

American Journal of Epidemiology 2007 166(5):592-598;

doi:10.1093/aje/kwm11

# Association of Maternal Smoking and Alcohol Consumption with Young Adults' Cannabis Use: A Prospective Study

Mohammad Reza Hayatbakhsh<sup>1</sup>, Rosa Alati<sup>1</sup>, Delyse M. Hutchinson<sup>2</sup>, Konrad Jamrozik<sup>1</sup>, Jake M. Najman<sup>1,3</sup>, Abdullah A. Mamun<sup>1</sup>, Michael O'Callaghan<sup>4</sup> and William Bor<sup>5</sup>

<sup>1</sup> School of Population Health, University of Queensland, Brisbane, Australia

<sup>2</sup> National Drug and Alcohol Research Centre, University of New South Wales, Sydney, Australia

<sup>3</sup> School of Social Science, University of Queensland, Brisbane, Australia

<sup>4</sup> Child Development and Rehabilitation Services, Mater Children's Hospital, Brisbane, Australia

<sup>5</sup> Mater Centre for Service Research in Mental Health, Mater Hospital, Brisbane, Australia

Correspondence to Dr. Mohammad Reza Hayatbakhsh, The University of Queensland, QADREC, School of Population Health, Herston Road, Herston, Queensland 4006, Australia (e-mail: [m.hayatbakhsh@sph.uq.edu.au](mailto:m.hayatbakhsh@sph.uq.edu.au)).

*Received for publication November 10, 2006. Accepted for publication March 7, 2007.*

## ABSTRACT

This 2006 study examined 1) whether maternal use of tobacco and consumption of alcohol when a child is 5 and 14 years of age predict cannabis use in young adults, and 2) whether this association is explained by possible confounding or mediating factors. Data were taken from a prospective birth cohort study of mothers and their children in Brisbane, Australia. This study was based on a cohort of 3,176 young adults who participated at the 21-year follow-up of the study and for whom data were available on maternal smoking and alcohol consumption 5 and 14 years after their birth. After controlling for possible confounders, the authors found that maternal smoking at 14 years was associated with frequent use of cannabis in offspring at 21 years, regardless of maternal smoking at 5 years. Children of mothers who drank more than one glass of alcohol at 5 years and continued at 14 years were more likely to use cannabis in early adulthood. The association between maternal substance use and offspring cannabis use was partially mediated by adolescent externalizing behavior and smoking measured at 14 years. Prevention programs that address maternal and adolescent tobacco use and adolescent externalizing behavior should be considered as strategies to reduce cannabis use by young adults.

adult; alcohol drinking; cannabis; maternal behavior; smoking

## INTRODUCTION

Cannabis is the most widely used illicit drug in Australia and other developed countries (1). Surveys show that initiation to cannabis use typically occurs during adolescence (ages 14–19 years) and early adulthood (ages 20–29 years), with 26 percent of adolescents and more than half of all young adults (55 percent) in Australia reporting having ever used cannabis (2). Statistics also show that the average age at first use has been declining in recent decades in Australia (2).

Understanding the factors that predict cannabis use may help in preventing widespread experimentation with this drug by adolescents and young adults (3). There are a variety of theories concerning why use of licit and illicit substances is initiated. For example, social learning theory (4), social cognitive theory (5), and social control theory (6) focus on how an individual's social environment affects his or her behavior. The family environment is an important influence on child and adolescent behavior (7). One aspect of this influence is the evidence suggesting that children of substance-using parents are at increased risk of a range of adverse outcomes. Several studies report a link with the development of substance use in adolescence and adulthood (8–15), but this association with parental substance use has not been consistently apparent (16). O'Callaghan et al. (9) found that maternal smoking when a child is age 5 and 14 years predicted adolescent smoking. In multivariate models, the association between maternal smoking at child's age 5 years and adolescent smoking remained significant for mothers who continued to smoke at the 14-year follow-up. In the same large, longitudinal study of Australian youth, exposure to maternal drinking in adolescence explained 36 percent of the variance in alcohol disorders reported in early adulthood (17).

Despite the evidence of an association between parental smoking and drinking and increased rates of these behaviors in adolescent and young adult offspring, evidence concerning the association of parental alcohol consumption and tobacco use with children's later uptake of cannabis is limited (11, 13, 15). It is not known whether there is a particular period in the child's life course (e.g., childhood or adolescence) when familial substance use is particularly influential. In addition, it is uncertain whether any influence of parental smoking and drinking is mediated by children's problem behaviors and early initiation to tobacco use and alcohol consumption.

Using data from a prospective birth cohort study, we examined 1) whether maternal smoking and alcohol consumption at child's age 5 and 14 years predict cannabis use in the offspring in early adulthood, and 2) whether aspects of the timing and persistence of maternal smoking and drinking appear to be particularly influential with regard to cannabis use in offspring. Furthermore, we investigated whether the associations of maternal smoking and alcohol consumption at child's age 5 and 14 years with young adults' cannabis use appear to be mediated by adolescent problem behaviors and early smoking and alcohol consumption at age 14 years.

## **MATERIALS AND METHODS**

### **Participants**

The data were taken from the 21-year Mater-University of Queensland Study of Pregnancy (18), a birth cohort study of women enrolled at the Mater Misericordiae Hospital in Brisbane, Australia, between 1981 and 1983. Baseline data were collected at the first antenatal visit from 7,223 consecutive women who subsequently gave birth to live singleton babies and were followed up at 3–5 days; 6 months; and 5, 14, and 21 years after the birth. For the present 2006 study, we included 4,549 mothers (and children) who provided information about smoking and alcohol consumption at both 5 and 14 years, of whom 3,176 (69.8 percent) children also completed the 21-year questionnaire items on cannabis use. Written informed consent from the mother was obtained at all phases of data collection and

from the young adult at the 21-year follow-up of the study. Ethics committees at the Mater Hospital and the University of Queensland approved each phase of the study.

### **Instruments**

#### **Maternal smoking and alcohol consumption.**

At the 5- and 14-year follow-ups, mothers were asked to indicate the number of cigarettes they smoked per day during the last week. Options for this question were none, 1–9, 10–19, 20–29, 30–49, and 50 or more. Using the mothers' responses at 5 and 14 years, we created a composite variable that classified the mothers into four groups: did not smoke cigarettes at 5 and 14 years; smoked cigarettes at 5 but not at 14 years; did not smoke cigarettes at 5 but smoked at 14 years; and smoked cigarettes at both 5 and 14 years.

The frequency and quantity of maternal alcohol consumption at the 5- and 14-year follow-ups were measured with the following two questions: 1) How often do you drink alcohol? and 2) How much alcohol do you usually drink at those times? For both 5 and 14 years, we created a dichotomous variable for maternal alcohol consumption (abstainer or up to one drink per day/more than one drink per day). Using this variable, we grouped mothers into four categories: abstainers or consumption of up to one drink per day at both 5 and 14 years, those who reported imbibing more than one drink of alcohol daily at one of 5 years and 14 years but not the other, and those who consumed more than one drink per day at both points.

#### **Young adults' cannabis use.**

Cannabis use by the offspring was assessed at the 21-year follow-up via a self-report questionnaire in which participants were asked, In the last month, how often did you use cannabis, marijuana, pot, etc.? Options for response included have never used; used every day; every few days; once or so in the last month; and not in the last month. On the basis of the frequency of use reported at the 21-year follow-up, cannabis ever users were divided into two categories: 1) "occasional use" (referring to use of cannabis "once in the last month" or "not in the last month"); and 2) "frequent use" (referring to use of cannabis "every day" or "every few days").

#### **Other covariates.**

Maternal sociodemographic variables included age (below 20 and 20 years or older); education (did not complete high school, completed high school, and post-high school education) assessed when the child was born; and gross family income at the 5-year follow-up (family income was classified as "low" if below the 25th centile).

Maternal marital status was assessed at the 5-year follow-up (married or de facto (living together)/unpartnered). The quality of the marital relationship was also assessed at 5 years via the short form of the Dyadic Adjustment Scale ([19](#)). We then divided mothers into three categories: an unpartnered group as well as partnered mothers with good adjustment or poor adjustment (top 20 percent of scores for marital disagreement).

Maternal mental health at the 5-year follow-up was assessed by using the short form of the Delusions-Symptoms-States Inventory ([20](#)). In this study, mothers were regarded as having symptoms of depression and anxiety if they reported three or more of the seven symptoms in the Delusions-Symptoms-States Inventory depression and anxiety subscales.

Symptoms of internalizing (anxiety and depression) and externalizing (aggression and delinquency) behavior in the adolescents at 14 years were assessed by using the Youth Self-Report (21), a self-completed questionnaire for subjects aged 11–18 years that inquires about behavior in the previous 6 months. The Youth Self-Report has good reliability and validity (22). In the current study, cases of internalizing and externalizing at the 14-year follow-up were both selected by using 10 percent cutoffs of scores on the relevant subscale.

The extent of drug use (smoking and alcohol consumption) at 14 years was assessed via self-report. On the basis of their responses, we divided participants into two categories: 1) nonsmokers and smokers and 2) abstainers and drinkers.

### **Statistical analysis**

We used univariate logistic regression to estimate the risk (expressed as the odds ratio and 95 percent confidence interval) of young adults' use of cannabis for each category of maternal smoking and alcohol consumption (reference categories were mothers being nonsmokers and drinkers of up to one glass of alcohol per day, respectively (table 1)). We first examined the univariate association of self-reported maternal smoking and drinking at child's age 5 and 14 years with young adults' use of cannabis. To assess whether the timing of maternal smoking and drinking was important, young adults' use of cannabis was regressed against the composite variables (maternal smoking at child's age 5 and 14 years; and maternal alcohol consumption at child's age 5 and 14 years). Because the outcome variable consisted of three possible values (cannabis never use, occasional use, and frequent use), we analyzed the data by using multinomial logistic regression, with never use of cannabis being the reference category.

**TABLE 1. Univariate associations between young adults' cannabis use and maternal smoking and alcohol consumption at child's age 5 and 14 years, Brisbane, Australia, 2006\***

Variable	No.	Young adults' use of cannabis at 21 years						
		Never use (%)	Occasional use			Frequent use		
			%	OR†	95% CI†	%	OR	95% CI
<b>Maternal smoking at 5 years</b>								
Nonsmoker	2,109	54.7	35.0	1.0		10.2	1.0	
Smoker	1,067	43.5	41.3	1.5	1.3, 1.7	15.2	1.9 11.5, 2.3	
<b>Maternal smoking at 14 years</b>								
Nonsmoker	2,319	54.7	35.3	1.0		10.0	1.0	
Smoker	857	40.8	42.2	1.6	1.4, 1.9	16.9	2.3 11.8, 2.9	
<b>Maternal smoking over time</b>								
None	2,011	55.5	34.5	1.0		9.9	1.0	
Only at 5 years	308	49.0	40.3	1.3	1.0, 1.7	10.7	1.2 0.8, 1.8	
Only at 14 years	98	37.8	45.9	2.0	1.3, 3.1	16.3	2.4 1.3, 4.4	
At both 5 and 14 years	759	41.2	41.8	1.6	1.4, 2.0	17.0	2.3 1.8, 3.0	
<b>Maternal drinking at 5 years</b>								
Abstainer/≤1 drink/day	2,960	51.9	36.5	1.0		11.7	1.0	
>1 drink/day	216	38.4	46.8	1.7	1.3, 2.3	14.8	1.7 1.1, 2.6	
<b>Maternal drinking at 14 years</b>								
Abstainer/≤1 drink/day	2,835	52.3	36.3	1.0		11.4	1.0	
>1 drink/day	341	39.6	44.3	1.6	1.3, 2.1	16.1	1.9 1.3, 2.6	
<b>Maternal drinking over time</b>								
None	2,731	52.8	35.8	1.0		11.4	1.0	
Only at 5 years	104	36.5	49.0	1.9	1.2, 2.9	12.5	1.5 0.8, 2.9	
Only at 14 years	229	40.2	44.1	1.6	1.2, 2.2	15.7	1.8 1.2, 2.7	
At both 5 and 14 years	112	38.4	44.6	1.7	1.1, 2.6	17.0	2.1 1.2, 3.6	

\*Proportions in the table are row %.

† OR, odds ratio; CI, confidence interval.

To examine the impact of a range of possible confounding factors, we progressively developed three multivariate models ([table 2](#)). First, we examined the association of maternal smoking and alcohol consumption with young adults' use of cannabis (model 1). In model 2, we adjusted for child's gender and sociodemographic variables. We subsequently adjusted for maternal anxiety and depression and for use of illicit drugs at 5 years (model 3).

**TABLE 2. Multivariate associations between young adults' cannabis use and maternal smoking and alcohol consumption at child's age 5 and 14 years, Brisbane, Australia, 2006**

Variable	Young adults' use of cannabis at 21 years (N = 3,034)											
	Model 1*				Model 2†				Model 3‡			
	Occasional use		Frequent use		Occasional use		Frequent use		Occasional use		Frequent use	
	OR§	95% CI§	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Maternal smoking												
None	1.0		1.0		1.0		1.0		1.0		1.0	
Only at 5 years	1.3	1.0, 1.7	1.3	0.8, 1.9	1.2	1.0, 1.6	1.1	0.7, 1.7	1.2	0.9, 1.6	1.1	0.7, 1.6
Only at 14 years	2.0	1.2, 3.1	2.5	1.4, 4.7	1.9	1.2, 3.0	2.3	1.3, 4.4	1.8	1.2, 2.9	2.1	1.1, 4.0
At both 5 and 14 years	1.5	1.3, 1.9	2.2	1.7, 2.9	1.5	1.2, 1.8	2.2	1.7, 2.9	1.5	1.2, 1.8	2.1	1.5, 2.8
Maternal drinking												
None	1.0		1.0		1.0		1.0		1.0		1.0	
Only at 5 years	1.7	1.1, 2.5	1.2	0.6, 2.2	1.6	1.0, 2.4	1.2	0.6, 2.3	1.4	0.9, 2.2	1.0	0.5, 1.9
Only at 14 years	1.5	1.1, 2.0	1.6	1.0, 2.4	1.5	1.1, 2.0	1.6	1.1, 2.5	1.5	1.1, 2.0	1.6	1.1, 2.5
At both 5 and 14 years	1.5	1.0, 2.4	1.8	1.0, 3.2	1.5	0.9, 2.2	1.7	1.0, 3.1	1.4	0.9, 2.2	1.6	0.9, 2.9

\* Adjusted for maternal smoking and alcohol consumption.

† Adjusted for covariates in model 1 plus child's gender, maternal education, family income, maternal marital status, and marital relationship at child's age 5 years.

‡ Adjusted for covariates in model 2 plus maternal anxiety and depression and maternal use of illicit drugs at 5 years.

§ OR, odds ratio; CI, confidence interval.

We also explored the associations with possible mediating factors (23) by examining the relation between the main independent variables (maternal smoking and drinking) and the presumed mediators (child internalizing and externalizing, and child smoking and alcohol consumption at 14 years). All of the latter were associated with maternal smoking ( $p < 0.01$ ). Adolescent smoking and alcohol consumption were also associated with maternal alcohol consumption ( $p < 0.01$ ). We then constructed four regression models to examine the associations between these mediating factors and young adults' cannabis use. Our regression analyses indicated that all of adolescent externalizing, smoking, and alcohol consumption were associated with young adults' cannabis use ( $p < 0.0001$ ). Therefore, we progressively controlled the association of maternal smoking and alcohol consumption with young adults' cannabis use (table 3) for child externalizing behavior (model 4), smoking (model 5), and alcohol consumption (model 6) measured at 14 years. All analyses were carried out by using Stata version 9 software (Stata Corporation, College Station, Texas). Number of subjects in particular analyses varied slightly because of missing data for some covariates.

**TABLE 3. Multivariate associations between young adults' cannabis use and maternal smoking and alcohol consumption at child's age 5 and 14 years, after controlling for**

**potential mediators and confounders, Brisbane, Australia, 2006**

Variable	Young adults' use of cannabis at 21 years (N = 3,016)											
	Model 4*				Model 5†				Model 6‡			
	Occasional use		Frequent use		Occasional use		Frequent use		Occasional use		Frequent use	
	QR§	95% CI§	QR	95% CI	QR	95% CI	QR	95% CI	QR	95% CI	QR	95% CI
Maternal smoking												
None	1.0		1.0		1.0		1.0		1.0		1.0	
Only at 5 years	1.2	0.9, 1.6	1.1	0.7, 1.7	1.3	1.0, 1.7	1.1	0.7, 1.7	1.3	1.0, 1.7	1.1	0.7, 1.8
Only at 14 years	1.7	1.0, 2.7	1.9	1.0, 3.6	1.7	1.0, 2.7	1.7	0.9, 3.3	1.6	1.0, 2.6	1.7	0.8, 3.3
At both 5 and 14 years	1.4	1.1, 1.7	1.9	1.4, 2.5	1.3	1.1, 1.6	1.7	1.2, 2.2	1.3	1.1, 1.6	1.7	1.3, 2.3
Maternal drinking												
None	1.0		1.0		1.0		1.0		1.0		1.0	
Only at 5 years	1.4	0.9, 2.3	1.0	0.5, 2.1	1.5	0.9, 2.3	1.0	0.5, 2.1	1.5	0.9, 2.3	1.0	0.5, 2.1
Only at 14 years	1.5	1.1, 2.0	1.7	1.1, 2.6	1.4	1.1, 2.0	1.6	1.0, 2.4	1.4	1.0, 1.9	1.5	1.0, 2.3
At both 5 and 14 years	1.5	0.9, 2.3	1.8	1.0, 3.3	1.4	0.9, 2.2	1.6	0.9, 3.0	1.4	0.9, 2.1	1.6	0.9, 2.9

\* Adjusted for all covariates in table 2 plus adolescent externalizing at 14 years.

† Adjusted for covariates in model 4 plus adolescent smoking at 14 years.

‡ Adjusted for covariates in model 5 plus adolescent alcohol consumption at 14 years.

§ QR, odds ratio; CI, confidence interval.

We used inverse probability weighting (24) with robust estimates for standard errors to account for those lost to follow-up. All of the individual and familial variables available at 5 and 14 years were included in this exploratory logistic regression model to determine whether those participants remaining in the study differed significantly from those who did not. The results from subsequent analyses, including inverse probability weighting based on these factors, did not differ significantly from those from the unweighted analyses presented here, suggesting that our results were not substantially affected by selection bias related to loss to follow-up.

**RESULTS**

At the 21-year follow-up, 3,176 young adults provided information about frequency of cannabis use. About half (50.9 percent) reported never having tried cannabis. Of the remainder, 37.2 percent had used cannabis occasionally, while 11.9 percent reported use of cannabis at least every few days during the month preceding the 21-year survey. According to mothers' self-reports, 9.7 percent had been smokers at child's age 5 but not at child's age 14 years, 3.1 percent had not smoked at child's age 5 but were smoking at child's age 14 years, and a further 24 percent of young adults had mothers who smoked at both points. In addition, 3.3 percent of mothers reportedly drank more than one glass of alcohol a day at child's age 5 but not at age 14 years, 7.2 percent did so at child's age 14 but not at child's age 5 years, and 3.5 percent of young adults had mothers who drank more than one glass of alcohol daily at both 5 and 14 years.

Table 1 shows univariate associations between young adults' frequency of cannabis use and self-reported maternal smoking and alcohol drinking (more than one glass per day) at child's age 5 and 14 years. Relative to children of persistent nonsmokers, those young adults whose mothers smoked at 5 years but not at 14 years were not at increased risk of cannabis use as young adults. In contrast, children of mothers who reported smoking at 14 years (but not at 5 years) were more likely to use cannabis at 21 years, with the effect being stronger for frequent use of cannabis. Risk of frequent use of cannabis for children whose mothers smoked at both 5 and 14 years was similar to the risk for those children whose mothers

reported smoking at 14 years only. [Table 1](#) also shows that children of mothers who drank more than one glass of alcohol per day at both 5 and 14 years had an increased risk of cannabis use in early adulthood, with the stronger association being for frequent use of cannabis. The magnitude of the association with frequent cannabis use for individuals whose mothers reported drinking daily at child's age 14 (but not 5) years was somewhat weaker.

We conducted a series of multivariate regression analyses to examine the contribution of a number of potentially confounding covariates in predicting young adults' cannabis use. In interpreting the results of these multinomial regression analyses, within each stratum of outcome the reference category is defined by never use of cannabis and the lowest level of the chief independent variables of interest. Model 1 indicated that, compared with findings for the unadjusted analyses, maternal smoking is associated with young adults' cannabis use, independent of maternal drinking. However, the associations for maternal drinking were substantially attenuated after we controlled for maternal smoking. Further adjustment for sociodemographic factors (model 2) measured early in the child's life and for maternal mental health and maternal use of illicit drugs (model 3) measured at 5 years did not lead to attenuation of the associations between maternal smoking and cannabis use in their offspring but continued to weaken the apparent association between maternal drinking at both 5 and 14 years and young adults' cannabis toward the null.

[Table 3](#) shows the associations between maternal smoking and drinking and young adults' use of cannabis, accounting for the hypothesized mediating effects of adolescent externalizing behavior, and adolescent smoking and alcohol consumption. Adjustment for adolescent externalizing behavior attenuated some of the association for maternal smoking at 14 years or 5 and 14 years but not maternal drinking (model 4). Additional control for adolescent smoking (model 5) slightly decreased the magnitude of associations between maternal smoking and drinking and frequent use of cannabis at 21 years. Specifically, the relation between maternal smoking at child's age 14 years and young adults' use of cannabis was no longer significant after adjusting for adolescents' use of tobacco. In contrast, the association of maternal smoking at both 5 and 14 years with young adults' cannabis use remained significant. Inclusion of adolescent alcohol consumption in the model (model 6) did not substantially alter the associations. None of the associations between maternal drinking and young adults' use of cannabis remained obviously significant in the fully adjusted model.

## DISCUSSION

The results of this study suggest that maternal smoking during early adolescence of a child increases the risk of cannabis use by that child during early adulthood, regardless of maternal smoking at child's age 5 years. This association was stronger for frequent use of cannabis. Individuals whose mothers smoked at 5 (but not 14) years were not at greater risk of cannabis use in early adulthood. The analyses show that the association between maternal smoking and young adults' cannabis use is moderately attenuated by a selected group of confounding variables. Our data further suggest that at least part of the association between maternal smoking and cannabis use is explained by externalizing behavior and early initiation to smoking by the child at 14 years.



Our data also indicate that maternal drinking predicts young adults' cannabis use to some extent. However, the association was weaker or nonsignificant when we accounted for the predictive contribution of maternal smoking and a range of other covariates. We also found that adolescent externalizing behavior and early smoking and alcohol consumption do not appear to mediate the association between maternal drinking and young adults' cannabis use.

The finding that maternal smoking predicts later use of cannabis by children is consistent with previous studies indicating that children of parents who smoke tobacco are more likely to smoke in adolescence or early adulthood ([8–13](#), [17](#)). Our data also support studies suggesting that parental substance use (other than alcohol) predicts development of illicit drug use in children ([11](#), [13](#)). However, to our knowledge, no previous study has specifically investigated the association of maternal smoking and alcohol consumption with use of cannabis in children, independent of possible confounding factors such as parental use of illicit drugs. Furthermore, except for one previous paper ([9](#)), this is the only study known to investigate the apparent impact of timing and persistence of maternal smoking and drinking.

Conceivably, the associations we found might be due to genetic factors shared by mother and child ([25–28](#)), but studies of twins do not provide consistent support for such a hypothesis ([29](#)). Our study did not have the capacity to examine genetic factors. In any case, our data provide little support for a genetic trait underlying cannabis use, since the relation with cannabis use in offspring was stronger for maternal smoking at child's age 14 than at child's age 5 years. This finding seems to provide greater support for a social learning and/or environmental explanation rather than a genetic effect. Our multivariate model showed that the apparent association for maternal smoking is not due to the potential confounding factors relating to the family environment for which we had data. A second possibility is that young adults' cannabis use is a direct or indirect consequence of maternal substance use. The current results accord with the various social theories that suggest children of substance users would be likely to begin using substances themselves perhaps because of modeling by parents.

Our analyses indicate that the association between maternal smoking and cannabis use in the offspring is partly explained by the child's externalizing behavior and smoking at age 14 years. This finding in part supports the known theory of a "gateway" effect, which postulates that children move from experimenting with and using legal substances, such as tobacco, to experimenting with illegal but readily available substances such as cannabis. Our results point to an extension of the gateway theory to include a "transgenerational gateway" effect. This pathway begins with early exposure to parental tobacco use and alcohol consumption and leads first to the child's experimentation with "legal" substances before continuing to early and more regular use of cannabis.

Alternatively, it may be that parental substance use is a proxy measure for parenting and supervision style, which increases the adolescent's contact with drug-using peers ([11](#)) or that exposure to parental substance use directly increases the child's frequency of contact with friends who use substances ([12](#)). We did not have data to test these hypotheses.

## Limitations

Although the study used comprehensive health and psychosocial assessments at each time period, we were unable to consider a number of potentially important factors, such as genetic predisposition, paternal mental health, and paternal and sibling smoking and alcohol consumption. In addition, the Mater-University of Queensland Study of Pregnancy does not allow examination of influences such as parental monitoring and supervision styles and peer group modeling during the interval between the 14- and 21-year follow-ups. Studies with the capacity to assess both parental disciplining style and peer influences in conjunction with family structure should attempt to ascertain whether these family and environmental factors influence the associations we have demonstrated.

Second, we relied on self-reports of maternal substance use and young adults' cannabis use. There is a possibility that mothers or children underreport their substance use. Moreover, we did not have data on maternal alcohol consumption and smoking between 5 and 14 years. Ideally, we would need measures collected at short, regular intervals because both alcohol consumption and smoking may change. In addition, the Mater-University of Queensland Study of Pregnancy has not collected data on paternal smoking and alcohol consumption. In a sensitivity analysis, we addressed this limitation. Using maternal report about partner smoking at 14 years, we tested the association between paternal smoking and young adults' cannabis use. This analysis indicated an effect similar to the one we found for maternal smoking at 14 years. Indeed, findings of other studies do not suggest different effects for parents ([10](#)).

Another limitation is the sizable reduction in the sample between the 5- and 21-year surveys. Of the 4,549 subjects for whom we collected information related to maternal smoking and alcohol consumption at the 5- and 14-year follow-ups, only 69.8 percent completed the 21-year questionnaire as young adults. Dropout in the study may influence our results in two different ways. If the association between maternal substance use and cannabis use among those lost to follow-up was higher than in the study group, our findings would underestimate the true association. The threat to the validity of our findings if the association we observed is not evident or is in the opposite direction among those lost to follow-up is much more limited. Given the likely causal pathways and the positive association reported by other authors, overestimating the relation is unlikely. In any case, as described in the Materials and Methods section, we used inverse probability weighting and found that selective attrition is unlikely to have had any material impact on our results.

## Conclusion and implication

This prospective study suggests that maternal smoking in early adolescence predicts increased cannabis use by young adults, regardless of maternal smoking in early childhood. The complex association of parental and adolescent substance use and externalizing behavior suggests the need for comprehensive family treatment ([30](#)), which may have to start before children begin smoking or using cannabis.

## ACKNOWLEDGEMENTS

The core study was funded by the National Health and Medical Research Council of Australia.

The authors thank the Mater-University of Queensland Study of Pregnancy data collection team and Greg Shuttlewood, University of Queensland, who helped to manage the data for the Mater-University of Queensland Study of Pregnancy. They also thank Rosemary Aird and her colleagues for phase 7 data collection.

Conflict of interest: none declared.

## REFERENCES

1. Hall W, Pacula RL. Cannabis use and dependence: public health and public policy (2003) Cambridge, United Kingdom: Cambridge University Press.
2. Australian Institute of Health and Welfare. 2004 National Drug Strategy Household Survey: first results (2005) Canberra, Australia: AIHW. (Drug statistics series no. 13).
3. Ministerial Council on Drug Strategy. National Cannabis Strategy 2006–2009. (2006) Commonwealth of Australia.  
([http://www.dassa.sa.gov.au/webdata/resources/files/National\\_Cannabis\\_Strategy.pdf](http://www.dassa.sa.gov.au/webdata/resources/files/National_Cannabis_Strategy.pdf))
4. Bandura A. Social learning theory (1977) Englewood Cliffs, NJ: Prentice Hall.
5. Bandura A. Social foundations of thought and action: a social cognitive theory (1986) Englewood Cliffs, NJ: Prentice-Hall.
6. Hirschi T. Causes of delinquency (1969) Berkeley, CA: University of California Press.
7. Kumpfer KL, Olds DL, Alexander JF, et al. Family aetiology of youth problems. Drug abuse prevention through family interventions—Ashery RS, Robertson EB, Kumpfer KL, eds. (1998) Rockville, MD: US Department of Health and Human Services, National Institute on Drug Abuse, National Institute on Drug Abuse. (NIDA research monograph 177).
8. Chassin L, Presson CC, Sherman SJ, et al. Family history of smoking and young adult smoking behavior. *Psychol Addict Behav* (1994) 8:102–10.
9. O'Callaghan FV, O'Callaghan M, Najman JM, et al. Prediction of adolescent smoking from family and social risk factors at 5 years, and maternal smoking in pregnancy and at 5 and 14 years. *Addiction* (2006) 101:282–90.
10. Peterson AV, Leroux BG, Bricker J, et al. Nine-year prediction of adolescent smoking by number of smoking parents. *Addict Behav* (2006) 31:788–801.
11. Chassin L, Pillow DR, Curran PJ, et al. Relation of parental alcoholism to early adolescent substance use: a test of three mediating mechanisms. *J Abnorm Psychol* (1993) 102:3–19.

12. Flay BR, Hu FB, Siddiqui O, et al. Differential influence of parental smoking and friends' smoking on adolescent initiation and escalation and smoking. *J Health Soc Behav* (1994) 35:248–65.
13. Biederman J, Faraone SV, Monuteaux MC, et al. Patterns of alcohol and drug use in adolescents can be predicted by parental substance use disorders. *Pediatrics* (2000) 106:792–7.
14. Merikangas KR, Stolar M, Stevens DE, et al. Familial transmission of substance use disorders. *Arch Gen Psychiatry* (1998) 55:973–9.
15. Merikangas KR, Dierker LC, Szatmari P. Psychopathology among offspring of parents with substance abuse and/or anxiety disorders: a high-risk study. *J Child Psychol Psychiatry* (1998) 39:711–20.
16. Avenevoli S, Merikangas KR. Familial influences on adolescent smoking. *Addiction* (2003) 98(suppl 1):1–20.
17. Alati R, Najman JM, Kinner SA, et al. Early predictors of adult drinking: a birth cohort study. *Am J Epidemiol* (2005) 162:1098–107.
18. Najman JM, Bor W, O'Callaghan M, et al. Cohort profile: The Mater-University of Queensland Study of Pregnancy (MUSP). *Int J Epidemiol* (2005) 34:992–7.
19. Spanier GB. Measuring dyadic adjustment: new scales for assessing the quality of marriage and similar dyads. *J Marriage Fam* (1976) 38:15–28.
20. Bedford A, Foulds GA. *Delusions-Symptoms-States Inventory of anxiety and depression* (1978) Windsor, United Kingdom: National Foundation of Educational Research.
21. Achenbach TM. *Manual for the Youth Self-Report and 1991 profile* (1991) Burlington, VT: University of Vermont Department of Psychiatry.
22. Wiznitzer M, Verhulst FC, van den Brink W, et al. Detecting psychology in young adults: the young adult self-report, the General Health Questionnaire and Symptom Checklist as screening instruments. *Acta Psychiatr Scand* (1992) 86:81–4.
23. Baron RM, Kenny DA. The moderator-mediator variable distinction in social psychological research: conceptual, strategic, and statistical considerations. *J Pers Soc Psychol* (1986) 51:1173–82.
24. Hogan JW, Roy J, Korkontzelou C. Handling drop-out in longitudinal studies. *Stat Med* (2004) 23:1455–97.
25. Lynskey MT, Heath AC, Nelson EC, et al. Genetic and environmental contributions to cannabis dependence in a national young adult twin sample. *Psychol Med* (2002) 32:195–207.

26. de Souza CT, Diaz T, Sutmoller F, et al. The association of socioeconomic status and use of crack/cocaine with unprotected anal sex in a cohort of men who have sex with men in Rio de Janeiro, Brazil. *J Acquir Immune Defic Syndr* (2002) 29:95–100.
27. Degenhardt L, Hall W, Lynskey M. The relationship between cannabis use, depression and anxiety among Australian adults: findings from the National Survey of Mental Health and Well-Being. *Soc Psychiatry Psychiatr Epidemiol* (2001) 36:219–27.
28. Kendler KS, Karkowski LM, Corey LA, et al. Genetic and environmental risk factors in the aetiology of illicit drug initiation and subsequent misuse in women. *Br J Psychiatry* (1999) 175:351–6.
29. Heath AC, Cates R, Martin NG, et al. Genetic contribution to risk of smoking initiation: comparisons across birth cohorts and across cultures. *J Subst Abuse* (1993) 5:221–46.
30. Bor W. Prevention and treatment of childhood and adolescent aggression and antisocial behaviour: a selective review. *Aust N Z J Psychiatry* (2004) 38:373–80.