



Is driving under the influence of cannabis becoming a greater risk to driver safety than drink driving? Findings from a longitudinal study

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ABSTRACT

The present study examined the associations driving under the influence of (a) cannabis and (b) alcohol, and motor vehicle collisions during, in a longitudinal study of a New Zealand birth cohort ($n=936$). Participants reported significantly ($p<.0001$) greater rates of driving under the influence of cannabis than driving under the influence of alcohol during ages 21–25. Also, there were statistically significant bivariate associations between increasing levels of both: (a) driving under the influence of cannabis and (b) self-reported driving under the influence of alcohol, and increased risks of active motor vehicle collisions ($p<.0001$). These associations were adjusted for potentially confounding factors including average distance driven and self-reported risky driving behaviours. After adjustment, the associations between driving under the influence of cannabis and motor vehicle collisions remained marginally significant ($p=.064$), whereas adjustment for confounding factors reduced the association between driving under the influence of alcohol and motor vehicle collisions to statistical non-significance ($p>.70$). The results of the present study suggest that, for some populations, the risks of driving under the influence of cannabis may now be greater than the risks of driving under the influence of alcohol.

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1. Introduction

In recent years, there have been reports of an increasing use of cannabis by young people in many societies (Rey et al., 2002; von Sydow et al., 2001). In turn, these findings have led to a growing number of investigations into the health and other effects of cannabis (Hall and Pacula, 2003; Hall, 2006). One aspect of this concern has focussed on the extent to which cannabis may have adverse effects on driving behaviours and lead to increased risks of motor vehicle collisions and subsequent injury (Chesher, 1995; O'Kane et al., 2002; Ramaekers et al., 2004). However, the evidence on the extent to which cannabis may have adverse effects on driver behaviour has been somewhat mixed. While a number of laboratory studies have found that cannabis intoxication may lead to impairment of cognitive abilities and motor skills employed in driving (Menetrey et al., 2005; Papafotiou et al., 2005; Ramaekers et al., 2006; Rizzo et al., 2005), epidemiological evidence has been less consistent, with some studies reporting links between cannabis use and increased risks of motor vehicle collisions (Asbridge et al., 2005; Bedard et al., 2007; Drummer et al., 2004;

Laumon et al., 2005), whereas others have failed to find persistent associations between cannabis intoxication and motor vehicle collisions (Blows et al., 2005; Fergusson and Horwood, 2001a; Johnson et al., 1995; Lowenstein and Koziol-McLain, 2001; Movig et al., 2004; Smink et al., 2005).

Although the evidence on the role of cannabis use in motor vehicle collisions and injury remains contentious, it has been widely assumed that cannabis use plays a smaller role in these outcomes than drink-driving behaviours (National Traffic Safety Administration, 1999; Sexton et al., 2002). This has led to many societies investing in drink-driving legislation and awareness campaigns, whereas relatively little attention has been paid to the issue of driving under the influence of cannabis. One of the consequences of such policies may be to reduce the rates of drink-driving behaviour in the community, while placing no such sanctions on driving under the influence of cannabis. Such conditions could produce a complex set of conditions in which drink-driving makes a declining contribution to rates of motor vehicle collision, while cannabis use may make an increasing contribution as a result of an increasing use of cannabis by young people.

In this paper we use data gathered over the course of a 25-year longitudinal study to compare rates and consequences of driving under the influence of (i) cannabis and (ii) alcohol, in a cohort of New Zealand-born young people studied to the age of 25. The specific aims of the study were

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- (a) to assess self-reported rates of driving under the influence of (i) cannabis and (ii) alcohol;
- (b) to examine the statistical linkages between driving under the influence of each substance, and self-reported motor vehicle collisions;
- (c) to adjust associations between driving under the influence of cannabis or alcohol and collisions for confounding factors, including driving distance and self-reported risky driving behaviours.

2. Methods

The data were gathered during the course of the Christchurch Health and Development Study (CHDS). In this study, a birth cohort of 1265 children (635 males, 630 females) born in the Christchurch (New Zealand) urban region in mid-1977 has been studied at birth, 4 months, 1 year and annually to age 16 years, and again at ages 18, 21 and 25 years (Fergusson and Horwood, 2001b; Fergusson et al., 1989). The analyses were based on the 936 (460 males, 476 females) study participants who reported driving an automobile during the period 21–25 years (out of 1003 study participants assessed at age 25; 74% of the original sample, and 93% of the portion of the sample assessed at age 25). All study information was collected on the basis of signed and informed consent from study participants.

2.1. Driving under the influence of cannabis and alcohol, ages 21–25

At age 25, participants were questioned about the number of occasions on which they had driven under the influence of (a) cannabis and (b) alcohol, during each year from ages 21 to 25. Participants were asked to estimate the number of times they had driven "... a vehicle when you were under the influence of cannabis", and the number of times they had driven "... a vehicle while drunk or over the limit", during each year from ages 21 to 25 years. The precise definition of "under the influence" was left to the determination of the individual participant. Under New Zealand law, the blood alcohol content limit is 80 mg per 100 ml (30 mg per 100 ml for those aged <20 years). Driving under the influence of cannabis is illegal in New Zealand.

2.2. Active motor vehicle collision involvement, ages 21–25

As part of the assessment at age 25, sample members were questioned as to their involvement in motor vehicle collisions during the period 21–25 years. Collisions were defined to include all incidents where a motor vehicle being driven by the respondent 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 collision reported, respondents were asked to provide a detailed description of the incident. Based on the participant's description of each incident, collisions were classified as either "active" or "passive" using a procedure similar to that described by West (West, 1993). Active collisions were defined to be those which resulted primarily from the driving behaviours of the respondent and for which the respondent could be held responsible in law. Passive collisions were those which resulted primarily from other drivers' behaviours or from totally unexpected circumstances (e.g. an animal ran in front of the car). Ratings of collision type were made by three raters on the basis of the narrative material provided by respondents. There was better than 95% agreement between these raters in their assignment of incidents to active or passive collisions. For the purposes of the present study, the analyses were limited to active motor vehicle collisions only. Of the

cohort, 7.9% reported at least one active motor vehicle collision during the period 21–25 years, with a total of 325 active motor vehicle collisions reported. Of these collisions, 27 (8.3%) were reported to have resulted in injury to at least one individual. Only two collisions (one active, one passive) were reported to have involved the death of an individual.

2.3. Covariate factors

A wide range of covariate factors were considered for inclusion as covariates in the analyses, based on: (a) their correlation with driving under the influence of either cannabis or alcohol at ages 21–25 and (b) previous research on the present cohort suggesting that the factors were related to driving under the influence of cannabis or alcohol, and motor vehicle collisions. These factors included:

2.3.1. Driving-related factors

2.3.1.1. Risky driving behaviours. The extent of the young person's involvement in risky or illegal driving behaviours (other than drink driving) in each year from ages 21 to 25 was assessed, from reports made at age 25, 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 kph; 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. Participants' 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 4 years. The reliabilities of these scales, assessed using coefficient alpha, ranged from .78 to .82. Reported driver behaviour scores were very stable over time, with across time correlations that ranged from .85 to .94.

2.3.1.2. Annual distance driven. At age 25, respondents were questioned concerning the distances they had driven over the period from 21 to 25 years. This information was used to derive an estimate of the total distance driven in each year from age 21 to 25 years. Distances were graded on a 6-point scale ranging from 1 = <5000 km to 6 = >25,000 km per annum. The reported distributions of distance travelled were very similar over the 4-year period, with a median distance travelled in the region of 10,000 km per annum.

2.3.1.3. Driver attitudes. Attitudes to driving practices were assessed at age 25 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 5-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 α , was .60.

2.3.1.4. Driver experience. Participants were questioned, at age 25, 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. In New Zealand, driving licences may be obtained from age 15 years. 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 25, the majority (52%) of drivers had held a licence for 9–10 years, 25% for 7–8 years and 5% for less than 2 years.

2.3.2. Personal and background factors

2.3.2.1. Gender. Recorded at birth.

2.3.2.2. *Anti-social personality disorder, ages 21–25.* At ages 21 and 25, participants were interviewed using custom-written survey items to assess DSM-IV (American Psychiatric Association, 1994) diagnostic criteria for anti-social personality disorder. For the purposes of the present analysis, sample members who met diagnostic criteria for anti-social personality disorder at either 21 or 25 years were classified as having the disorder (5.2% of the sample).

2.3.2.3. *Childhood conduct problems, ages 7–9.* Conduct problems were assessed at age 7–9 years using a scale that combined items from the Rutter (Rutter et al., 1970) and Conners (Conners, 1969, 1970) child behaviour rating scales. Separate ratings were obtained from the child's parent and class teacher. Parent and teacher ratings were summed for each year and then averaged over the interval from 7 to 9 years to provide a robust measure of the child's tendencies to conduct problems. The reliability of the resulting scale, assessed using coefficient α was .97.

2.3.2.4. *Leaving school without qualifications.* Sample members who had never attained secondary school qualifications by age 21, either while they were at high school or subsequently as adult students, were classified as having no high school qualifications: 18.1% of the sample had failed to attain any high school qualifications.

2.3.2.5. *Deviant peer affiliations, ages 21–25.* At ages 21 and 25, participants were questioned using a series of custom-written items concerning the extent to which their friends used tobacco, alcohol or illicit drugs, had problems associated with substance use, or engaged in criminal behaviour or had problems with the law.

These items were summed to provide a scale measure of the extent of affiliation with delinquent or substance-using peers at each age. For the purposes of the present analyses, the resulting scale scores were averaged to provide a measure of the extent of deviant peer affiliations over the period 21–25 years.

2.4. Statistical analyses

The annual rates of driving under the influence of (a) cannabis and (b) alcohol were compared over the period 21–25 years using a paired *t*-test.

Linkages between the reported annual frequencies of (a) driving under the influence of cannabis and (b) driving under the influence of alcohol, and rates of active motor vehicle collisions were analysed using a Generalised Estimating Equation (GEE) modelling approach (Zeger and Liang, 1986) with Poisson regression. The GEE approach enables the estimation of a range of models, including Poisson regression, within a longitudinal repeated measures framework.

To adjust the associations between driving under the influence of cannabis and alcohol and active motor vehicle collisions for confounding factors, the model specified above was extended to include terms for the frequency of driving under the influence of both cannabis and alcohol, and terms corresponding to the confounding factors described above. The confounding factors were entered into the model using forwards and backwards methods of variable selection and elimination in order to produce stable models with statistically significant confounding factors. The models fitted were of the form:

$$\log(Y_{it}) = B_0 + B_1X_{1it} + B_2X_{2it} + \sum B_jZ_{ijt} + E_{it} \quad (2)$$

where Y_{it} was the frequency of active motor vehicle collisions reported by the i th subject in a given annual interval t , X_{1it} and X_{2it} were the corresponding reports of driving under the influence of cannabis and driving under the influence of alcohol, respectively, by participant i in interval t , Z_{ijt} were a set of covariate factors (e.g. driver behaviour, average distance driven), and E_{it} was the disturbance or error term of the model. The error terms E_{it} were assumed to be correlated with an unstructured correlation matrix. A diagrammatic representation of the fitted model can be found in Fig. 1.

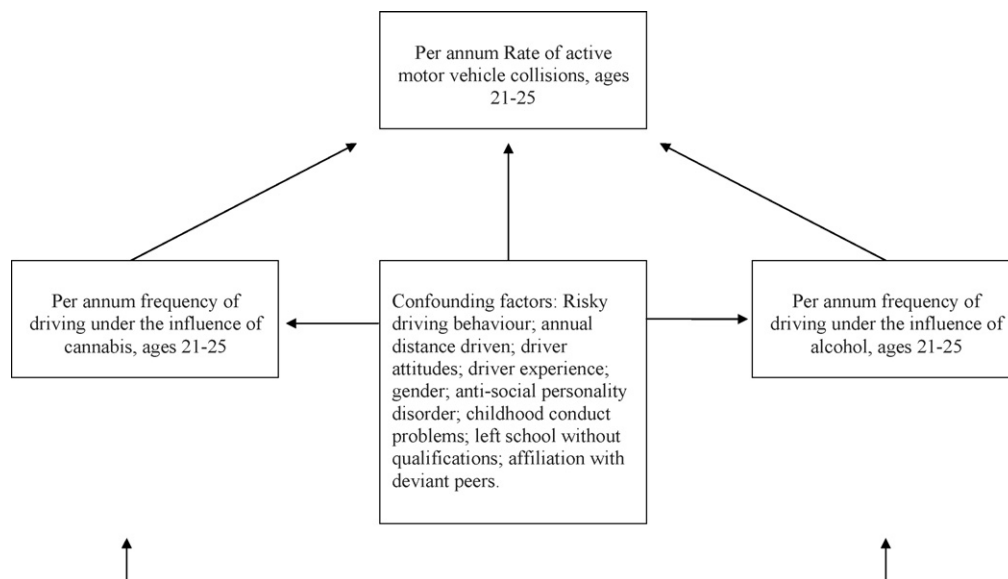


Fig. 1. Model of the associations between driving under the influence of cannabis, driving under the influence of alcohol, and rates of motor vehicle collisions, ages 21–25.

Table 1
Per annum rates of driving under the influence of (a) cannabis and (b) alcohol, ages 21–25

| Substance | Per annum frequency of driving under the influence | | | | Mean (S.D.) ^a number of occasions, ages 21–25 |
|------------------------|--|------------|-------------|-----------|--|
| | Never | 1–10 times | 11–20 times | 21+ times | |
| Cannabis % of sample | 79.0 | 10.8 | 4.9 | 5.2 | 8.96 (22.22) |
| Average N ^b | 740 | 101 | 46 | 49 | |
| Alcohol % of sample | 72.8 | 25.2 | 1.5 | 0.5 | 3.52 (10.61) |
| Average N ^b | 681 | 236 | 14 | 5 | |

^a Test of significance; paired *t*-test, $t = 8.03$, $p < .0001$.

^b Sample sizes quoted represent the average number of participants reporting a given frequency of driving under the influence in each year over the 4-year observation period from 21 to 25 years.

Model fitting was conducted using STATA 8.0 (StataCorp., 2003). Estimates of the unadjusted incidence rate ratios (IRRs; calculated by e^b , where b is the regression parameter for cannabis or alcohol) corresponding to the observed collision rate data for varying frequencies of driving under the influence of cannabis or alcohol were calculated from Poisson regression models in which the frequency of driving under the influence of cannabis or alcohol was treated as a categorical variable. The adjusted IRRs were calculated from the fitted model parameters for the frequency of driving under the influence of cannabis or alcohol derived from the GEE covariate-adjusted model described above. In addition, covariate-adjusted rates of active motor vehicle collisions were computed using methods described by Lee (1981).

3. Results

3.1. Per annum rates of driving under the influence of cannabis and alcohol

Table 1 shows the per annum rates of self-reported driving under the influence of cannabis and alcohol, averaged over the period ages 21–25. The table shows that while a similar proportion of the cohort reported driving under the influence of cannabis (21%) or alcohol (27.2%) per year, the frequency of driving under the influence of cannabis was far higher; overall, cohort members reported driving

under the influence of cannabis on an average of 8.96 times over the 4-year study period, compared to 3.52 times for driving under the influence of alcohol ($p < .0001$). These figures imply that, over the 4-year study period, driving under the influence of cannabis was over 2.5 times more frequent than driving under the influence of alcohol.

3.2. Associations between driving under the influence of cannabis/alcohol and motor vehicle collisions

Table 2 shows the associations between per annum rates of driving under the influence of cannabis and alcohol and rates of active motor vehicle collisions. These associations are described in two ways: (a) by the population-averaged rates of collisions per annum and (b) by the IRR and 95% CI. The table shows rates and IRRs both prior to, and following adjustment for confounders. The table shows:

1. Prior to adjustment for confounding factors, driving under the influence of cannabis and alcohol were both associated with increased rates of self-reported collisions. Those driving under the influence of cannabis on more than 20 occasions in a given year had rates of collisions that were 2.25 (95%CI: 1.65–3.07) times than for those who did not drive under the influence ($p < .0001$). Those who drove under the influence of alcohol on

Table 2
Per annum rates of motor vehicle collisions (ages 21–25), by frequency of driving under the influence of cannabis and alcohol, before and after adjustment for confounding factors ($n = 936$)

| | Per annum frequency of driving under the influence | | | | p^a |
|-------------------------------|--|-------------|-------------|-------------|--------|
| | Never | 1–10 times | 11–20 times | 21+ times | |
| Before adjustment | | | | | |
| Cannabis | | | | | |
| Rate (per 100) ^b | 7.7 | 10.3 | 11.0 | 17.4 | <.0001 |
| IRR (95% CI) | 1 | 1.33 | 1.43 | 2.25 | |
| | – | (0.88–2.00) | (0.73–2.79) | (1.65–3.07) | |
| Alcohol | | | | | |
| Rate (per 100) ^b | 7.5 | 12.5 | 15.2 | 15.8 | <.001 |
| IRR (95% CI) | 1 | 1.60 | 1.90 | 1.94 | |
| | – | (1.22–2.11) | (0.88–4.12) | (0.84–4.50) | |
| After adjustment ^c | | | | | |
| Cannabis | | | | | |
| Rate (per 100) | 8.1 | 9.2 | 10.2 | 11.4 | .064 |
| IRR (95% CI) | 1 | 1.12 | 1.25 | 1.40 | |
| | – | (0.99–1.26) | (0.98–1.58) | (0.98–1.98) | |
| Alcohol | | | | | |
| Rate (per 100) | 8.6 | 8.9 | 9.1 | 9.4 | .764 |
| IRR (95% CI) | 1 | 1.03 | 1.06 | 1.09 | |
| | – | (0.85–1.25) | (0.72–1.55) | (0.62–1.93) | |

^a Wald χ^2 .

^b The rate provided is the population-averaged per annum rate of motor vehicle collisions (see Section 2).

^c Adjusted for: driving under the influence of alcohol/cannabis; annual distance driven; self-reported risky driving behaviours.

more than 20 occasions had rates of collisions that were 1.94 (95%CI: 0.84–4.50) times higher than for those who did not drive under the influence of alcohol.

- Following adjustment for the two confounding factors that remained statistically significant after forward and backward selection of covariates to arrive at a stable model (annual distance driven; self-reported risky driving behaviours), the associations between driving under the influence of cannabis and alcohol and active motor vehicle collisions were substantially reduced. For cannabis, the association was reduced to marginal significance ($p = .064$), and the adjusted IRR shows that those using cannabis on more than 20 occasions in a given year had rates of collisions that were 1.40 times higher than for those who did not drive under the influence of cannabis. For alcohol, the association became statistically non-significant after adjustment ($p = .76$), although the adjusted estimates suggested a small trend for increasing frequency of driving under the influence of alcohol to be associated with increased rates of collision.

4. Discussion

In this analysis, we have used data gathered over the course of a longitudinal study to examine the risks posed by driving under the influence of cannabis and alcohol for a cohort of young adults studied from ages 21 to 25. This research produces the surprising conclusion that, for this cohort, driving under the influence of cannabis posed a greater risk to driver and vehicle safety than drink driving. Two lines of evidence supported this conclusion.

First, there were marked differences in the frequency with which respondents reported driving under the influence of cannabis and alcohol, with rates of driving under the influence of cannabis being 2.5 times higher than rates of driving under the influence of alcohol (8.96 versus 3.52). These findings clearly suggest that, in terms of exposure, driving under the influence of cannabis was far more common.

Second, analysis of rates of self-reported “active” motor vehicle collisions showed that, following control for covariate factors, driving under the influence of cannabis was marginally associated with increased rates of collision, whereas driving under the influence of alcohol was not. Thus, on the grounds of both the frequency of driving under the influence, and the consequences of such driving, cannabis proved to be a greater threat to driver safety for this cohort than alcohol.

These conclusions may appear to be paradoxical in the light of the generally accepted conclusion that alcohol use poses a far greater threat to driver safety than cannabis use (National Traffic Safety Administration, 1999; Sexton et al., 2002). However, the apparent conflict may be explained in the following way. In recent years, there have been two social trends that have probably acted to (a) reduce the risks posed by driving under the influence of alcohol and (b) increase the risks posed by driving under the influence of cannabis. In terms of the first trend, increasingly stringent road rules and enforcement have made drink driving an activity that may lead to quite severe legal sanctions (Clayton, 1997). These legal features have been reinforced by growing public disapproval and approbation for drink driving (Anderson and Ingram, 2000). Parallel to these trends, there has been a growth in the use of cannabis (Rey et al., 2002; von Sydow et al., 2001), and an increase in the general potency of cannabis (ElSohly et al., 2000; Licata et al., 2005). This increase in cannabis use has not been accompanied by the same level of public concern about the effects of driving under the influence of cannabis, as the case has been for driving under the influence of alcohol. In addition, without an effective means to conduct roadside drug-driving testing (Terry and Wright, 2005),

there is very little legal deterrent to driving under the influence of cannabis. The evidence from this research suggests that the net effects of these trends may have been to create a situation in which the risks of driving under the influence of alcohol have been declining, whereas the risks of driving under the influence of cannabis have been increasing. The comparisons made in this analysis suggest that, for this cohort, these trends have reached a point where the risks posed by driving under the influence of cannabis exceeded the risk of driving under the influence of alcohol.

These conclusions are, of course, subject to a number of important caveats. First, the findings describe the conditions that applied to a specific cohort studied in a specific social context. The extent to which these findings apply to other cohorts and contexts remains to be examined. Second, the analyses were based on self-report, raising the following issues: (a) the true but non-observed rates of driving under the influence and collisions may differ from the rates reported by cohort members; (b) driving under the influence of cannabis and alcohol were self-reported, and no information was available concerning blood levels of alcohol and THC; (c) specific collisions were not linked to specific instances of intoxication. Third, the collisions reported in this analysis were largely relatively minor, and for the most part did not involve injury. This raises important issues concerning the extent to which the findings of this study generalise to more severe collisions involving injury and death. Fourth, it is possible that there may have been factors that increased the risk of collisions in those reporting driving under the influence of cannabis and alcohol, but that were not measured or accounted for in the present investigation. Fifth, it was not possible to differentiate the extent to which participants may have driven under the influence of both cannabis and alcohol at the same time, which may have influenced the outcome of the study. Finally, the fact that rates of cannabis use are highest amongst young adults (Substance Abuse and Mental Health Services Administration, 2002) would suggest that the results of the present study may be specific to that age group.

Within the limitations imposed by these caveats, the results of the present study may suggest that the increasing use of cannabis, coupled with declining rates of drink-driving behaviours, may be producing a situation in which the risks of driving under the influence of cannabis are becoming greater than the risks of driving under the influence of alcohol. In turn, this conclusion raises complex questions about the need to regulate driving under the influence of cannabis, and the mechanisms by which this end may be achieved.

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