic measures (below).

2.2.5.1. Annual frequency of cannabis use (ages 16–25). At ages 18, 21, and 25 years, cohort members were questioned about their use of cannabis since the previous assessment. Each assessment included questions about cannabis use for each year of the assessment period; for example, the 18-year assessment included questions on cannabis use over the periods 16–17 and 17–18 years. In this way the data collection provided an account of the individual's reported frequency of cannabis use for each year from age 16–17 to age 24–25. For the purposes of this analysis, the annual frequency data were classified into a series of class intervals as follows: did not use cannabis; used less than monthly on average (1–11 times); used at least monthly on average (12–50 times); used at least weekly (>50 times); resulting in a four-level measure representing frequency of cannabis use during each year from ages 16 to 25.

2.2.5.2. Affiliation with substance-using peers (ages 16–25). This was assessed at ages 16, 18, 21, and 25 on the basis of participant reports of the extent to which their friends used tobacco, alcohol, or illicit drugs or had problems resulting from alcohol or illicit drugs during the previous 12 months, $\alpha = .69-.77$. For the purposes of the present analysis, these scales were split into quartiles in order to create a four-level measure representing the extent of the individual's involvement with substance-using peers at each assessment (Fergusson and Horwood, 1999; Fergusson et al., 1999).

2.2.5.3. Frequency of cigarette smoking (ages 16–25). At ages 16, 18, 21, and 25 years, participants were questioned about their current frequency of cigarette smoking. For the purposes of the present analyses, these data were classified

into a series of four class intervals ranging from non-smoker to 20+ cigarettes per day.

2.2.5.4. Frequency of alcohol use (ages 16–25). This was assessed at ages 16, 18, 21, and 25 for the previous 12 months. For the purposes of the present analyses, these data were classified into a series of four class intervals representing the self-reported frequency of drinking alcohol ranging from “never” to “almost every day”.

2.3. Missing data

As noted previously, the analyses were based on approximately 900 sample members, which represented between 79% and 81% of the original cohort of 1265 participants. To assess the possible effects of sample selection bias, tests were conducted to examine the extent to which the obtained sample was representative of the original cohort of 1265 participants enrolled in the study. This analysis showed that there were slight but statistically significant ($p < .05$) tendencies for the obtained sample to under-represent individuals from more socially disadvantaged backgrounds (low parental education, low socioeconomic status, single-parent family). To take these biases into account, the sample was poststratified into a series of groups on the basis of these characteristics, and the probability of study participation estimated for each group using the methods described by Carlin et al. (1999). All analyses were then repeated with the data for the analysis sample weighted by the inverse of the probability of study participation. In addition, there were small amounts of missing data for some covariate factors. To examine the implications of missing values, regression imputation of missing data was conducted and the analyses repeated with the missing values on each covariate replaced by the imputed values. In all cases, these reanalyses produced essentially the same pattern of results to those reported here, suggesting that the conclusions of this study were unlikely to have been influenced by missing data and selection bias.

3. Results

3.1. Rates of illicit drug use and illicit drug abuse/dependence

Over the period from ages 16–25 years, 42.9% ($n = 458$) of the sample reported using illicit drugs other than cannabis on at least one occasion, and 10.8% ($n = 115$) met DSM-IV criteria for abuse/dependence (see Section 2). Amongst the cohort, 35% reported having used hallucinogens (ecstasy, LSD); 26% reported having used stimulants (including methamphetamine), barbiturates, or other (illicitly obtained) prescription medicines; 17% reported having used substances such as mushrooms and datura; 5% reported having used solvents; 9% reported having used cocaine; and 4% reported having used opiates including heroin and morphine.

3.2. Factors associated with illicit drug use and illicit drug abuse/dependence, ages 16–25

Table 1 shows the results of regression analyses linking a series of factors to annual rates of illicit drug use and illicit drug abuse/dependence over the period from 16 to 25 years. Assessments of illicit drug use and abuse/dependence (other than cannabis) were made at annual intervals from ages 16 to 25. To analyze these repeated measures data, logistic generalized estimating equation (GEE) models were fitted for each predictor variable (Gibbons et al., 1988) in which the log odds of either: (a) illicit drug use; or (b) illicit drug abuse/dependence in a given

Table 1
Associations between illicit drug involvement and predictors, ages 16–25

Predictor	Illicit drug use			Illicit drug abuse/dependence		
	B	S.E.	p^a	B	S.E.	p^a
Parental adjustment						
Parental illicit drug use	.87	.22	<.0001	1.41	.34	<.0001
Parental criminal offending	1.30	.28	<.0001	1.79	.39	<.0001
Parental alcohol problems	.84	.27	<.001	.84	.58	>.10
Abuse exposure (0–16 years)						
Exposure to interparental violence	.08	.03	<.01	.28	.06	<.0001
Exposure to childhood sexual abuse	.36	.11	<.001	.69	.17	<.0001
Exposure to childhood physical abuse	.56	.14	<.0001	.69	.22	<.001
Individual factors						
Gender	−.94	.16	<.0001	−.91	.32	<.01
Novelty-seeking score (age 16)	.98	.10	<.0001	1.09	.13	<.0001
Childhood and adolescent adjustment						
Conduct problems ages 7–13	.06	.01	<.0001	.11	.01	<.0001
Attention problems ages 7–13	.04	.02	>.10	.17	.02	<.0001
Time-dynamic substance use/peer factors, ages 16–25						
Annual frequency of cannabis use	1.58	.06	<.0001	1.73	.12	<.0001
Affiliation with substance-using peers	.95	.06	<.0001	1.33	.12	<.0001
Frequency of alcohol use, ages	1.07	.11	<.0001	.81	.18	<.0001
Frequency of cigarette smoking	.68	.06	<.0001	.85	.09	<.0001

^a Wald chi square.

year were modelled as a linear function of the predictor and age. Random-effects models provide a single estimate of the regression coefficients pooled over the repeated measures of the outcome variable. The models fitted were of the form:

$$\text{logit}(Y_{it}) = B_{0i} + B_1 X_i + B_2 A_t + U_{it} \quad (1)$$

where Y_{it} was the measure of use or abuse/dependence for participant I at time t , B_{0i} was an individual-specific random-effects intercept term, X_i was the predictor of interest (or X_{it} , if the predictor was time-dynamic), A_t was the measure of the respondent's age (centered at age 21), and U_{it} was the disturbance term for the models. The results of these analyses are presented in Table 1, which shows parameter estimates, standard errors, and significance levels for the statistically significant risk factors for illicit drug use and abuse/dependence (see Section 2). The table shows:

1. For both use and abuse/dependence there were significant associations with parental illicit drug use ($p < .0001$), and parental criminal offending ($p < .0001$). In addition, illicit drug use (but not abuse/dependence) was associated with parental alcohol problems ($p < .001$).
2. Illicit drug use and abuse/dependence were significantly associated with: exposure to interparental violence ($p < .001$); exposure to sexual abuse in childhood ($p < .001$); and exposure to childhood physical abuse ($p < .001$).
3. Both illicit drug use and abuse/dependence were also significantly associated with individual factors, including male gender ($p < .01$) and novelty-seeking ($p < .0001$).

4. Use and abuse/dependence were also significantly associated with conduct problems during ages 7–13 ($p < .0001$). Abuse/dependence, but not illicit drug use, was associated with attention problems during ages 7–13 ($p < .0001$).
5. Illicit drug use and abuse/dependence were also significantly associated with a range of time-dynamic measures of substance use and peer influence during ages 16–25, including annual frequency of cannabis use ($p < .0001$), affiliation with substance-using peers ($p < .0001$), frequency of cigarette smoking ($p < .0001$), and frequency of alcohol use ($p < .0001$).

3.3. Multivariate analyses of risk factors for illicit drug use and illicit drug abuse/dependence, ages 16–25

The results presented in Table 1 were extended to fit two multivariate logistic GEE models of the linkages between the factors listed in Table 1 and the risks of illicit drug use and illicit drug abuse/dependence over the period 16–25 years. These models were fitted in three steps, as follows:

- i. In the first model, the fixed predictors presented in Table 1 (parental adjustment factors; abuse exposure factors; individual factors; childhood and adolescent adjustment factors) were entered in blocks, with forward and backward elimination of variables to identify a stable and parsimonious set of predictors of illicit drug use and abuse/dependence. These models were of the form:

$$\text{logit}(Y_{it}) = B_{0i} + \sum B_j X_{ij} + B_2 A_t + U_{it} \quad (2)$$

where Y_{it} was the measure of use or abuse/dependence at time t , B_{0i} was a random-effects intercept term, X_{ij} were the

set of fixed predictor variables in the fitted model, A_t was the measure of the respondent's age (centered at age 21), and U_{it} was the model disturbance term.

The second model extended the first model by including the time-dynamic factors listed in Table 1 (annual frequency of cannabis use ages 16–25; affiliation with substance-using peers ages 16–25; frequency of alcohol use and cigarette smoking, ages 16–25), with the factors being entered into the models simultaneously. The factors were represented as four-level categorical variables in order to permit direct comparisons of effect sizes (see Section 2). In addition, to take into account age related changes in the strength of association between the predictors and outcome measures, tests of age \times predictor interaction terms were entered into the models in forward and backward stepwise fashion, with only statistically significant interactions retained in the final models. These models were of the form:

$$\text{logit}(Y_{it}) = B_{0i} + \Sigma B_j X_{ij} + \Sigma B_k X_{ikt} + B_2 A_t + \Sigma B_p A X_{ipt} + U_{it} \tag{3}$$

where X_{ij} was the set of fixed predictors, X_{ikt} was the set of time-dynamic predictors, and $A X_{ipt}$ was the set of potential interaction terms between age and the predictors X .

The third model extended the second model by including a lagged cumulative dichotomous measure of previous illicit drug use, in order to account for issues of reverse causality, in which contemporaneous measures of cannabis use and other illicit drug use and abuse/dependence may cause somewhat inflated estimates of association.

Tables 2 and 3 show the regression coefficients, standard errors, and tests of significance for each model at each step for: (a) illicit drug use and (b) illicit drug abuse/dependence. The tables show:

1. In the first step of the analyses, several factors emerged as statistically significant predictors of illicit drug use and abuse/dependence. These factors included exposure to childhood sexual abuse ($p < .0001$), gender ($p < .01$), novelty-seeking ($p < .0001$), and conduct problems at ages 7–13 ($p < .05$). In addition, parental illicit drug use was a statistically significant predictor for illicit drug use (parental illicit drug use, $p < .05$).
2. In the second step of the analyses, the results showed that:
 - a. Four of the time-dynamic factors were significant predictors of illicit drug use, while two of the factors were significant predictors for illicit drug abuse/dependence. For illicit drug use, these factors included annual frequency of cannabis use ($p < .0001$), extent of affiliation with substance-using peers ($p < .0001$), frequency of alcohol use ($p < .0001$), and frequency of cigarette smoking ($p < .01$). For illicit drug abuse/dependence, significant predictors were annual frequency of cannabis use ($p < .0001$), and affiliation with substance-using peers ($p < .0001$). In addition, for both illicit drug use and abuse/dependence there were significant age \times cannabis use interactions ($p < .0001$), suggesting that the associations between cannabis use and illicit drug use and abuse/dependence decreased in magnitude over time.
 - b. The results also showed that when the time-dynamic measures of cannabis use, peer substance use, cigarette smoking, alcohol use, and interaction terms were entered into the models along with the fixed predictors, the associations between the fixed predictors and both illicit drug use and illicit drug abuse/dependence were reduced in magnitude, with most associations being reduced to statistical non-significance. The exceptions to this pattern were the associations between novelty-seeking and illicit drug use, which remained statistically significant ($p < .0001$).

Table 2
Parameter estimates for multivariate regression models of risk factors for illicit drug use, ages 16–25

Predictors	Illicit drug use								
	Model including fixed covariates			Model including fixed and time-dynamic covariates			Model including fixed and time-dynamic covariates, and lagged illicit drug use		
	B	S.E.	p^a	B	S.E.	p^a	B	S.E.	p^a
Parental illicit drug use	.51	.22	<.05	.05	.17	>.70	.01	.15	>.90
Childhood sexual abuse	.44	.11	<.0001	.09	.09	>.20	-.02	.08	>.70
Female gender	-1.44	.24	<.0001	-.11	.17	>.50	.03	.14	>.80
Novelty-seeking	.83	.09	<.0001	.32	.07	<.0001	.16	.06	<.01
Conduct problems ages 7–13	.02	.01	<.05	-.01	.01	>.30	-.01	.01	>.10
Cannabis use ages 16–25	–	–	–	1.44	.07	<.0001	1.09	.07	<.0001
Affiliation with substance-using peers ages 16–25	–	–	–	.50	.06	<.0001	.32	.06	<.0001
Alcohol use ages 16–25	–	–	–	.60	.11	<.0001	.58	.11	<.01
Cigarette smoking ages 16–25	–	–	–	.15	.06	<.01	.03	.05	>.50
1-year-lagged measure of illicit drug use	–	–	–	–	–	–	1.26	.13	<.0001
Age \times cannabis use	–	–	–	-.07	.02	<.0001	-.10	.02	<.0001

^a Wald chi square.

Table 3
Parameter estimates for multivariate regression models of risk factors for illicit drug abuse/dependence, ages 16–25

Predictors	Illicit drug abuse/dependence								
	Model including fixed covariates			Model including fixed and time-dynamic covariates			Model including fixed and time-dynamic covariates, and lagged illicit drug use		
	<i>B</i>	S.E.	<i>p</i> ^a	<i>B</i>	S.E.	<i>p</i> ^a	<i>B</i>	S.E.	<i>p</i> ^a
Childhood sexual abuse	.55	.11	<.0001	.17	.15	>.20	.11	.14	>.40
Female gender	−.94	.30	<.01	−.04	.42	>.90	−.04	.34	>.80
Novelty-seeking	.85	.12	<.0001	.32	.17	>.05	.22	.14	>.10
Conduct problems ages 7–13	.05	.01	<.0001	.03	.02	>.10	.01	.01	>.30
Cannabis use ages 16–25	–	–	–	1.57	.14	<.0001	1.11	.15	<.0001
Affiliation with substance-using peers ages 16–25	–	–	–	.89	.14	<.0001	.59	.14	<.0001
1 year-lagged measure of illicit drug use	–	–	–	–	–	–	1.91	.28	<.0001
Age × cannabis use	–	–	–	−.11	.04	<.0001	−.14	.04	<.0001

^a Wald chi square.

3. In the third step of the analyses, the addition of the lagged measure of illicit drug use reduced the strength of the associations between the predictors and the measures of illicit drug use and illicit drug abuse/dependence. The lagged measure of illicit drug use was a statistically significant predictor for both illicit drug use and abuse/dependence ($p < .0001$).

The results of these analyses suggest that the time-dynamic substance use and peer factors mediated the linkages between the predictors and both illicit drug use and illicit drug abuse/dependence, indicating that the pathway to involvement with illicit drugs leads through the use of cannabis and other substances, and through social processes including affiliation with substance-using peers. The exception to this pattern was a persistent significant association between novelty-seeking and illicit drug use. In addition, the finding of significant age by cannabis use interactions suggested that the strength of these associations changed over time (see below).

3.4. Effect size estimates and evaluation of interaction effects

In order to illustrate the relative contributions of the factors to the final models presented in Tables 2 and 3, estimates of effect size were generated for the statistically significant time-dynamic predictors and novelty-seeking. For the purposes of the present analyses, estimates of the odds ratio (OR) and 95% confidence intervals were computed for each of the four levels of each time-dynamic factor (cannabis use; peer substance use; and alcohol use) and the quartile measure of novelty-seeking. Tables 4 and 5 show estimates of the ORs and 95% confidence intervals for the statistically significant predictors, for both: (a) illicit drug use and (b) illicit drug abuse/dependence.

In addition, in order to illustrate the statistically significant age × cannabis use interaction for both illicit drug use and abuse/dependence, ORs and 95% confidence intervals were calculated for the data at ages 16–17, 20–21, and 24–25.

Examination of the tables reveals that:

1. Annual frequency of cannabis use made the strongest contribution to both illicit drug use and illicit drug abuse/dependence. Those using cannabis at least weekly at some point during the period 16–25 years had odds of illicit drug use that ranged from 92.20 (95% CI: 46.53–182.72; age 16–17) to 7.53 (95% CI: 4.48–12.43; age 24–25) times greater than those who did not use cannabis, and had odds of illicit drug abuse/dependence that ranged from 117.92 (95% CI: 26.31–523.74; age 16–17) to 6.49 (95% CI: 2.19–19.20; age 24–25) times greater than those who did not use cannabis. By contrast, the odds ratios for those individuals in the highest quartile for affiliation with substance-using peers, the highest quartile for novelty-seeking, and who used alcohol almost every day had odds of illicit drug use and abuse/dependence that ranged from 1.62 to 5.87. The results of these analyses suggest that, amongst the predictors of illicit drug use and abuse/dependence identified in the analyses presented in Tables 2 and 3, the annual frequency of cannabis use was the strongest predictor of both illicit drug use and illicit drug abuse/dependence.
2. The age × cannabis use interaction for both illicit drug use and illicit drug abuse/dependence indicated that the associations between cannabis use and other illicit drug use and abuse/dependence declined with increasing age. For example, the odds of illicit drug use for those in the highest level of cannabis use declined from 92.20 at age 16–17 to 7.53 at age 24–25, suggesting that while the association between cannabis use and other illicit drug use was very strong in adolescence, this association tended to diminish greatly by early adulthood.

4. Discussion

One of the important findings to emerge from these analyses was the relatively high rate of non-cannabis illicit drug

Table 4
Adjusted odds ratios (and 95% confidence intervals) for multivariate models of risk factors for illicit drug use, at ages 16–17, 20–21, and 24–25

Predictor	Group	Age 16–17		Age 20–21		Age 24–25	
		OR	(95% CI)	OR	(95% CI)	OR	(95% CI)
Annual frequency of cannabis use	Never	1	–	1	–	1	–
	Less than monthly	4.52	(3.60–5.67)	2.97	(2.60–3.41)	1.96	(1.65–2.32)
	At least monthly	20.41	(12.94–32.20)	8.85	(6.74–11.63)	3.84	(2.72–5.37)
	At least weekly	92.20	(46.53–182.72)	26.31	(17.50–39.69)	7.53	(4.48–12.43)
Extent of affiliation with substance-using peers	1–25%	1	–	1	–	1	–
	26–50%	1.38	(1.23–1.55)	1.38	(1.23–1.55)	1.38	(1.23–1.55)
	51–75%	1.91	(1.52–2.41)	1.91	(1.52–2.41)	1.91	(1.52–2.41)
	76–100%	2.64	(1.88–3.74)	2.64	(1.88–3.74)	2.64	(1.88–3.74)
Frequency of alcohol use	Never	1	–	1	–	1	–
	At least once per month	1.78	(1.45–2.20)	1.78	(1.45–2.20)	1.78	(1.45–2.20)
	At least once per week	3.19	(2.10–4.84)	3.19	(2.10–4.84)	3.19	(2.10–4.84)
	Almost every day	5.70	(3.03–10.70)	5.70	(3.03–10.70)	5.70	(3.03–10.70)
Novelty-seeking score	1–25%	1	–	1	–	1	–
	26–50%	1.19	(1.05–1.32)	1.17	(1.05–1.32)	1.17	(1.05–1.32)
	51–75%	1.38	(1.11–1.73)	1.38	(1.11–1.73)	1.38	(1.11–1.73)
	76–100%	1.62	(1.16–2.28)	1.62	(1.16–2.28)	1.62	(1.16–2.28)

Table 5
Adjusted odds ratios (and 95% confidence intervals) for multivariate models of risk factors for illicit drug abuse/dependence, at ages 16–17, 20–21, and 24–25

Predictor	Group	Age 16–17		Age 20–21		Age 24–25	
		OR	(95% CI)	OR	(95% CI)	OR	(95% CI)
Annual frequency of cannabis use	Never	1	–	1	–	1	–
	Less than monthly	4.90	(2.97–8.06)	3.02	(2.24–4.08)	1.87	(1.30–2.68)
	At least monthly	24.05	(8.85–64.97)	9.13	(5.02–16.64)	3.48	(1.69–7.17)
	At least weekly	117.92	(26.31–523.74)	27.61	(11.24–67.90)	6.49	(2.19–19.20)
Extent of affiliation with substance-using peers	1–25%	1	–	1	–	1	–
	26–50%	1.80	(1.38–2.36)	1.80	(1.38–2.36)	1.80	(1.38–2.36)
	51–75%	3.25	(1.90–5.58)	3.25	(1.90–5.58)	3.25	(1.90–5.58)
	76–100%	5.87	(2.61–13.20)	5.87	(2.61–13.20)	5.87	(2.61–13.20)

use, with over 40% of the cohort using these drugs on at least one occasion, and over 10% meeting DSM-IV criteria for abuse or dependence. Most of the illicit drug use involved so-called “party drugs” including ecstasy, amphetamines, and LSD. The use of harder drugs, including cocaine and heroin, was uncommon, reported by less than 9% of the cohort. These findings are generally consistent with findings reported in Australasia (Coffey et al., 2000; Fergusson and Horwood, 2000; Lynskey et al., 1999; Poulton et al., 2001; Swift et al., 2001), but are slightly higher than comparable figures for studies conducted in North America and Europe (Chilcoat and Anthony, 1996; Kandel et al., 1997; von Sydow et al., 2001).

To examine the contributions of a range of risk factors to the development of illicit drug use and abuse/dependence, a three-stage regression approach was used. In the first stage of the analysis the role of various fixed childhood factors including parental adjustment, exposure to abuse in childhood, individual factors including gender and novelty-seeking, and conduct and attention problems in childhood and early adolescence was analysed. This analysis showed that risks of later illicit drug were increased amongst those with parents who had used illicit drugs at least once, were exposed to sexual abuse in childhood, were male, who had higher scores on novelty-seeking, and who displayed higher levels of conduct problems in childhood. These findings are consistent with a large literature that has identified a range of similar factors as predisposing factors in the development of illicit drug use (for reviews see: Anderson, 2006; Bloor, 2006; Compton et al., 2005; Galea et al., 2004; Hawkins et al., 1992; Mayes and Suchman, 2006; Rehm et al., 2006; Ripple and Luther, 1996).

In the second and third stages of the analysis the statistical model was extended and refined by the inclusion of a series of time-dynamic covariates and controls for reverse causality. The final fitted model suggested that risks of later illicit drug use were determined by a series of factors that include cannabis use, affiliation with substance-using peers, alcohol use, cigarette smoking, and novelty-seeking. The risks of illicit drug abuse/dependence were determined by both cannabis use and affiliation with substance-using peers. In general, the analyses suggested that, with the exception of novelty-seeking, accounting for time-dynamic substance use and peer factors reduced the associations between the childhood fixed factors and illicit drug use and abuse/dependence to statistical non-significance.

Of the time-dynamic factors included in the final models, cannabis use had the largest and most complex associations. In particular, the study findings suggested an interactive relationship between age and the use of cannabis in the development of other forms of illicit drug involvement. In this relationship the effects of cannabis use were strongest at younger ages, and declined progressively with age. Furthermore, the size of association depended on the extent of use of cannabis. The net results of these findings is that risks of illicit drug use that were over 90 times higher amongst 16–17-year olds who used cannabis at least weekly when compared to non-users of cannabis. By the age of 25, these risks had reduced to nearly eight times higher. In addition, these associations were controlled for reverse causality by including a lagged measure of other illicit drug use in the

model. These findings are consistent with the view that exposure to cannabis use increases risks of other forms of illicit drug use and abuse/dependence, even when due allowance is taken of childhood factors and possible reverse causal associations. This conclusion is consistent with the previous analysis of these data using a fixed effects regression model (Fergusson et al., 2006).

These findings on the role of cannabis in the development of other forms of illicit drug use highlight three important points. The first is that the association was dose dependent, such that the effects of cannabis on other illicit drug involvement depended on the amount used. The second is that the association was age dependent such that young users were more susceptible to the effects of cannabis than older users. The third important feature of the associations was that much of the association between childhood factors and other forms of illicit drug use and abuse/dependence was mediated via cannabis use. This finding is important in the light of claims that the association between cannabis use and other forms of illicit drug use can be explained by common childhood factors (Donovan and Jessor, 1985; Hays et al., 1987; Huba et al., 1981; Morral et al., 2002). The present study suggests quite the opposite conclusion in which cannabis use mediated the effects of childhood factors on later illicit drug abuse.

While the use of cannabis appeared to play a central role in the transition to various forms of other illicit drug use and abuse/dependence, these risks were also influenced by other factors. Specifically, there was also evidence to suggest that alcohol use may play a small gateway effect in encouraging illicit drug use, with increasing alcohol use being associated with increasing illicit drug use even after control for both the use of cannabis and reverse causal effects. This result is consistent with findings that suggest that alcohol use may play a role in leading to involvement with illicit drugs other than cannabis (Center on Addiction and Substance Abuse, 1994; Kandel and Yamaguchi, 2002).

An important factor contributing to the likelihood of other illicit drug use was the extent of the young person's affiliation with substance-using peers, with those having higher exposure to such peers being more than twice as likely to use other illicit drugs, and more than five times more likely to report other illicit drug abuse/dependence. It is likely that peer affiliation contributes to illicit drug use in several ways including: (a) providing a source of information about illicit drugs; (b) providing a source of supply of drugs; and (c) providing a social support system that encourages the use of illicit drugs. These findings are consistent with previous findings that have suggested that affiliation with substance-using peers may play an important role in the development of substance use and abuse/dependence (Bloor, 2006; Duncan et al., 1998; Jenkins, 1996; Wills et al., 1998).

There was also evidence to suggest that personality factors also played a role in the transition to the use of illicit drugs, with those scoring high on novelty-seeking being more prone to use illicit drugs than those scoring low on this dimension. These findings are consistent with previous findings suggesting that variations in propensities to risk-taking may play a role in the development of illicit drug use and abuse (Acton, 2003; Adams et al., 2003; Evren et al., 2007; Khan et al., 2005; Staiger et al., 2007).

In summary, the findings of this 25-year longitudinal study suggest that the development of illicit drug use and abuse/dependence in adolescence and young adulthood involves an accumulative process that includes exposure to adversity in childhood, childhood adjustment, personality and individual factors, the use of cannabis, affiliation with substance-using peers, and alcohol use. Of these factors, the use of cannabis appears to play the strongest role, with this being particularly evident for young users and heavy users of cannabis. These findings highlight the importance of developing a better understanding of the processes that link the use of cannabis to the increased use of other illicit drugs. While there have been frequent criticisms of the view that cannabis acts as a gateway drug that increases risks of other forms of illicit drug use (Donovan and Jessor, 1985; Hays et al., 1987; Huba et al., 1981; MacCoun, 1998; Morral et al., 2002), the evidence gathered in this longitudinal study strongly points in that direction. As shown in the present paper, cannabis use was the factor that is most strongly related to other forms of illicit drug use. A previous study of the same birth cohort showed that the associations between cannabis use and other illicit drug use in this cohort could not be explained away as being due to non-observed sources of confounding (Fergusson et al., 2006) and persisted after control for reverse causality. These findings clearly suggest that the use of cannabis plays a central but as yet poorly understood role in facilitating the transition to other forms of illicit drug use.

These conclusions are of course subject to a number of caveats. First, the findings apply to a particular cohort studied in a specific social context, and the extent to which these results apply to other cohorts and social context is unknown. Second, the analyses are based on self-report data and are subject to the usual limitations that apply to such data. Finally, the results of the regression analysis are subject to the threats to validity from omitted sources of confounding.

However, within these limitations the findings of this 25-year longitudinal study suggest that the development of illicit drug use and abuse in adolescence involved an accumulation of risk factors including exposure to adversity in childhood, childhood adjustment, personality and individual factors, the use of cannabis, affiliation with substance-using peers, and alcohol use, with the most influential of these factors being the use of cannabis.

Conflicts of interest

The authors declare no conflicts of interest.

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