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RESEARCH REPORT

Initiation and progression of cannabis use in a population-based Australian adolescent longitudinal study

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Abstract

Aims. *To examine predictors of cannabis use initiation, continuity and progression to daily use in adolescents.* **Design.** *Population-based cohort study over 3 years with 6 waves of data collection.* **Participants.** *2032 students, initially aged 14–15 years, from 44 secondary schools in the state of Victoria, Australia.* **Measurements.** *Self-report cannabis use was categorized on four levels (none, any, weekly, daily) and summarized as mid-school (waves 2/3) and late-school (waves 4/5/6) use. Background, school environment, mid-school peer use and individual characteristics were assessed.* **Findings.** *Peer cannabis use, daily smoking, alcohol use, antisocial behaviour and high rates of school-level cannabis use were associated with mid-school cannabis use and independently predicted late-school uptake. Cannabis use persisted into late-school use in 80% of all mid-school users. Persisting cannabis use from mid- to late-school was more likely in regular users (odds ratio (OR) 3.4), cigarette smokers (OR any smoking: 2.0, daily smoking: 3.3) and those reporting peer use (OR 2.1). Mid-school peer use independently predicted incident late-school daily use in males (OR 6.5) while high-dose alcohol use (OR 6.1) and antisocial behaviour (OR 6.6) predicted incident late-school daily use in females.* **Conclusions.** *Most cannabis use remained occasional during adolescence but escalation to potentially harmful daily use in the late-school period occurred in 12% of early users. Transition was more likely in males, for whom availability and peer use were determinants. In contrast, females with multiple extreme behaviours were more likely to become daily users. Cigarette smoking was an important predictor of both initiation and persisting cannabis use.*

Introduction

There is concern about cannabis use by young people in most developed countries (Adlaf & Smart, 1991; Fergusson, Lynskey & Horwood, 1993; Johnston, OMalley & Bachman 1998; Hall, Johnston & Donnelly, 1999; Lynskey & Hall, 1999). Cannabis use is typically initiated during adolescence with patterns of heaviest use usually occurring during late adolescence and young adulthood (Chen & Kandel, 1995).

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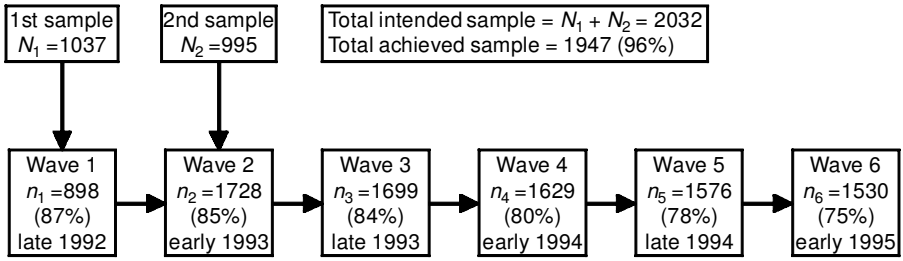

Figure 1. *Participation rates of 2032 secondary school students in the adolescent health cohort study in Victoria, Australia.*

Controversy remains about the extent of the harmful social and health consequences of occasional use of this drug. Debate has been polarized between those who argue that adolescent cannabis use is essentially a benign, transient practice with few social and health consequences for the great majority of young people (Shedler & Block, 1990; Robins, 1995) and those who view cannabis as having the potential to lead to escalating drug use and its attendant problems (Kandel et al., 1986; Newcomb & Bentler, 1988; Fergusson, Lynskey & Horwood, 1996; Hall, 1997). Its peak use also coincides with the time of greatest risk for adverse effects of substance use such as accidental injury, educational and legal difficulties (Hall, 1995).

Most information on the risk factors for cannabis use derive from cross-sectional and retrospective studies. These studies have generated useful hypotheses but the processes involved can only be explored longitudinally, that is, with prospective measurement at multiple time-points of drug use and putative risk factors (Kandel, 1980; Farrington, 1991; Cicchetti & Rogosch, 1999). Longitudinal studies beginning early in life have identified childhood and early adolescent risk factors for cannabis use, but infrequent observations during the adolescent years have limited the ability of these studies to clarify risk processes around mid- to late teens, a period of rapid change in drug use behaviour. Well documented risk factors for licit and illicit substance use include ready substance availability together with affiliation with drug-using peers (Dembo et al., 1979; Kandel & Andrews, 1987; Maddahian, Newcomb & Bentler, 1988), but predictors of more regular use have been less explored than those for initial uptake. Further, few investigators have distinguished between occasional/experimental use and more regular use, thereby being insensitive to the possibility that risk factors for the two levels may differ.

The aims of this report are to use data from a 3-year prospective study of a representative sample of Australian adolescents to quantify the correlates of early cannabis use and to quantify risk factors for incident use, continuation and progression in use.

Method

Procedure and sample

Data were collected from subjects in a 6-wave cohort study of adolescent health performed throughout the state of Victoria, Australia between August 1992 and July 1995. The cohort was defined using a two-stage sampling procedure. At stage 1, 45 schools were selected from a stratified frame of government, catholic and independent schools (total number of students 60 905). One school from the initial cross-sectional survey was unavailable for the cohort study leaving a total of 44 schools. At the second stage, a single intact class was randomly selected from each school and these students were measured in wave 1. At the second wave of data collection, 6 months later, when the cohort had moved into year 10, a second intact class from the same grade at each participating school was selected at random (Fig. 1). Thus half the participants had been interviewed once before wave 2. The entire sample was followed-up from wave 2 to completion of the study.

The study was presented as dealing with important adolescent health issues and covered both adolescent mental health and life-style. Written parental permission was sought at entry into the study. Subjects completed the questionnaire at intervals of 6 months between year levels

9 and 12 (6 waves). The mean age at wave 1 was 14.5 (SD 0.5) years and at wave 6, 17.4 years (SD 0.4). The survey was administered at school using 28 laptop computers which allowed the collection of detailed self-report data through the use of branched questionnaires (Paperny et al., 1990). Subjects who were unavailable for follow-up at school were interviewed by telephone. The proportion of interviews conducted by telephone increased from 2% in wave 2 to 14% in wave 6.

Measures

Cannabis use

Assessment of cannabis use was based on self-reported frequency. Participants described their cannabis use during the past 6 months using the following rating scale: (1) never used, (2) not used in the past 6 months, (3) a few times, (4) monthly, (5) weekly and (6) daily. Cannabis use was summarized over two periods of the study: the highest reported level of cannabis use in waves 2 and 3, and similarly in waves 4, 5 and 6. These intervals correspond to the third last year at school, and the last 2 years of school. For convenience, these intervals are referred to as "mid-school" and "late-school", respectively, although the second interval contained data from 219 (11%) participants who had left school before their final year.

Background and putative risk factors

A wide range of social, demographic, peer and individual factors were examined as possible predictors of cannabis use. These were selected on the basis of prior review of the literature which identified factors most likely to be related to cannabis use and subject to availability within our data. The factors included were:

Demographic variables

These were assessed at study entry and included gender, place of birth, metropolitan or rural location of school and parental separation or divorce. However, rural school location was not associated with any cannabis use variable and so was dropped from all outcome analyses.

Peer cannabis use

At each wave, participants reported whether (1) none, (2) some or (3) most of their friends used cannabis. This variable was summarized over the mid-school period so that those reporting in at least one wave that most of their friends used cannabis were characterized accordingly.

School level of cannabis use

In order to examine early exposure to regular cannabis use at school, the proportion of students within each school using cannabis at least weekly was calculated at wave 2. The schools were then divided into tertiles on the basis of these proportions. In all analyses of late-school cannabis use with the three-level variable describing school-level exposure, only the highest category held a univariate association (if at all) with the outcome variable. Therefore the binary variable, top tertile vs. middle or bottom tertile, was used in each analysis.

Cigarette smoking

Participants reporting that they had smoked on 6 or 7 days in the previous week were categorized as daily smokers. If daily smoking was recorded in either waves 2 or 3 then the individual was characterized as a daily smoker during the mid-school period (291 of the 1890 participants). For more detailed analysis of the effects of smoking, occasional smoking was defined as reporting smoking in the last month, but less than 6 days in the past week. Non-smoking was defined as not having smoked in the past month.

Alcohol consumption

Subjects reporting that they had drunk alcohol in the week before the survey were asked to complete a 1-week retrospective alcohol diary (beverage- and quantity-specific). Two measures of alcohol consumption were derived from the diary in waves 2 and 3:

(1) Those who reported drinking on three or more days in the previous week in either wave 2 or 3 were classified as frequent drinkers in the mid-school period (123 of 1890 participants).
(2) Subjects were characterized by their average consumption of ethanol per drinking day (one unit equivalent to one standard drink,

9 g ethanol). Those with an average of five units or greater were classified as high dose drinkers (312 of 1890 participants).

Antisocial behaviour

Antisocial behaviours were evaluated with 10 items from the Moffitt & Silva (1988) self-report early delinquency scale. Items included antisocial behaviour relating to property damage (vandalism, car damage, making graffiti), interpersonal conflict (fighting, carrying weapons, running away from home, expulsion from school) and theft (stealing property from parents, or other, stealing cars). Items concerning alcohol or other substance use were not included. The reference period was 6 months. Antisocial behaviours were categorized according to whether more than one behaviour was endorsed "more than once" in order to distinguish participants with more global antisocial behaviours. If this occurred in either wave 2 or wave 3, individuals were characterized as displaying antisocial behaviour in the mid-school period (240 of 1890 participants).

Mental health

A computerized form of the Clinical Interview Schedule (CIS-R) was used to rate psychiatric morbidity (Lewis & Williams, 1989; Lewis et al., 1992). This is a structured psychiatric interview designed for assessing symptoms of general psychiatric morbidity in non-clinical populations and includes indicators of depression and anxiety. The instrument generates 14 subscales which can then be added to form a scale indicating the degree of psychiatric morbidity. Mean scores for waves 2 and 3 were calculated and then dichotomized at the 11/12 cut-point, corresponding to the level at which a general practitioner might be concerned about a subject's mental health (Lewis & Williams, 1989; Lewis et al., 1992). Thirty-two per cent of females and 15% of males scored above this threshold.

Data analysis

Data analysis was undertaken using Stata (StataCorp, 1999). Initially, cannabis use was assessed using a three-category ordinal scale: (1) not used in previous 6 months, (2) used in the last 6 months but less often than weekly and (3) weekly or more regular use. We considered two alternative ways of analysing this data. The first alternative was to dichotomize cannabis use as: (1) versus (2)–(3); or (1)–(2) versus (3), and then to examine separate logistic regression models fitted to these dichotomous outcomes. This approach would have resulted in two different odds ratio (OR) estimates of the association of a factor with cannabis use. A marked difference between these OR would indicate that the association was different at different parts of the ordinal scale. If the underlying association with cannabis use that we were trying to estimate was, in fact, the same across the ordinal scale (i.e. the underlying OR were equal) then this analysis method would be inefficient and would ignore some of the information from the three-category scale. To optimize efficiency we used the alternative strategy of fitting ordinal logistic regression models. Within these models, it was possible to perform likelihood-ratio (LR) tests (Peterson & Harrell, 1990) of the assumption of a factor's association with cannabis use being constant across the ordinal scale (the proportional odds (PO) assumption (McCullagh, 1980)). All variables in the multivariable ordinal models included in this report complied with the proportional odds assumption at the 0.05 level of significance.

Exploratory univariate analyses were performed followed by multivariable ordinal logistic regression modelling. First-order interactions with gender were tested in all models using the LR test comparing the more complex model with the simpler model. All reported confidence intervals (CI) are based on a 95% confidence level.

Other analyses performed were on the binary outcomes: poor survey completion, late-school daily use and persistence from early to late-school use. These analyses used multivariate logistic regression. In the case of the predictive model for daily cannabis use, backwards stepwise selection was used to examine interaction terms with gender, keeping all main terms in the model. Items were dropped if $p > 0.2$ and reincluded if $p < 0.1$. A similar process was then used in the selected model in order to examine the main terms, dropping terms if $p > 0.1$, and reincluding if $p < 0.05$.

Results

Sample characteristics

From the total sample of 2032 students on class registers, 1947 (95.8%) completed the questionnaire at least once in the course of the study. Based on the intended sample, response rates across waves were as follows: wave 1, 87%; wave 2, 85%; wave 3, 84%; wave 4, 80%; wave 5, 78%; and wave 6, 75%. The gender ratio of the cohort (males 47.0%) was similar to that in Victorian schools at the time of sampling (Australian Bureau of Statistics, 1993). A total of 1890 (93%) young people participated in waves 2–6. The mean age at wave 2 was 15.4 (SD 0.5) years and at completion of the follow-up was 17.4 years (SD 0.4).

Two hundred and three subjects (11%) completed only one or two waves between waves 2 and 6. Characteristics of these low completers were examined in a logistic regression model. Males were over-represented (OR 1.8, 95% CI 1.3–2.5), as were non-Australian-born subjects (OR 2.0, CI 1.3–3.1), those who had experienced parental divorce or separation (OR 2.6, CI 1.8–3.7) and those who reported using cannabis at least weekly at study inception (OR 1.9, CI 1.0–3.5).

Four major outcome analyses were performed and are shown in Fig. 2. This figure illustrates one cross-sectional analysis and three prospective analyses that are the subject of this report. Table 1 shows the frequency of mid-school cannabis users by late-school users, and defines the observations included in the prospective analyses (2) to (4) illustrated in Fig. 2.

(1) Mid-school cannabis use

Twenty-one per cent of the 1864 participants in waves 2 and 3 (24% of males and 18% of females) reported using cannabis in the mid-school period of follow-up (Fig. 2). As daily use was infrequent we combined this category with weekly use to generate a three-level variable describing cannabis use: (1) none, (2) less often than weekly (<weekly), (3) weekly or more often (weekly +). Male gender held a modest univariate association with mid-school cannabis use, but this association was not sustained after adjustment for covariates (Table 2). Reported peer use held the strongest independent association with cannabis use with a greater than 10-fold increase in odds. Antisocial behaviours, daily smoking and high-dose alcohol use were markedly associated with cannabis use, showing between three- and five-fold increases in odds, while alcohol use on three or more days was only modestly associated. Having divorced or separated parents showed a slightly elevated univariate risk, which was still evident after adjustment for possible confounders. There was no evidence of an association with either psychiatric morbidity or Australian birth after adjustment for confounders.

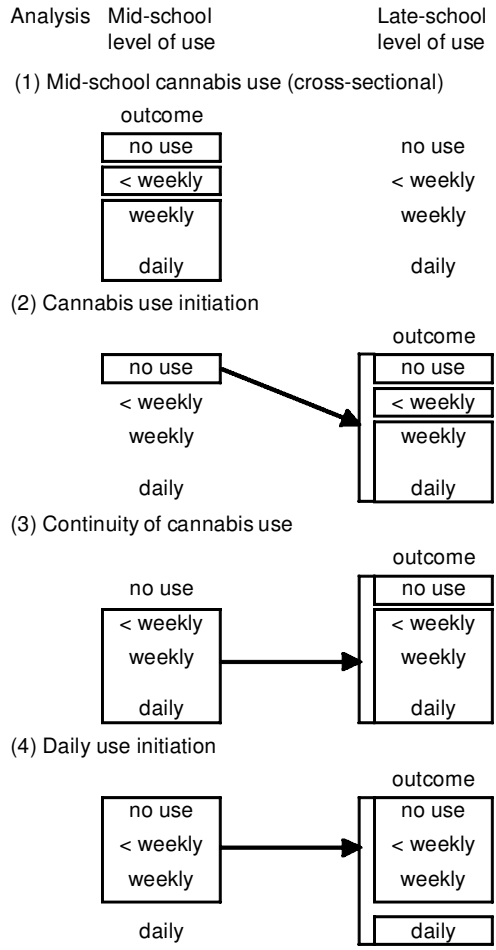

Figure 2. *Description of analyses. Shaded areas indicate data included in analysis, borders indicate boundaries between categories, gaps between categories indicate levels of outcome, and arrows indicate path of transition.*

Table 1. *Frequency of mid-school cannabis use by late-school cannabis use. Figures in brackets are row percentages*

Mid-school cannabis use	Late-school cannabis use				
	None	<Weekly	Weekly	Daily	Total
None	1153 (85.6)	163 (12.1)	26 (1.9)	5 (0.4)	1347 (100)
<Weekly	63 (24.5)	123 (47.9)	61 (23.7)	10 (3.9)	257 (100)
Weekly	3 (4.0)	22 (29.3)	28 (37.3)	22 (29.3)	75 (100)
Daily	3 (10.0)	2 (40.0)	8 (35.0)	7 (100)	20 (15.0)
Total	1222 (71.9)	310 (18.3)	123 (7.2)	44 (2.6)	1699 (100)

There were 123 non-users, 25 < weekly, 10 weekly and seven daily cannabis users from the mid-school period who had no late-school observations.

Table 2. *Associations with mid-school cannabis use measured on three levels*: OR from ordinal logistic regression models* (n = *1864)*

Explanatory variable	Univariate		Multivariate	
	OR	95% CI	OR	95% CI
Gender (male vs. female)	1.4	1.2–1.8	1.2	0.86–1.5
Australian birth	1.7	1.2–2.4	1.3	0.85–2.1
Divorced/separated parents	2.3	1.8–3.0	1.5	1.1–2.1
Peer cannabis use	26	19–35	12	8.6–17
Daily smoking	11	8.3–14	4.7	3.5–6.4
Alcohol >2 days per week	6.0	4.2–8.7	1.6	1.0–2.5
High dose drinker	8.7	6.7–11	3.2	2.3–4.3
Antisocial behaviours	8.6	6.5–11	3.9	2.8–5.5
Psychiatric morbidity	2.1	1.7–2.7	1.0	0.76–1.4

* Levels of cannabis use: none (79%), less than weekly (15%), weekly or more often (6%). 1. Proportional odds (PO) assumed for all variables and interaction terms. 2. Overall likelihood-ratio test of PO assumption for multivariable model: $\chi^2_{(8)} = 7.8$; $p = 0.45$.

(2) Prediction of first cannabis use

Four hundred and forty-four of 1725 late-school participants (34% of males, 24% of females) reported cannabis use in the late-school period. Eighteen per cent reported using less than weekly, 7% weekly and 2.6% daily. Incident late-school cannabis use was examined in 1347 individuals who had not reported using cannabis in the mid-school period and had observations available in the late-school period (Fig. 2). In the multivariate ordinal model, peer use, daily smoking, frequent and high-dose alcohol use and antisocial behaviours all predicted cannabis uptake in the late-school period with between a two- and three-fold increase in odds (Table 3). Early exposure to a high level of school cannabis use was also predictive of subsequent cannabis initiation. Gender was not associated with late school initiation. There were no first order interactions with gender.

(3) Continuity between mid- and late-school any cannabis use

We defined participants who reported any level of use in both mid- and late-school as continuing users. Continuing users (N = 283, 57% male) were compared with those reporting mid-school

Table 3. *Prediction of late-school cannabis use measured on three levels* for adolescents with no earlier reports of cannabis use (n = 1347): OR from ordinal logistic regression models.*

	Univariate		Multivariate	
Explanatory variable	OR	95% CI	OR	95% CI
Gender (male)	1.4	0.52–1.0	1.3	0.94–1.8
Australian birth	1.9	1.1–3.3	1.6	0.91–2.7
Divorced/separated parents	1.6	1.1–2.5	1.4	0.88–2.1
High level of weekly cannabis use in school at study inception	1.8	1.3–2.4	1.7	1.2–2.4
Mid-school: most peers used cannabis	2.5	1.2–4.8	2.0	1.0–4.2
Mid-school: daily smoker	2.9	1.8–4.8	2.3	1.3–3.9
Mid-school: alcohol >2 days/week	4.1	2.3–7.3	2.1	1.1–3.9
Mid-school: high dose drinker	3.9	2.6–5.8	2.6	1.7–4.1
Mid-school: antisocial behaviours	3.4	2.1–5.5	2.3	1.4–3.8
Mid-school: psychiatric morbidity	1.6	1.1–2.2	1.5	1.0–2.1

* Levels of cannabis use: no use (83%), less than weekly (13%), weekly or more often (4%). 1. Proportional odds (PO) assumed for all variables. 2. Overall likelihood-ratio test of PO assumption for final multivariable model: $\chi^2_{(10)} = 11.7$; $p = 0.31$

cannabis use but who reported no subsequent use ($N = 69$, 46% male) (Fig. 2). Seventy-five per cent of the 257 < weekly mid-school users and 94% of 95 weekly + mid-school users continued (Table 4). In the initial analysis it was clear that daily smoking was an important predictor of continued use. In order to examine this effect further we included mid-school smoking in the model on three levels: non-smoker (60/83 continued), smoked in the last month (104/129 continued) and daily smoking (161/182 continued). Compared with non-smokers, occasional smokers were at double the risk of continuation and daily smokers were at over three times elevated risk, with evidence of a dose effect with increasing frequency of smoking. More frequent mid-school cannabis use and peer use were associated with a three-fold and two-fold elevation in risk, respectively. Although there was evidence of an interaction between parental divorce and gender (likelihood ratio χ^2 (1) = 5.9, $p = 0.015$), the effect of divorce within each gender was not substantial. The residual gender effect showed that males were at increased risk of continuing after allowing for this interaction (males to females adjusted OR 2.6, 1.3–5.6). Interaction between gender and mid-school level of cannabis use could not be tested due to the small number of weekly + users who discontinued. There were no other significant first order interactions with gender.

(4) Daily cannabis use

Young people reporting daily cannabis use were considered to be at high risk of harmful and dependent patterns of use so we were particularly interested in patterns of continuity and progression to daily use. Forty-four young people (3.7% of males and 1.7% of females) of the 1699 with observations in both periods reported using cannabis daily in late-school (another two had late-school but no mid-school observations) (Table 1). Only five of these had not reported some mid-school use. Twelve per cent of all mid-school users (25/192 males and 14/146 females) reported late-school daily use, constituting 4% of < weekly mid-school users and 31% of weekly + mid-school users. There was strong evidence of a dose–response relationship between late-school daily use and level of mid-school use after adjustment for confounders (adjusted OR: less than weekly use mid-school 4.4, 1.3–15; weekly use mid-school 27, 7.0–1.5; daily use mid-school 25, 4.3–142).

Prediction of initiation into late-school daily cannabis use

The onset of daily cannabis use was examined in those participants not previously reporting daily cannabis use in the mid-school period (Fig. 2). There were 37 reports (24 males) of incident late-school daily cannabis use (male versus.

Table 4. *Prediction of continuation of cannabis use from mid-school into late-school (n = 283) for those adolescents reporting earlier cannabis use (n = 352): OR from logistic regression models*

	Univariate		Multivariate	
Explanatory variable	OR	95% CI	OR	95% CI
Australian birth	1.6	0.66–3.7	2.4	0.92–6.1
Parental divorce				
females	2.1	0.87–5.3	2.1	0.82–5.6
males	0.63	0.26–1.6	0.47	0.14–1.6
High level of weekly cannabis use in school at study inception	1.1	0.66–1.9	0.87	0.49–1.6
Mid-school: cannabis use weekly +	4.8	2.0–12	3.4	1.3–9.0
Mid-school: most peers used cannabis	2.5	1.4–4.4	2.1	1.1–4.0
Mid-school:				
Non-smoker	1		1	
Smoked in the last month	1.7	0.86–3.2	2.0	1.0–4.2
Daily smoker	2.9	1.5–5.7	3.3	1.6–7.2
Mid-school: alcohol > 2 days/week	1.1	0.55–2.3	0.61	0.27–1.4
Mid-school: high dose drinker	1.3	0.75–2.2	0.62	0.33–1.2
Mid-school: antisocial behaviours	2.0	1.1–3.7	1.5	0.74–3.0
Mid-school: psychiatric morbidity	1.2	0.68–2.1	1.0	0.55–2.0

female OR 2.2, 1.1–4.3). All main effects and interactions between gender and the explanatory variables were examined using backwards stepwise regression. As all incident cases of daily cannabis use were participants born in Australia, this variable was not included in the analysis.

There was evidence of important interactions between gender and three mid-school predictors (Table 5). Males who reported that most of their peers used cannabis were at six-fold increased risk, in contrast to females for whom this effect was negligible. Conversely, females, unlike males, were at around six-fold elevated risk if they reported earlier high dose drinking or antisocial behaviours. There was a trend for school-level exposure to cannabis use to predict incident daily cannabis use in late-school, independent of gender. The residual effect for gender was not significantly predictive of daily use at $p = 0.05$ (OR 3.8, 0.82–18). Parental divorce or separation (univariate OR: 3.2, 1.6–6.3), mid-school daily smoking (univariate OR: 5.5, 2.4–13), mid-school frequent alcohol use (univariate OR: 3.8, 1.6–8.9) and mid-school psychiatric morbidity (univariate OR: 2.0, 1.0–3.9) were removed from the model during the selection process as they were not predictive of initiation into daily cannabis use in the multivariate model.

Discussion

One in five Australian adolescents used cannabis during the mid-teens. For the great majority the frequency of cannabis use remained at low levels with around two-thirds of all users in both mid- and late-school periods reporting less than weekly use. By examining progression to daily use we were able to delineate a group who were at unequivocal risk of harmful use. The mid- to late teens was an important period for progression in use with 13% of male and 9% of female mid-school users going on to daily cannabis use.

This study differs from earlier work in that it is based on the repeated measurement of cannabis use at multiple points. It is therefore able to address questions of both initiation of use and progression to higher levels of use. As school retention rates were 98% in this state in the year of initial sampling, the sample frame provided an almost representative adolescent study population (Australian Bureau of Statistics, 1993). The age range is around the previously reported peak age for initiation of cannabis use (Chen & Kandel, 1995). One issue of importance is that of the validity of self-report of cannabis use. Self-report of cannabis use has been demonstrated to have good construct validity, to have reasonable stability and to be no worse in this regard than other self-report measures (O'Malley, Bachman & Johnstone, 1983). Stability has been shown to be related to the recall period so we can expect that the daily and weekly response categories were reasonably

Table 5. *Prediction of initiation into late-school daily cannabis use (n = 37) by adolescents who reported none or less than daily mid-school cannabis use (n = 1679): OR from logistic regression models*

	Univariate		Multivariate	
Explanatory variable	OR	95% CI	OR	95% CI
High level of weekly cannabis use in school at study inception	3.6	1.9–7.1	2.0	0.97–4.3
Mid-school: cannabis use (weekly or less often)	29	11–74	8.7	2.8–26.8
Mid-school: most peers used cannabis				
Females	11	3.5–32	1.3	0.35–4.6
Males	23	9.3–58	6.5	2.3–18.3
Mid-school: high dose drinker				
Females	29	7.8–107	6.1	1.4–25.4
Males	4.0	1.7–9.0	1.0	0.41–2.6
Mid-school: antisocial behaviours				
Females	22	6.9–69	6.6	1.9–23.3
Males	3.9	1.7–9.0	0.91	0.36–2.4

reliable. Although the occasional category used a 6-month reference period, enhanced ability to remember unusual events could have countered a tendency to under-report (O'Malley et al., 1983). Another source of bias could have been the lower participation rates noted to be associated with weekly cannabis use at study entry. There was possibly the potential for misspecification of cannabis use in individuals absent from waves within each study period. We have assumed that patterns of associations observed in the data were similar for individuals for whom data was missing. This could have resulted in slightly biased OR estimates.

Different mechanisms have been suggested to explain the uptake of illicit drugs in young people. The stage theory implies that use of one drug further down a sequence, for example alcohol and/or nicotine, in some way facilitates the use of drugs at higher levels, for example cannabis (Adler & Kandel, 1981; Yamaguchi & Kandel, 1984; Welte & Barnes, 1985; Fleming et al., 1989; Graham et al., 1991; Ellickson, Hays & Bell, 1992; Kandel, Yamaguchi & Chen, 1992). Evidence from these studies is also consistent with the hypothesis that drug use is determined by a single underlying dimension of vulnerability to drug use or "transition proneness" (Jessor & Jessor, 1977) and that the use of different drugs at different times is an opportunistic response to changing environmental conditions such as availability. The concept of vulnerability has been extended further to suggest that drug use was one of a constellation of deviant behaviours described collectively as a syndrome of problem behaviours (Donovan & Jessor, 1985). The veracity of these theories can be informed by examining risk processes involved in the natural history of cannabis use.

In this study, prior use of cannabis was found to be strongly and independently predictive of subsequent use. Overall, four-fifths of those who reported earlier cannabis use continued at some level. Only five of the 44 using cannabis daily in the later period had not reported earlier use, with strong evidence that more frequent early use substantially increased the propensity to later, possibly harmful, daily use. Specifically, both weekly and daily use carried around a six-fold elevated risk of later daily use relative to occasional use. However, it must be remembered that escalation was far from being an inevitable consequence of early occasional use in that only 4% of mid-school occasional users made this transition.

Quitting and persistence in cannabis use in adolescence has not been studied previously in non-clinical settings. Eighty-two per cent of those reporting cannabis in the mid-school period continued use in the late school period. Continued use was more common among males, young people reporting more regular cannabis use, smokers and those with cannabis using friends.

The co-occurrence of tobacco use and cannabis use is well documented (Hall, 1995). We

found that although both alcohol use and smoking were associated with cannabis uptake, only smoking was independently predictive of persistent use by early users. This finding indicates that it is the co-occurrence of smoking rather than alcohol use that distinguishes between transient experimentation and entrenched behaviour, with the degree of entrenchment apparently related to smoking frequency. It is interesting to speculate whether the mechanism is purely social, reflecting the companionable experience in common with smoking cigarettes and smoking cannabis, or whether there may in part be an underlying physiological or psychological vulnerability to both nicotine and cannabis dependency in these young people. This vulnerability may simply be that initiation of cannabis is unlikely in the absence of some prior history of smoking as a method of drug ingestion. That peer use was also an independent predictor of persistent use tends to support the possibility of a social determinant component. The lack of independent association with other norm-violating behaviours or with symptoms of depression and anxiety would seem to discount problem behaviour or psychological vulnerability as the mechanism.

A number of previous studies have reported that tendencies in childhood to disruptive or norm-violating behaviours are important predictors of the development of cannabis use (Shedler & Block, 1990; Lynskey & Fergusson, 1995). In an extension of these findings and in contrast to persisting use, we found that antisocial behaviour in the mid-school period was predictive of cannabis uptake. As is already well-documented, we found that reported peer cannabis use held clear and robust associations with cannabis use and was strongly predictive of uptake. Further, to the best of our knowledge, this is the first study to specifically examine the influence of the level of cannabis use within the individual's school environment measured at the school level. Elevated risk of cannabis initiation associated with environmental cannabis use is consistent with earlier reports that family, peer and community levels of drug use are important determinants of substance use behaviours (Hawkins, Catalano & Miller, 1992).

The analysis method we used to examine risk factors for cannabis initiation allowed us to infer that the influence of each risk factor was similar for incident occasional use and incident regular use. This finding must be interpreted cautiously as the test of "proportional odds" had low power, but it may indicate that identified factors endowed a general blanket of risk, irrespective of the level of uptake.

Initiation of daily cannabis use in the late-school period differed between males and females. Males were more than twice as likely to make the transition to daily use but earlier norm-violating behaviour, indicated by antisocial behaviour and high-dose drinking, was found to predict of daily use only in females. This observation lends credence to the existence of a syndrome of problem behaviours described by Donovan & Jessor (1985), but only for young women. Males, on the other hand, appeared to be responding more to social expectations and opportunities indicated by their greater responsiveness to peer influences. This finding has important implications for the prevention of harmful substance use and suggests that different strategies may be needed to address risks of heavy cannabis use in young males and females. Prevention of early cannabis use is likely to affect rates of daily cannabis use in both sexes. For boys preventive and early treatment interventions might sensibly address the peer social context. In contrast, girls who become daily users appear to lead more chaotic lives and it is likely that intervention responses would sensibly extend beyond a focus on cannabis alone.

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