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Cannabis use and traffic accidents in a birth cohort of young adults

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Abstract

Objective: to examine linkages between cannabis use and traffic accident risks in a birth cohort of 907 young New Zealanders studied from 18 to 21 years. *Methods:* during the course of a 21-year longitudinal study of a birth cohort of 907 New Zealand born children information was gathered on (a) annual frequency of cannabis use over the period from 18 to 21 years; (b) annual rates of traffic accidents during the period 18–21 years; (c) measures of driver behaviours and characteristics. The association between cannabis use and traffic accident risk was examined among the 907 sample members who reported driving a motor vehicle between the ages of 18 and 21 years. *Results:* there were statistically significant relationships between reported annual cannabis use and annual accident rates. This association was present only for 'active' accidents in which driver behaviours contributed to the accident; those using cannabis more than 50 times per year had estimated rates of active accidents that were 1.6 (95% CI 1.2–2.0) times higher than the rate for non-users. However, statistical control for driver behaviours and characteristics related to cannabis use (drink driving behaviour; risky/illegal driving behaviours; driver attitudes; gender) eliminated the association between cannabis use and traffic accident risks. *Conclusions:* although cannabis use was associated with increased risks of traffic accidents among members of this birth cohort, these increased risks appear to reflect the characteristics of the young people who used cannabis rather than the effects of cannabis use on driver performance. © 2001 Elsevier Science Ltd. All rights reserved.

Keywords: Cannabis; Driving; Traffic accidents; Risk taking; Drink driving

1. Introduction

In a recent article, Strang et al. (2000) have commented on the re-emergence of debates about cannabis use and the need for further research to address key issues in this area. One of the issues they highlight concerns the linkages between cannabis and unsafe driving. In particular, they point to a growing concern over possible linkages between the use of cannabis and increased risks of motor vehicle accidents among young adults resulting from an increased prevalence of illicit drug use in this age group. They note that many drivers stopped by the police or being treated for injuries are found to test positive for cannabis (Soderstrom et al., 1995; Tomaszewski et al., 1996). In addition, there is clear evidence from controlled studies that cannabis produces driving impairment (Moskowitz, 1985; Robbe, 1994; Chesher, 1995). However, it is less clear whether cannabis use in the general population and under normal (uncontrolled) driving conditions is linked with increased traffic accident risk and even less clear, whether any such linkages reflect cause and effect relationships in which the use of cannabis leads to increased risks of motor vehicle accidents (Chesher, 1995; Strang et al., 2000). In particular, a major threat to the validity of causal inferences in this area comes from possible confounding factors that are (a) associated with increased risks of cannabis use; (b) contribute to risks of traffic accidents. For example, it may be suggested that any correlation between cannabis use and accident risk reflects the fact that both cannabis use and accidents are a reflection of underlying tendencies to risk taking behaviours (Chesher, 1995).

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In this paper we address these issues by reporting on the results of a longitudinal study of the linkages between cannabis use and risks of traffic accidents in a birth cohort of New Zealand children studied up to the age of 21 years. The principal aims of this analysis were (a) to document the extent to which cannabis use in young adulthood (18–21 years) was associated with increased risks of traffic accidents; (b) to examine whether any associations between cannabis use and accident risk could be explained by the effects of confounding factors that may have been associated with both the use of cannabis and increased risks of traffic accidents.

2. Method

The data described in this paper were gathered during the course of the Christchurch Health and Development Study (CHDS). In this project an unselected birth cohort of 1265 children born in Christchurch's (New Zealand) urban region during a 4-month period in mid-1977 has been studied at birth, 4 months, 1 year and annual intervals to age 16, 18 and 21 years, using information gathered from a combination of sources including parental interviews; child interview; psychometric testing; teacher report; medical, police and other records. At age 21, 1011 of the original 1265 cohort members were assessed. This sample represented 80% of the original cohort and 90% of the cohort members who were still alive and resident in New Zealand at age 21. The present analysis is based on the 907 sample members interviewed at age 21 who reported driving a motor vehicle during the period from age 18 to 21 years. The following measures were used in the analysis.

2.1. Cannabis use

At age 21, sample members were questioned concerning their use of cannabis over the period from 18 to 21 years (Fergusson and Horwood, 2000). Specifically, young people were asked to estimate the number of occasions on which they had used cannabis in each of the periods 18–19, 19–20 and 20–21 years. For analysis purposes, the reported frequency of cannabis use in each year was classified according to a four-point scale — never used cannabis; used cannabis on 1–10 occasions; used cannabis on 11–50 occasions; used cannabis on more than 50 occasions (while this scaling is somewhat arbitrary, experimentation with a range of alternative scalings all produced essentially identical conclusions to those reported here). The distribution of the frequency of cannabis use in each year can be seen from the sample numbers reported in Table 1.

In addition to the reported frequency of cannabis use, sample members were questioned using items from the Composite International Diagnostic Interview (World Health Organization, 1993) to assess DSM-IV (American Psychiatric Association, 1994) symptom criteria for cannabis abuse and cannabis dependence. On the basis of this questioning it was possible to classify sample members according to whether or not they met DSM-IV diagnostic criteria for cannabis abuse or dependence in each year from age 18 to 21 years. The proportion of sample members who met criteria for cannabis abuse/dependence in any year ranged from 12.3 to 13.1% over the 3-year period. In the present analysis, these diagnostic measures have been used to provide an assessment of the sensitivity of the conclusions drawn concerning the association between cannabis use and accident risk to alternative measures of cannabis involvement.

At age 21, information was also obtained from an informant (significant other) concerning the sample member's frequency of cannabis use. Informant data were available for 93.5% of the cohort. The informant was a person nominated by the subject, (typically a parent, friend or partner), who the subject felt would be able to provide an external perspective on the subject's behaviour and adjustment. On the basis of the significant other report data, sample members were classified into three groups reflecting the reported extent of cannabis use at age 21 — non users (60% of the sample); occasional users (34%); frequent users (6%). In the present analysis the significant other report data are used to address the possibility of bias introduced by the use of self report measures of both cannabis use and traffic accidents (see Supplementary Analyses).

2.2. Traffic accident involvement

As part of the assessment at age 21, sample members were questioned concerning their involvement in motor vehicle accidents over the period from 18 to 21 years (Horwood and Fergusson, 2000). Accidents were defined to include all incidents where a motor vehicle being driven by the subject was involved in a collision with another vehicle, object, person or animal or where the individual seriously lost control of the vehicle, irrespective of damage or injury. For each accident reported, the young person was asked to provide a detailed description of the incident including the nature of the accident; how the accident occurred; what damage or injury resulted from the accident; whether the young person had been drinking alcohol or using illicit drugs within 12 h of the accident and how much; whether the police became involved. Based on the subject's description of each incident, accidents were

classified as either 'active' or 'passive', using a procedure similar to that described by West (1993). Active accidents were defined to be those which resulted primarily from the subject's driving behaviours and for which the subject could be held responsible in law. Passive accidents were those which resulted primarily from other drivers' behaviours or from totally unexpected circumstances (e.g. animal ran in front of car). Ratings of accident type were made by two raters on the basis of the narrative material provided by subjects. There was better than 95% agreement between these raters in their assignment of incidents to active or passive accidents.

The 907 subjects reported a total of 624 accidents (477 active, 147 passive) over the 3-year period. Examination of the reported patterns of substance use prior to the accident showed that of the active accidents, in 41 cases (8.6%) the subject reported using alcohol but not cannabis; in 31 cases (6.5%) the subject reported using cannabis but not alcohol; and in 21 cases (4.4%) the subject reported using both cannabis and alcohol in the 12 h prior to the accident. The vast majority (85%) of accidents involving cannabis use occurred to regular, heavy users of cannabis who reported a frequency of use of at least twice per week on an average during the year in which the accident occurred. In at least half of the cases involving alcohol consumption, the reported level of alcohol consumed would have resulted in the subject's breath alcohol level being over the legal limit at the time of the accident. In only five cases (3.4%) did the subject report substance use prior to a passive accident (three involving alcohol only; one cannabis only; one both cannabis and alcohol).

Consideration was given to further classifying accidents according to whether the accident resulted in injury. However, of the 624 accidents reported, only 49 (7.9%) involved injury; one of these resulted in the death of a passenger and 16 involved hospitalisation of the subject or another party. These numbers were insufficient to enable detailed analysis of injury accident risk.

2.3. Driving related factors

To control for possible confounding of the association between cannabis use and accident rates by driving related factors such as driver experience, attitudes, and behaviours, the following measures were included in the analysis. These measures had been identified in a previous analysis as being significant predictors of accident rates (Horwood and Fergusson, 2000) and were also significantly correlated with cannabis use. It can be shown that a necessary condition for variables to act as confounders is that they are correlated with the exposure variable (cannabis use).

2.3.1. Drink driving behaviours

The extent of the young person's involvement in drink driving behaviour was assessed using a six-item scale in which the young person reported the frequency with which they had engaged in the following drink driving behaviours: driving a motor vehicle within 4 h of drinking alcohol; driving when drunk or over the legal alcohol limit; driving when seriously intoxicated; being stopped or arrested for driving while over the legal alcohol limit; continuing to drive after drinking alcohol despite previous arrest(s) for drink driving offences; driving after drinking alcohol even though friends or relatives tried to prevent this. The legal blood alcohol concentration for persons aged under 20 in New Zealand is 30 mg per 100 ml, and for persons aged 20 and over, 80 mg per 100 ml. Each item was scored on a six-point scale ranging from 0 = never to 5 = 21 + occasions. Subjects were asked to report the frequency of each behaviour in each of the 3 years 18–19, 19–20, 20–21, and the six items were summed to produce an overall measure of the extent of drink driving behaviour in each year. The resulting scale scores were of moderate reliability, with alpha coefficients ranging from 0.70 to 0.78. However, the correlations between the drink driving scores over time ranged between 0.69 and 0.84, suggesting substantial stability in reported drink driving behaviours over the 3-year period. For analysis purposes, the drink driving score for each year was classified into four class intervals ranging from those who did not report drink driving in a given year to those whose drink driving scores placed them in the most drink drive prone 5% of the cohort (Horwood and Fergusson, 2000).

2.3.2. Driver behaviours

The extent of the young person's involvement in risky or illegal driving behaviours (other than drink driving) in each year from age 18 to 21 was assessed, from reports made at age 21, using an instrument based on the violations subscale of the Driver Behaviour Questionnaire described by Reason et al. (1991), but modified to reflect New Zealand conditions. This instrument recorded the frequency with which young people reported committing a series of 12 driving violations including exceeding the speed limit by more than 20 km/h; driving without a seat belt; deliberately driving through red lights; street racing; driving without a licence; driving when the licence had been suspended; driving without a current vehicle registration; driving without a current vehicle warrant of fitness; changing lanes without signalling; overtaking without a clear view of the road ahead; overtaking illegally; and driving too close to other vehicles. Responses were graded on a four-point scale ranging from 0 = never to 3 = nearly every day. Subjects' responses were summed across the 12 items to produce a total driving behaviour score

reflecting the extent of involvement in risky or illegal driver behaviours in each of the 3 years. The reliabilities of these scales, assessed using coefficient alpha, ranged from 0.78 to 0.82. Reported driver behaviour scores were very stable over time, with across time correlations that ranged from 0.85 to 0.94.

2.3.3. Driver attitudes

Attitudes to driving practices were assessed at age 21 using the Attitudes to Driving Violations Scale (West and Hall, 1997). This scale rates the extent to which subjects agree with a series of seven items regarding traffic violations (e.g. decreasing the speed limit on motorways is a good idea, penalties for speeding should be more severe). Ratings were made on a five-point scale ranging from 1 = strongly agree to 5 = strongly disagree, and a total score was computed from a sum of the seven items. This score ranged from 7 to 34 with a high score indicating a laissez-faire attitude to driving violations. The reliability of the scale, assessed using coefficient alpha, was 0.60.

2.3.4. Driver experience

Subjects were questioned, at age 21, concerning the types of motor vehicle they drove and the length of time that they had held a licence to drive each type of vehicle. The number of years that the young person had held a driver's licence for any vehicle was used to provide an overall measure of driver experience. At age 21, the majority (55%) of drivers had held a licence for 3–5 years, 25% for 1–3 years and 20% for less than a year.

2.3.5. Annual distance driven

At age 21, subjects were questioned concerning the distances they had driven over the period from 18 to 21 years. This information was used to derive an estimate of the total distance driven in each year from age 18 to 21 years. Distances were graded on a six-point scale ranging from 1 = < 5000 to 6 = > 25 000 km per annum. The reported distributions of distance travelled were very similar over the 3-year period, with a median distance travelled in the region of 10 000 km per annum. However, the proportion of the sample reporting mileages in excess of 25 000 km per annum doubled from 8% at age 18–19 to 16% at age 20–21.

2.4. Social, family and individual factors

To control for possible confounding of the association between cannabis use and accident rates from sources other than driving related factors, a range of measures of social, family and individual characteristics were available from the data base of the study. These confounding factors were identified from a previous analysis (Horwood and Fergusson, 2000) of risk factors associated with traffic accidents in this cohort and included:

1. Measures of socio-demographic characteristics including maternal age at the birth of the subject; maternal education (no qualifications/high school qualifications/tertiary qualifications); family socioeconomic status assessed using the Elley and Irving (1976) scale of occupational status for New Zealand; family type (single parent/two parent).
2. Measures of family functioning including parental change and conflict; parental history of alcohol problems or criminality; parental illicit substance use; parental use of physical punishment (Fergusson and Lynskey, 1997; Fergusson et al., 1992).
3. Measures of individual characteristics including gender; child IQ assessed using the Wechsler Intelligence Scale for Children WISC-R, (Wechsler, 1974) at the age of 8 years; novelty seeking assessed using the Tridimensional Personality Questionnaire (Cloninger, 1987) administered at the age of 16 years; measures of conduct and attentional problems based on the Rutter et al. (1970), Conners (1969, 1970) parental and teacher behaviour rating scales, assessed at annual intervals from the point of school entry to adolescence (Fergusson et al., 1991).
4. Measures of adolescent lifestyle including quantity and frequency of alcohol use at age 18; annual measures of the extent of alcohol abuse symptomatology over the period from 18 to 21 years, assessed using standardised DSM-IV (American Psychiatric Association, 1994) diagnostic criteria for alcohol abuse; measures of affiliations with delinquent or substance using peers over the period from age 14 to 18 years (Fergusson and Horwood, 1999).

2.5. Statistical analysis

Linkages between measures of cannabis use and accident rates were analysed using a general estimating equation (GEE) modelling approach (Zeger and Liang, 1986). The GEE approach enables the estimation of a range of linear models within a longitudinal framework. The approach also permits the use of differing distributional assumptions and differing assumptions about the across time correlations of model disturbances. In the present instance the general model fitted was:

$$\log(Y_{it}) = B_0 + B_1 X_{it} + \sum B_j Z_{ij} + E_{it}$$

where Y_{it} was the frequency of accidents reported by the ith subject at time t, X_{it} was the corresponding report of cannabis use by subject i at time t, Z_{ij} was a set of covariate factors (e.g. gender, driver experience, driver behaviour), and E_{it} was the disturbance or error term of the model. The model disturbance was assumed to have a Poisson distribution and the fitted model

assumed an unstructured correlation matrix between the disturbance terms (E_{it}) across time. Model fitting was conducted using STATA 6.0 (StataCorp, 1999). The regression parameters from the fitted GEE models have the interpretation of the predicted effect of a one unit change in the predictor variable on the log transformed accident rate over time. However, a more useful statistic is the rate ratio. This may be interpreted as the relative increase in the annual accident rate for a one-unit increase in the predictor variable, when all other predictors in the model have been taken into account (the rate ratio may be estimated by raising the base of natural logarithms (e) to the power of the parameter of interest).

To take account of missing data due to sample attrition, the methods described by Carlin et al. (1999) were used. These methods involved a two-stage analysis process. In the first stage of the analysis, a sample selection model was constructed by using data gathered at birth to predict participation. The model fitted was:

$$\text{logit}(O_{it}) = B_0 + \sum B_j X_{ij}$$

where logit(O_{it}) was the log odds that the ith subject would have been observed at time t and X_{ij} was a set of variables describing this subject at the initial (birth) interview. These measures included maternal age; maternal education; maternal smoking during pregnancy; ethnicity, family socio-economic status and family type (one-parent- or two-parent family). On the basis of the fitted regression model, the sample was post-stratified into a series of groups and the probability of study participation estimated for each group. The observations for each individual were then weighted by the inverse of this probability in the fitted regression models.

3. Results

3.1. Frequency of cannabis use and accident risk

Table 1 shows the relationships between self reported frequency of cannabis use at ages 18–19, 19–20, 20–21 years and corresponding rates of traffic accidents. In this table, the frequency of cannabis use has been classified into four class intervals that range from those who reported no cannabis use in a given year, to those who reported using cannabis on more than 50 occasions. As explained in Section 2, accidents were classified as active (accidents which resulted from the subject's driving behaviours) and passive (accidents that resulted from other drivers' behaviours). The table also includes an overall summary analysis, which shows rates of accidents over the period from 18 to 21 years, assessed on the basis of person years exposure to the cannabis use categories. The table shows that, at all ages, there was a general tendency for increasing frequency of cannabis use to be associated with corresponding increases in the rate of active traffic accidents. The person year analysis suggests that, on an average, young people who reported using cannabis on more than 50 occasions in a year had rates of active traffic accidents that were 1.9 times the rate of accidents of those who did not use cannabis. However, rates of passive accidents appeared to be generally unrelated to the frequency of cannabis use.

To represent the results in Table 1, GEE models were fitted to the data (see Section 2). The models assumed that the accident outcome measures had a Poisson distribution and modelled the log of the accident rate in each year as a linear function of the individual's reported frequency of cannabis use in that year. To take account of variations in exposure to risk resulting from variation in distance travelled and driver experience the analysis also included measures of the estimated distance driven by the respondent during each year and duration of time for which the individual had held a driving licence. The results of this analysis are reported in Table 2 which shows estimates of the model parameters, standard errors and tests of statistical significance for the cannabis use variable for each accident outcome (active; passive). The table gives the parameters for the fitted models prior to and following statistical control for the measures of driver experience. This table shows:

Table 1
Rate of active and passive traffic accidents (per 100 individuals per annum) by annual frequency of cannabis use

Age (years)	Frequency of cannabis use			
	Never	1–10 Times	11–50 Times	51+ Times
18–19 (N)	(452)	(229)	(70)	(156)
Active accidents	13.1	15.7	21.4	32.1
Passive accidents	5.3	4.8	5.7	7.7
19–20 (N)	(441)	(224)	(88)	(154)
Active accidents	13.6	16.1	12.5	23.4
Passive accidents	4.3	4.5	5.7	6.5
20–21 (N)	(469)	(199)	(93)	(146)
Active accidents	18.1	13.1	21.5	29.5
Passive accidents	6.0	8.0	4.3	2.7
Overall (N)[a]	(1362)	(652)	(251)	(456)
Active accidents	15.0	15.0	18.3	28.7
Passive accidents	5.2	5.7	5.2	5.7

[a] Number of person years at risk.

Table 2
Effects of cannabis use on rates of traffic accidents before and after adjustment for distance travelled and driver experience

Measure	Parameter	S.E.	P	Rate ratio (95% CI)
Active accidents				
Effect of cannabis alone	0.158	0.041	<0.001	1.17 (1.08–1.27)
Effect of cannabis adjusted for distance travelled and driver experience	0.145	0.041	<0.001	1.16 (1.07–1.25)
Passive accidents				
Effect of cannabis alone	0.030	0.067	>0.60	1.03 (0.90–1.17)
Effect of cannabis adjusted for distance travelled and driver experience	0.003	0.066	>0.90	1.00 (0.88–1.14)

1. The frequency of cannabis use was significantly ($P < 0.001$) related to rates of active traffic accidents both prior to and following control for measures of driver experience. The strength of this association is given by the rate ratio estimate which shows the proportionate increase in the rate of active traffic accidents for a one unit change in the frequency of cannabis use (when this measure was scored in the classes shown in Table 1). The adjusted rate ratio of 1.16 implies that those who used cannabis on more than 50 occasions in a given year had rates of active traffic accidents that were $1.16^3 = 1.6$ (95% CI 1.2–2.0) times higher than those who did not use cannabis in that year.
2. In contrast, the analysis suggested that cannabis use was not significantly ($P > 0.60$) related to rates of passive traffic accidents either before or after control for measures of driver experience.

3.2. Adjustment for confounding factors

Although the results in Table 2 suggest a clear and significant association between cannabis use and rates of active accidents, as noted earlier, it is possible that this association reflects the presence of confounding factors that were (a) related to cannabis use; (b) associated with increased risks of traffic accidents. Exploration of a large number of potentially confounding factors (see Section 2) revealed that, apart from the measures of driver experience, only four factors (gender, drink driving behaviour, risky/illegal driving behaviour, driver attitudes) were significant confounders. On an average, cannabis users were more likely to be male, were more likely to engage in drink driving and other risky/illegal driving behaviours, and were likely to have more laissez-faire attitudes to driving violations, and these factors in turn were associated with increased risks of traffic accidents. In particular, the most important source of confounding appeared to arise from the associations between cannabis use and driver behaviour; the measures of cannabis use were correlated in the region of 0.37–0.42 with measures of risky/illegal driving behaviour and driver behaviour in turn was the strongest predictor of accident rates.

Table 3 shows the results of a regression model for active accident rates incorporating the significant confounding factors. The model also includes the measures of driver experience as previously said. The table shows that after control for confounding factors, the association between cannabis use and accident rates became very small and non-significant. The adjusted rate ratio (0.97) is very close to 1, suggesting that, for all practical intents and purposes, the frequency of cannabis use was unrelated to active accident risk when other factors were taken into account.

3.3. Supplementary analyses

To examine whether the above conclusions were altered by changes in model specification the following additional analyses were conducted.

3.3.1. Tests of interaction

To examine whether the main effects model in Table 3 provided an adequate account of the data, this model was extended to include tests of interaction between gender and all risk factors, time of measurement and all risk factors, and between the frequency of cannabis use and other driver characteristics. No significant interactions were found, suggesting that the results held equally for males and females, for different ages, and that the effects of cannabis use on accident rates did not vary with driver behaviour or experience.

3.3.2. Measures of cannabis abuse/dependence

To examine whether the conclusions were robust to alternative measures of cannabis involvement, the data were reanalyzed using DSM-IV diagnostic measures of cannabis abuse/dependence in each year. These analyses produced essentially the same conclusions to the analysis of cannabis use. Specifically, there was a significant bivariate association between cannabis abuse/dependence and active accident risk (rate ratio = 1.6; 95% CI 1.2–2.0; $P < 0.001$). However, after adjustment for confounding factors and in particular, measures of risky/illegal driving behaviour, the association became small and non-significant (rate ratio = 1.04; 95% CI 0.7–1.3; $P > 0.75$). Similarly, there was no detectable

association between cannabis abuse/dependence and rates of passive traffic accidents.

3.3.3. Analysis of informant report data

A limitation of the preceding analyses is that they are based on self report data and results may reflect the presence of biases or correlated reporting errors in these self reports. To examine this issue, the data were re-analysed using (a) data on cannabis use provided by an informant (see Section 2); (b) self reported traffic accidents. This approach has the advantage of measuring the exposure variable (cannabis use) in a way that is independent of the assessment of the outcome (traffic accidents). In general, the findings from the analysis of informant/self report data produced results that were consistent with the findings reported earlier:

1. Those who were described by an informant as frequent users of cannabis had rates of active traffic accidents that were 1.6 times (95% CI 1.2–2.2; $P < 0.001$) higher than non-users. However, there was no significant association between informant reported cannabis use and rates of passive traffic accidents ($P > 0.25$).
2. Control for confounding factors (driver experience, gender, driver behaviour, driver attitudes) reduced the association between informant reported cannabis use and self reported active accidents to the point of statistical non-significance. After adjustment for confounders, those reported to be frequent users of cannabis had rates of active accidents that were 1.03 times (95% CI 0.75–1.40; $P > 0.80$) higher than non-users.

4. Discussion

In this study we have used longitudinally gathered data to examine linkages between reports of cannabis use and traffic accidents. This analysis leads to two major conclusions. First, it was clear that reports of increasing cannabis use were related to increasing rates of active (but not passive) traffic accidents. The GEE analysis suggested that young people who reported using cannabis on more than 50 occasions per annum had rates of active traffic accidents that were 1.6 times higher than those of non users. Second, most (if not all) of the elevated risk found among cannabis users was not due to their cannabis use, but to other risk taking behaviours that were associated with cannabis use. As a group, cannabis users were more prone to engage in drink driving and other risky/illegal driving behaviours; and to have attitudes that were more favourable to driving violations. The regression analysis suggest that it was these behaviours, and in particular the extent of involvement in risky/illegal driving behaviour, rather than the use of cannabis that accounted for their increased risk of active traffic accidents.

These results support the view that much, if not all, of the increased traffic accident risks found among cannabis users may be due to characteristics of people who use cannabis rather than the effects of cannabis on driver behaviour (Chesher, 1995). This conclusion is also generally consistent with the findings of previous research which has concluded that the effects of cannabis on driver risk are likely to be small, and certainly far smaller than the effects of alcohol on driver performance (Robbe, 1994; Chesher, 1995). However, an alternative explanation of the findings is that cannabis use is linked to accident risk by a causal chain model in which (a) cannabis use encourages unsafe driving practices and attitudes; (b) unsafe driving attitudes and practices lead to increased accident risk.

Although the present study has a number of methodological advantages including the use of a large and representative sample studied from adolescence into young adulthood, it also has some limitations that should be recognised. These limitations centre around the fact that the data on cannabis and traffic accidents have been gathered on the basis of self report. The use of self report data clearly raises issues about the reliability and validity of reports. It is unlikely that self reports of cannabis use and accident rates will be perfectly accurate and there is also the possibility of

Table 3
Fitted regression model of active accident rate on frequency of cannabis use and confounding factors

Measure	Parameter	S.E.	P	Rate ratio (95% CI)
Cannabis use	−0.032	0.045	>0.40	0.97 (0.89–1.06)
Drink driving behaviour	0.139	0.052	<0.01	1.15 (1.04–1.27)
Driver behaviour	0.054	0.010	<0.0001	1.06 (1.03–1.08)
Attitudes to driving violations	0.052	0.015	<0.001	1.05 (1.02–1.08)
Male gender	0.318	0.116	<0.01	1.38 (1.09–1.72)
Annual distance travelled	0.046	0.027	<0.10	1.05 (0.99–1.10)
Driver experience	−0.074	0.032	<0.05	0.93 (0.87–0.99)
Constant	−3.139	0.335	<0.0001	–

differential under reporting in which heavy cannabis users tend to under report their traffic accident history more frequently than other individuals. Such differential under reporting would introduce a downward bias into estimates of the association between cannabis use and accident risk. However, in defence of this methodology three points may be made. First, self report data are the only practical means by which information about cannabis use and traffic accidents can be gathered on a large and representative sample of the population. Second, the findings generally support the internal validity of the study to the extent that they show that while reported cannabis use was related to active traffic accidents in which the driver's behaviour contributed to the outcome, it was not related to passive traffic accidents in which the driver's behaviour did not contribute to the accident. This specificity of association clearly supports the view that the results reflect an association between cannabis and traffic accidents rather than measurement error or reporting bias. Finally, we have been able to replicate these findings using a study design in which the assessment of the use of cannabis was derived from an informant report, whereas the assessment of traffic accidents was based on self report. This study design produced very similar conclusions to the analysis of self report data. The fact that 'informant/self' and 'self/self' analyses produce similar conclusions, while not overcoming all concerns about reporting accuracy, tends to support the validity of the conclusions drawn.

Finally, although the findings show that for this cohort, cannabis use was not related to traffic accidents, after control for driver related factors, these findings do not show that, in general, cannabis use does not increase traffic accident risk. In particular, it is possible that these risks are increased only for those who use cannabis heavily and/or just prior to driving. It may be that this group was not represented in the present study in sufficient frequency for the effects of cannabis use on traffic accidents to be detected. Despite these limitations, the results are consistent with the view that much of the elevated traffic accident risk found amongst cannabis users is likely to be more due to the characteristics of those who use cannabis than to the effects of cannabis use on driver performance.

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