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A longitudinal investigation of psychological and social predictors of traffic convictions among young New Zealand drivers

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Abstract

The study aimed to determine, irrespective of driver licence status, whether young drivers with traffic conviction records at age 21 years differed from those without, with respect to prior personal characteristics measured around the minimum age of licensure (presently 15 years in New Zealand). From a broad range of psychological and social factors, the strongest and most stable predictors were male gender, part time work, rural residence, marijuana use, estimated driving exposure during the follow up period, and early motorcycle riding. Experiences of riding as a passenger with young drivers or with an alcohol intoxicated adult driver were also significant predictors. Some road safety implications are considered.

Keywords: Driver behaviour; Traffic violations; Health-risk behaviour

1. Introduction

1.1. Background

It is debatable as to what proportion of the social cost of motor vehicle traffic crashes is attributable to vehicle factors, driver error, and the physical road environment (Adams, 1985, pp. 8–10). In New Zealand, it has been estimated that 85% of social costs incurred in reported injury crashes are attributable to driver error, alone (Land Transport Safety Authority, 1995a). It is

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considered that driver behaviour plays the dominant role in traffic safety and that behavioural change currently offers the best opportunity for injury reduction (Evans, 1996). That young drivers, in particular, are at elevated risk of traffic crash involvement was the rationale for the introduction of the Graduated Driver Licensing System (GDLS) in New Zealand (New Zealand Government, 1987). The GDLS was promoted as a means whereby practical driving skills may be progressively enhanced and monitored while exposure to specific hazards, for example, nighttime driving, is restricted (Ministry of Transport, 1985).

Both a pattern of prior psychological and social characteristics (Beirness & Simpson, 1991), and a history of violating traffic regulations (Forsyth, Maycock & Sexton, 1995) have been identified as predictive of young drivers' crash involvement. These findings may indicate the existence of similar underlying patterns of factors that place the individuals concerned at elevated risk (Jessor, 1987a,b). Since officially recorded traffic crashes are relatively rare events, traffic convictions may provide a more sensitive and appropriate outcome for the study of 'poor driving' (Levonian, 1969), particularly among a cohort of limited size. Known biases in violation data, however, need to be taken into consideration. Official records contain information on the number of times that an individual is convicted of an illegal act, not the number of times that an individual commits that act. Variation in the level and pattern of enforcement can affect who is likely to be detected and prosecuted. For example, police may target those whom they consider most likely to commit offenses or concentrate enforcement efforts on areas where problem driving is considered more likely to occur (Crettenden & Drummond, 1994).

Data on exposure to driving are required, preferably including information about both the quality and quantity of exposure. Follow up should be for a time period sufficient to represent a driver's true traffic violation potential. While measures of driver characteristics concurrent with offending are of interest for the design and presentation of appropriate remedial interventions, prior measures are valuable for early identification. If the receipt of traffic convictions can be predicted, it may be possible to target early remedial interventions as part of the licensure and driver training processes. In such a way, the frequency of traffic convictions and the risk of involvement in traffic crashes may be reduced among young drivers, which, in turn, may reduce lifetime levels of risk.

1.2. Study aims and hypotheses

The primary aim was to determine whether young drivers who acquired a record of traffic convictions differed from those who did not with respect to prior personal characteristics and lifestyle. The research focus was on a broad range of factors within a multivariable context, given that this most closely approximates real life. The immediate objective was to construct a multivariable model that fitted the data well, was 'parsimonious' (Kleinbaum, Kupper & Muller, 1988, p. 317) (i.e. included a relatively small number of the more promising predictors), and reliable for the purposes of prediction (McCullagh & Nelder, 1983). The goal is to assist the design and implementation of appropriate and effective injury prevention interventions targeted at drivers early in their driving careers.

Problem-behaviour Theory (Jessor, Donovan & Costa, 1991; Jessor & Jessor, 1977) helped guide the selection of potential explanatory variables, but it should be noted that the measures used were obtained for other purposes as part of the Dunedin Multidisciplinary Health and

Development Study (DMHDS), and their retrospective selection was opportunistic. Data were not available to test models that require, for example, specific measures of behavioural intentions, perceptions of disapproval by significant others, and perceived behavioural control (Parker, Manstead & Stradling, 1995; Parker, Manstead, Stradling & Reason, 1992). Nevertheless, few studies have access to the broad range of demographic, social, psychological, and driving behaviour data available for the DMHDS (Silva & McCann, 1996). An earlier study found that conduct disorder and Attention Deficit Hyperactivity Disorder (ADHD) symptomatology were positively associated with having a traffic violation record by the age of 18 years (Nada-Raja et al., 1997). The present study focused on a broader range of factors, measured at or prior to the minimum age of licensure (15 years), as potential predictors of the receipt of traffic convictions between the ages of 16 and 21 years, irrespective of driver licence status. Gender and estimated exposure to driving during the follow up period were considered potential confounding factors.

It was hypothesised that, while taking into account gender and driving exposure, young drivers who reported driving related risk factors would be significantly more likely to acquire a traffic conviction record than those who did not. Being able to drive at an early age (e.g. 13 years) was considered a risk factor, given the likelihood of learning inappropriate behaviours prior to the legal minimum age of licensure (Reeder, Chalmers & Langley, 1996). Motorcycle riding was identified, given evidence that motorcyclists have worse traffic conviction records than car drivers (Hampton, 1970; Harano & Peck, 1968). The presence of early role models for inappropriate driving behaviour (e.g. riding as passenger with an intoxicated driver) was viewed as likely to provide negative observational learning experience and reinforce any tendency towards a risky lifestyle. A lack of personal support for the GDLS was considered a plausible risk factor for non-compliance with driving regulations. Finally, a perceived low risk of apprehension for illegal driving behaviours was viewed as a plausible risk factor.

Given that factors relatively distant from driving may be related to driving behaviour (Simpson & Beirness, 1992), it was hypothesised that young drivers with a history of adverse personal characteristics would be significantly more likely to acquire a traffic conviction record than those either lacking or showing less evidence of these characteristics. Since involvement in one health risk behaviour may predict involvement in other similar behaviours (Jessor, 1987a), increased risk was associated with either the presence of health–compromising behaviours (e.g. fighting, cigarette smoking), or the absence of health-promoting behaviour (participation in physical activity)—putting aside any increased risk of injury. The presence of adverse social environment factors was also hypothesised to increase risk. Increased risk of traffic offenses among young men has been associated with living in a situation other than with both parents (Shope, Waller & Lang, 1996). There is also evidence that traffic convictions are more frequent for novice drivers in the higher than the middle and lower socioeconomic groups (Forsyth et al., 1995). The population density of residential location was considered because rural residents are at greater risk of, for example, alcohol impaired driving (Bailey, 1995). Maternal (the questionnaire for parents of the cohort was almost entirely completed by mothers) opinions of the GDLS were considered relevant to the receipt of traffic convictions. Mothers may be sources of disapproval for problem behaviour (Jessor & Jessor, 1974) and risky transportation behaviour, for example, motorcycle riding (Reeder et al., 1996). Increased risk was hypothesised as likely to be associated with a number of other psychosocial factors, including a lack of involvement in conventional society (e.g. in school activities) (Donovan, Jessor & Costa, 1991), poor social skills (McGee & Williams, 1991),

symptoms of psychopathology, for example, depression (Holinger, 1981), and fatalistic attitudes towards health. A strong internal health locus of control tends to predict whether an individual is likely to adopt preventive health care measures (McLean & Pietroni, 1990). Finally, poor reading skill was included since it is associated with a range of negative outcomes (Williams & McGee, 1993), and tests based on written materials represent part of the driver licensure testing process.

2. Method

2.1. The study cohort

The participants in this study were members of a birth cohort enrolled in the DMHDS, a longitudinal study of health, development, attitudes, and behaviour. The method of selection and the composition of this cohort are described elsewhere (Silva & McCann, 1996). In summary, cohort members were drawn from children born at Queen Mary Hospital, Dunedin's only obstetric hospital, between April 1 1972 and March 31 1973. The cohort included all children whose mothers had resided in the Dunedin Metropolitan area and who were known to be still resident in the province of Otago when the children were 3 years of age. Of the 1139 children eligible at age 3 years, 1037 were followed up and assessed within a month of their third birthday. Thereafter, cohort members were followed up every 2 years until the age of 15 and then at ages 18 and 21 years. While the cohort is somewhat biased socioeconomically towards the advantaged and ethnically towards those of European descent, nevertheless, it contains the broad socio-economic spectrum (Reeder, Feehan, Chalmers & Silva, 1994).

By age 21 years, 17 cohort members had died (including six in motor vehicle traffic crashes), 10 could not be located, and 18 refused participation. Of the 992 followed up, consent for access to official driver licensing and traffic violation records was not available for 39, leaving a potential 953 records for analysis. From these 953, two further groups were excluded: those not resident in New Zealand throughout the follow-up period, and those for whom no self-report of either being able to drive or having driven a car/motorcycle was obtained during at least one of the assessments held at ages 15, 18 and 21 years. The remaining 840 drivers (391 females and 449 males) provided the basis for the present study.

2.2. Sources of information

A broad range of psychosocial data and data on driving opinions and behaviours were obtained from cohort members followed up at ages 13 and 15 years. Self-reported measures of exposure to driving were obtained at ages 18 and 21 years.

2.2.1. Psychological, social, and behavioural measures

Structured questionnaires were administered by trained staff to cohort members during confidential interviews conducted after written consent had been obtained. At age 13 years, consent was obtained from parents, at age 15 years it was obtained from parents and respondents, and at ages 18 and 21 years it was obtained from the respondents alone. Most interviews were conducted at the assessment Unit, though some were held elsewhere, for example, in residential institutions.

Demographic data and measures of parental opinions of the GDLS were obtained from responses to a parent questionnaire completed prior to interviews conducted with the cohort at age 15 years.

2.2.2. Traffic conviction records

Traffic conviction data were obtained with the assistance of authorised Land Transport Safety Authority (LTSA) staff. Motorcycling and car driving offenses are generally not distinguishable in historical records and, therefore, remain aggregated in the present study.

2.3. Measures and procedures

2.3.1. Driving related explanatory variables

At age 13 years, affirmative answers to the questions 'Can you drive a car?' (i.e. steering and controlling foot pedals) and 'Can you ride a motorcycle?' were taken as separate indicators of early driving. At that age, respondents were also asked about their perceptions of the risk of being apprehended for three illegal behaviours: driving a car while drunk, not using a seat belt, and driving a motorcycle without a driver's licence. At age 15 years, data were obtained on motorcycle riding, opinions about the GDLS restrictions on young drivers, and the experience of being a passenger with peers or adults who were driving while over the legal alcohol limit. At age 18 years, measures of estimated travel in kilometres during the past week were obtained from those who had driven a car or motorcycle. Similarly, at age 21 years, estimates of kilometres driven during an average week were obtained. Two driving exposure measures were created by summing the distances reported at ages 18 and 21 for each class of vehicle. Exposure groups were formed based on the tertiles of the two distributions. A fourth group included those who had not driven during the recall periods, but had driven at least once during the previous month.

2.3.2. Psychological and social explanatory variables

Potential explanatory variables not directly related to driving were classified into health-risk behaviour, family and background, and psychological and social domains. These divisions, broadly, reflect the conceptual structure of Problem-behaviour theory with, respectively, its grouping of social behaviour, antecedent–background, and social-psychological factors (Jessor & Jessor, 1977).

2.3.3. Health-risk behaviour

Six health compromising behaviours (four measures of substance use and two of violent or potentially violent behaviour) and one health promoting behaviour (participation in physical activity) were measured at age 15 years. For alcohol usage, cohort members were scaled according to a preconstructed variable representing the usual amount of alcohol consumed per drinking occasion, measured in millilitres (ml) of absolute alcohol (Casswell, Stewart, Connolly & Silva, 1991). Gender specific cutoffs were set at the upper quartiles of the distributions for females and males, as in a previous study (Reeder, Chalmers, Marshall & Langley, 1997). By this means the group with the highest usual consumption of alcohol was defined and identified as sufficiently large for analytical purposes. From the available smoking data (Stanton, Silva & Oei, 1991), a high risk group was formed for those who reported daily smoking, a moderate risk group from those who reported smoking during the month prior to interview, while the reference group

consisted of those who had not smoked during that month (Reeder et al., 1997). Other measures of substance use (marijuana and substance sniffing), along with measures of potentially violent (weapon carrying) or violent behaviour (fighting in a public place) were obtained from a delinquency questionnaire (Moffitt & Silva, 1988). In each case, the criterion for risk was any involvement during the year prior to interview. Total participation time in physical activity was measured with a version of the Minnesota Leisure Time Physical Activity Questionnaire (Taylor et al., 1978), modified as reported elsewhere (Reeder, Stanton, Langley & Chalmers, 1991). A cutoff was set at the lower quartile of the distribution in order to identify those at greatest risk from the potentially negative health consequences of a lack of exercise (Reeder et al., 1997).

2.3.4. Family and background

Eight measures were obtained from parent responses to a questionnaire completed prior to the interview of cohort members at age 15 years. The groups considered to be at greatest risk for six measures followed precedent (Stanton, McGee & Silva, 1989). These measures of risk were large family size (four or more children), low family socioeconomic status (level 5 or 6) (Elley & Irving, 1976; Irving & Elley, 1977), any separation from parents for 3 months or more during the previous 2 years, being raised by a single parent, poor maternal mental health (McGee, Williams, Kashani & Silva, 1983), and poor family social support (a score of 14 or less on the Family Relationship Index (FRI) (Holahan & Moos, 1983)). In addition, a measure of risk in residential location was defined as residence in a low population density area—overall, 85% of this group resided in centres with populations of less than 10,000 persons (McGee, Stanton & Feehan, 1991). Maternal opinions about the GDLS provisions for greater supervision and control of young drivers were scored according to the degree of 'caution' about teenage driving (Reeder et al., 1997).

2.3.5. Psychological and social measures

Of seven measures obtained during a mental health interview, six were used to assess the extent of personal involvement in society and one to assess perceptions of personal 'strengths' or competencies in life skills. Each measure was originally a component of a social competence index (SCI) (McGee & Williams, 1991). For the present study, each component was treated as a separate explanatory variable: (i) participation in clubs, sports, hobbies, and other leisure activities, (ii) involvement in part time work, (iii) involvement in school activities, (iv) social support and personal coping resources, (v) attachment to parents, (vi) attachment to peers, and (vii) perceived personal strengths. With the exception of involvement in part time work, which was dichotomous, each component was scored as having either low, medium, or high levels, and a low level was taken to indicate greatest risk (McGee & Williams, 1991).

Two other groups of measures were used. First, total symptom scores were obtained for three broad dimensions of psychopathology (anxiety, depression, and attention deficit disorder) (McGee et al., 1990). With respect to a fourth dimension, conduct disorder, several components (fighting, carrying a weapon, marijuana and alcohol use) were included in the health-risk behaviour domain. The remaining subcategory, 'oppositional disorder', was, therefore, the only dimension included in the present domain. For consistency with other measures, the nearest available cutoff point above the 75th percentile was used and those scoring at or above this level were deemed to be at increased risk.

Second, general beliefs about the extent of internal and external control that an individual exercises over their own health were measured by the Multidimensional Health Locus of Control (MHLC) Scale (Wallston, Wallston & De Villis, 1978), modified as described elsewhere (Stanton, Nada-Raja & Langley, 1995). Scores on the three subscales: the 'Chance' (C Scale), 'Internal' (I Scale), and the 'Powerful Others' (P scale) were obtained. The cut-off point established for the P and C scales was as close as possible to the 75th percentile of the distributions and those scoring above this level were considered at increased risk (Reeder et al., 1997). Similarly, a cutoff point as close as possible to the 25th percentile in the distribution was established for the I-scale and those scoring below this level were considered at risk.

Finally, reading skill was assessed by the Burt Word Reading Test (BURT) (Scottish Council for Research in Education, 1974), as adapted for use in New Zealand (Gilmore, Croft & Reid, 1981). Three groups were formed based on very low, below average, and average/above average scores. Very low scores were those at or below the mean for an 11-year-old according to national norms, below average scores were those above that norm, but below the means found for females and males in the cohort at age 15 years, and average/above average scores were those at or above the respective means (Reeder et al., 1997).

2.3.6. Outcome: traffic convictions

The outcome measure for the study was the number of traffic convictions in the official record. In New Zealand, penalties are imposed for driving and other traffic violations prosecuted under the Transport Act 1962 (New Zealand Government, 1962), its amendments and attendant regulations. Breaches of other transport laws are dealt with under a system whereby road users may pay an infringement fee within a certain time period in order to avoid court proceedings.

Three classes of traffic violation records can be linked to individual road users. First, a traffic conviction history is a summary of offenses for which a Traffic Offence Notice (TON) has been issued. These are the more serious offenses which must be heard before a court, and for which a conviction has been obtained. Included in this class of offenses are all alcohol related traffic convictions—not just those that have involved blood/breath levels of alcohol above the permitted limits or that have resulted in the injury or death of a third party. Second, a traffic offence history is a summary of those offenses for which an Infringement Offence Notice has been issued, but which have been dealt with through the court system. Such infringements do not, however, routinely involve an appearance in court unless the charge is contested and there is either a defended hearing or the imposed fine remains unpaid two months after the issue of the notice. Infringements only become convictions, and are only itemised as such on electronic personal records, if a court upholds the charge or the fine remains unpaid. The reason why a particular infringement has been dealt with through the courts cannot be determined from official records. Records of infringements are stored in an electronic file for a limited period, after which time they are purged from the system according to criteria that have more to do with resource allocation than offence type. Third, infringements that are processed administratively and which do not go to court are not itemised in official traffic violation records, but summarised as 'paid infringements only'.

Details such as offence types and dates for the less serious traffic violations are only recorded in the electronic database when they have been dealt with through the court system. With respect to speeding infringements, it should be noted that if the logged speed is 50 kph or more above the posted limit, a TON is issued and the case is dealt with by a District Court. The police also have

discretion with respect to speeding offenses in other circumstances that are judged to be dangerous. In such cases, police can issue a TON and charge drivers with a 'dangerous speeding' or a dangerous driving offence. Finally, records of breaking GDLS conditions are purged once a full licence is obtained, so it was not possible to access these records retrospectively for the cohort for the full follow up period.

Given the limitations with respect to other types of data, the study focused on the more serious traffic offenses for which a TON was issued, that were dealt with through the court system, and that resulted in a conviction. The major traffic offence categories used for the study were based on official classifications (Ministry of Transport, 1990).

2.3.7. Analytical procedures

The explanatory variables, based on measures obtained at age 13 or 15 years, were considered as plausible potential predictors of the outcome (the number of traffic convictions between the 16th and 21st birthdays), and examined using SAS version 6.10 (SAS Institute Inc., 1990) and multivariable poisson regression. Given the large number of these variables ($n=46$), it was considered inappropriate to enter them all into a single model, especially since they formed conceptually homogeneous 'domains' that could be screened in order to identify those most strongly associated with the outcome. A sequential model building procedure was adopted to simplify and structure the analysis, and facilitate the creation of a scientifically plausible model (Kleinbaum et al., 1988). The variables carried forward from each domain were those that were most important in a multivariable setting, i.e. better able in the presence of other variables within the same domain to account for variation in the number of traffic convictions.

First, domain specific analyses were run for groups of broadly similar variables, namely, (i) health-risk behaviour, (ii) family and background, (iii) social competence, (iv) other psychological and social measures, (v) factors proximal to driving at age 13 years, (vi) factors proximal to driving at age 15 years, and (vii) measures of estimated driving exposure (18–21 years). Second, the most promising explanatory variables within each of these domains (i.e. those that met a P-value criterion of $\leqslant 0.2$) were carried forward for entry into one of two inter-domain models: one for driving related factors, and one for factors more remote from the driving situation. In each case, gender was included as a potential explanatory variable. The 0.2 value is consistent with that 'more highly recommended' for the screening of potential explanatory variables than the more stringent $P \leqslant 0.05$, in order that potentially important variables are not prematurely excluded (Hosmer & Lemeshow, 1989, p. 108). Repeated Type 3 analyses were then performed, with the least significant variable being eliminated each time, until all variables remaining in each of the models met the criterion value of $P \leqslant 0.2$ (SAS Institute Inc., 1993, p. 35). Third, the variables remaining in the two inter-domain models were then combined and subjected to repeated Type 3 analyses, using the $P \leqslant 0.2$ criterion for retention in the modelling process, until the final regression model was obtained. Given the hypothesis that a dose response effect (i.e. a relationship of increasing strength with each increase in the level of the explanatory variable) would be observed for explanatory variables which had multiple levels, these were entered as ordinal variables. Reference cell coding, with the group deemed least at risk as the reference group (Hosmer & Lemeshow, 1989), was used for the calculation of point estimates as indicators of the extent of association (Rothman, 1986, p. 119).

Only those cohort members for whom full data for each of the explanatory variables and the outcome were available could be included in the regression modelling. This gave rise to the possibility that those excluded may have differed from those included with respect to the significant predictors of traffic convictions. In order to investigate this, cohort members included in the final analyses were compared with those who were not, with respect to all explanatory variables.

To evaluate the stability of the regression models, bootstrap procedures were applied at each model building stage, as described above, with the selection frequency criterion for inclusion being $\geq$40 out of 100 bootstrap models (Altman & Andersen, 1989). Backwards, stepwise logistic regression procedures were then applied using a *P*–value of 0.2 as the selection criterion, with the outcome transformed into a dichotomous variable. Logistic regression was used because an automated Type 3 analysis for Poisson regression was not available, and the two types of analyses are similar in nature. The final regression model was then evaluated by comparing the ranking of explanatory variables with their ranking in the bootstrap procedures according to the number of times out of 100 that they were selected.

The amount of variance accounted for by the final regression model was estimated using an R^2 measure based on the deviance residuals (Cameron & Windmeijer, 1996). Finally, a tree-based method based on logistic regression (Zhang & Bracken, 1995), was used to further explore the ability of the explanatory variables identified in the final regression model to discriminate between those with and those without traffic convictions. For this process, all covariates were converted to binary outcomes. The cohort was split into two subpopulations, based on the factor which most strongly distinguished between traffic conviction groups. A similar procedure was used to split each subpopulation, and this process was continued until the *P*–value set for node formation ($\leqslant 0.05$) was exceeded. The existence of statistically significant interactions at the 5% level was investigated for males and females, separately.

3. Results

Overall, 93 (11%) of the 840 cohort members included in the study had one or more TON convictions on their record: 54 had a single traffic conviction, 20 had two, eight had three, two had four, three had five, and six had six or more. Significantly fewer females (4%) than males (17%) had a conviction record ($\chi^2 = 36.19$; 1 d.f.; $P < 0.001$). This gender pattern was consistent across all offence classes with the exception of 'other noncompliance offenses' for which there was no significant gender difference. Only 1% of females, but 8% of males had two or more convictions and those with six or more were exclusively male.

The distribution of traffic convictions by major offence categories is presented in Table 1. All cases for which a level of blood/breath alcohol was recorded for an episode of offending were included in the drink driving category. The single speeding offence that resulted from the issue of a TON was included in the dangerous driving category.

Of the 46 variables considered in the study, 14 met the sequential modelling criteria and were carried forward into the final regression model. In Table 2, these variables are ranked according to the decreasing mean ratio (MR) and associated *P*-values obtained. The first ten ranked variables show a statistically significant ($P \leqslant 0.05$) relationship with the outcome. The number of times out

Table 1
Traffic convictions recorded for cohort members between the ages of 16 and 21 years by major offence classes

Offence class	Number of traffic convictions						Cohort members reporting
	1	2	3	4	⩾5	Total	($n=93$)
Drink driving	36	11	1	1	0	65	49
Dangerous driving	13	1	0	0	0	15	14
Careless driving	51	3	0	0	0	57	54
Driving while disqualified	8	4	1	0	3[a]	42	16
Other noncompliance	11	2	0	0	0	15	13
Total convictions						194	

[a] Two of these had five and one had 13 convictions.

Table 2
Explanatory variables in the final regression and bootstrap models

Rank	Explanatory variable (age assessed in parentheses)	Parameter estimate	Standard error	Mean Ratio	95% CI	*P*-value	Bootstrap (%) (rank)
1	Male gender	2.2292	0.4163	9.29	4.04–21.36	<0.001	100 (1)
2	No part time work (15)	−1.0910	0.2671	0.34	0.20–0.57	<0.001	96 (2)
3	Rural residence (15)	1.0953	0.3603	3.00	1.45–6.15	0.002	85 (4)
4	Low school attachment (15)	−0.4864	0.1748	0.61	0.43–0.87	0.005	56 (11)
5	Marijuana use (15)	0.7974	0.2876	2.22	1.25–3.95	0.006	89 (3)
6	M/c driving exposure (18–21)	0.7542	0.2726	2.13	1.23–3.67	0.006	71 (6)
7	M/c riding (13)	0.8359	0.3587	2.31	1.13–4.73	0.020	59 (9)
8	Poor social support (15)	−0.3468	0.1662	0.71	0.51–0.99	0.037	55 (12)
9	Riding with young drivers (15)	0.2636	0.1269	1.30	1.01–1.68	0.038	58 (10)
10	RWID (adult) (15)	0.3623	0.1806	1.44	1.00–2.06	0.045	70 (7)
11	Poor family relations (FRI) (15)	0.5282	0.2984	1.70	0.93–3.08	0.077	–[a]
12	Poor self-perceived strengths (15)	0.4584	0.2717	1.58	0.92–2.72	0.092	67 (8)
13	Non-use of seat-belt (13)	−0.2860	0.1732	0.75	0.53–1.06	0.097	71 (6)
14	High ADHD symptom score (15)	−0.4249	0.2982	0.65	0.36–1.19	0.154	–[a]
15	*Car driving (18–21)*	*Not selected for final regression model*					*81 (5)*

Note: All variables have 1 d.f.
[a] Not ranked, selected <40 times out of 100 bootstrap models.

of 100 that a variable was selected during the bootstrap procedures and the associated rankings are shown in the two right hand columns. The estimated R^2 for the final regression model was 44%. Gender interaction terms for each explanatory variable in this model did not reach significance at the $P \leqslant 0.05$ level, suggesting that the main effects were consistent for each gender.

The final regression model was based on the 504 (60%) of eligible cohort members for whom full data were available for each of the predictors and the outcome. A missing cases analysis was undertaken in order to determine whether, for each explanatory variable, the group for whom

Table 3
Missing cases analysis: variables for which cohort members included in final regression model differed significantly from those not included

Rank	Explanatory variable (age of assessment in parentheses)	Estimate	Standard error	Chi-square	*P*-value
1[a]	School attachment (15)	1.7923	0.1561	131.89	< 0.001
2	Parental opinions of GDLS (15)	0.9796	0.2014	23.67	< 0.001
3[a]	Residence (15)	0.7300	0.1621	20.28	< 0.001
4	Physical activity (15)	0.7102	0.1611	19.43	< 0.001
5	MHLC Chance (15)	0.7568	0.1729	19.17	< 0.001
6	MHLC Internal (15)	0.7568	0.1729	19.17	< 0.001
7	MHLC Powerful Others (15)	0.7568	0.1729	19.17	< 0.001
8	Low parental SES (15)	0.5853	0.1664	12.38	< 0.001
9[b]	Exposure to car driving (18–21)	0.6285	0.2014	9.74	0.002
10	Support for GDLS (15)	0.4993	0.1867	7.15	0.008
11[a]	Involvement in work (15)	0.6131	0.2610	5.52	0.019
12	Peer attachment (15)	−1.2092	0.5819	4.32	0.038

[a] Variable included in final regression model.
[b] Significant variable identified via bootstrap procedure.

there were missing data was significantly ($P \leqslant 0.05$) different from those for whom full data were available. The results of the missing cases analysis are presented in Table 3 with significant predictors ranked according to their level of significance.

Out of the 46 potential explanatory variables, only in the case of peer attachment did the missing cases group have a statistically significant lower mean number of total convictions, whereas for 11 other variables the missing cases had a statistically significant higher mean number of total convictions. Three of these variables appeared in the final model and a fourth, car driving exposure, 18–21 years, was identified in the bootstrap analysis.

A tree-based method involving logistic regression (Zhang & Bracken, 1995) was used to further explore the ability of the fourteen explanatory variables identified in the regression model to discriminate between those with traffic convictions and those without. The results are presented in Fig. 1. Inside each box is the number of those with traffic convictions (the first number) and the sample size of the node (the second number). The greatest difference, overall, occurred between females and males. Among females, the greatest difference was in motorcycle riding at age 13 years, which was reported by 8% of those with convictions but only 1% of those without. Among the remaining females, the greatest difference was in marijuana use, which was reported by 21% of those with convictions, but only 4% of those without convictions. Among males, the greatest difference was in marijuana use, which was reported by 37% of those with traffic convictions, but only 15% of those without. Among the remaining males, the greatest difference was in exposure to motorcycling between ages 18 and 21 years, which was reported by 27% of those with convictions but only 12% of those without. The numbers in the subpopulations do not sum to the population total because of missing data for some explanatory variables.

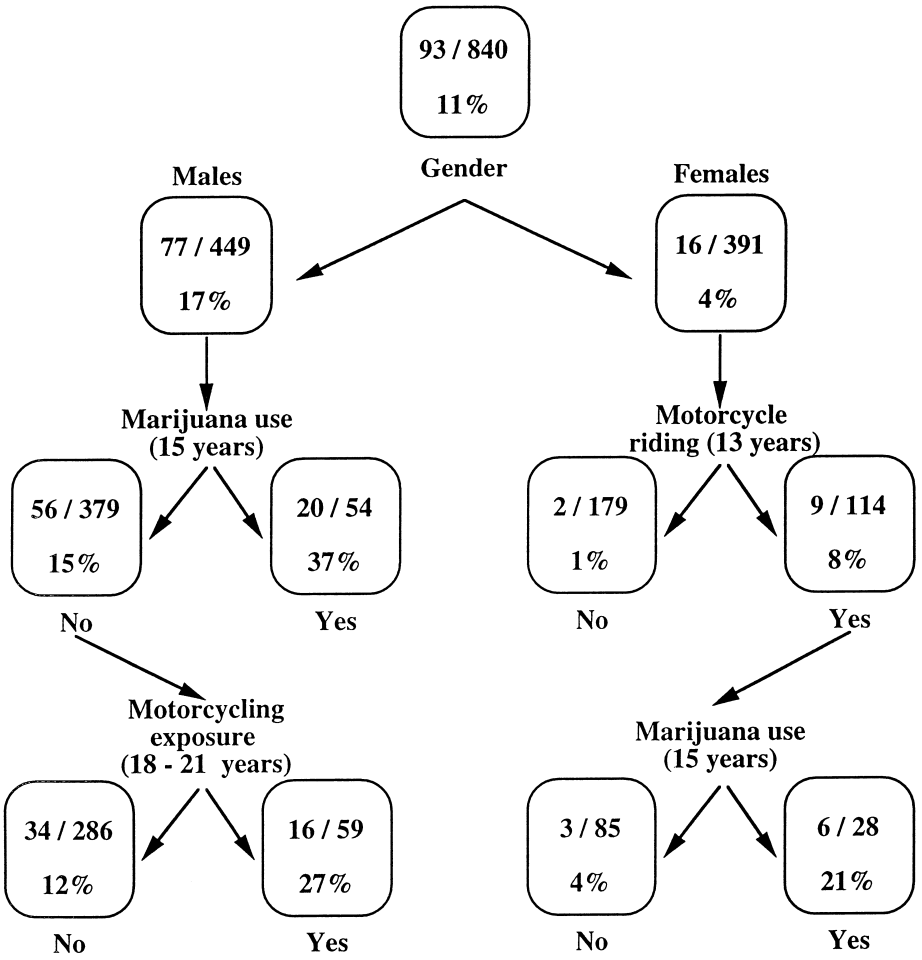

Fig. 1. Tree-based analysis of traffic convictions.

4. Discussion

4.1. Prediction of traffic convictions

The study demonstrated that traffic convictions between the ages of 16 and 21 years could be predicted from factors measured either prior to or around the minimum age for driver licensure in New Zealand (15 years). Overall, the final regression model accounted for 44% of the deviance residual in the number of traffic convictions. The bootstrap procedure confirmed the stability of many of the variables selected for inclusion in that model—five of the same variables were ranked among the top six selected by both procedures. The most important difference was the identification of car driving exposure during the follow up period as a significant predictor, in addition to motorcycling, whereas this highly plausible variable representing increased time at risk was

not selected for the final regression model. Another useful insight provided by the bootstrap procedure was the identification of some of the less stable components of the regression model, allowing attention to be focused on the stronger, most consistent predictors. Male gender was the strongest predictor, both in the regression model and the bootstrap procedures. That finding is consistent with other studies of young drivers (Farrow, 1985; Forsyth et al., 1995; Shope et al., 1996) and with New Zealand population data, where young males are prominent in both conviction and crash statistics (Land Transport Safety Authority, 1995b).

While taking into account the effects of gender and exposure to driving during the follow up period, two generic hypotheses were proposed in the study: that (a) factors relatively close to the driving situation, and (b) lifestyle factors relatively distant from the driving situation, would each provide significant predictors of traffic convictions. Both hypotheses received some support from the results.

4.2. Factors close to driving

The ability to ride a motorcycle at age 13 years was included in the final regression model, whereas the ability to drive a car at that age was not. Compared with car driving, motorcycle riding tends to start at a younger age and occur off-road, in particular, on farms (Reeder et al., 1996), where it may not be an illegal activity. Attitudes and behaviours inappropriate in a road traffic context may be acquired and generalised from an off-road environment. While early riding was not one of the strongest predictors in a multivariable context, on the basis of the tree analysis, it may be a relatively more important predictor of traffic convictions for females.

Perceptions, at age 13 years, of the risks of being caught while driving a motorcycle without a licence, driving a car while drunk, and not wearing a seat belt, were not related to subsequent traffic convictions, overall. Investigation of the relationships between perceptions of specific risks and equivalent offenses would require a larger cohort. The non-use of a seat belt at age 13 years was a negative predictor of traffic convictions, which went against the study hypothesis and earlier research (Maron et al., 1986). While the observed effect was relatively weak, it was selected for 71% of the bootstrap models. One plausible explanation could be that early experience of the negative consequences of not wearing a seat belt may be protective against later risky behaviour, but this requires further investigation.

The measure of the frequency of riding as a passenger with young drivers, while predictive of traffic convictions, was one of the less strong and stable predictors. Nevertheless, this finding suggests that such early experience of peers as role models for driving may have a negative effect on subsequent driving behaviour. The GDLS requirement that novice drivers must be accompanied by a fully licensed driver, 20 years or older, who has been qualified for at least two years, should act to counter this effect, if adequately enforced. Young drivers' opinions about the GDLS were not predictive of traffic convictions. The experience of riding as a passenger with an intoxicated adult driver was ranked as the seventh most common predictor by the bootstrap procedure. This finding is consistent with a social learning hypothesis that early role models for inappropriate behaviour may influence behaviour. Riding with an intoxicated peer, a measure more consistent with a 'risky lifestyle' hypothesis, was not a predictor, and there was little other evidence from the present study to support that hypothesis.

4.3. Factors distant from driving

Of the measures of health-risk behaviour, only marijuana use was selected for inclusion in the final regression model. That there should be an association between marijuana use and risky driving is consistent with earlier research which has found, for example, links between marijuana use and not wearing a seat belt (Maron et al., 1986), and marijuana use and traffic crash involvement by young drivers (Lang, Waller & Shope, 1996). In contrast to the findings of other studies, which have found relatively strong associations between alcohol use and risky transportation behaviours (Jessor, 1987b; Simpson & Beirness, 1992), usual alcohol consumption was not associated with the receipt of traffic convictions in the present study.

Two of the eight measures of family environment were selected for inclusion in the final regression model. For the FRI, the confidence interval included 1, and the relative instability of this factor as a predictor was confirmed by the bootstrap procedure. For these reasons, too much weight should not be attributed to this factor. Residence in a rural area, however, was the third strongest predictor in the final regression model and its stability was confirmed by the bootstrap procedure. This relatively strong association with the receipt of traffic convictions is consistent with the results of research on drivers of all ages who were involved in fatal traffic crashes in New Zealand (Bailey, 1995). Rural residents and those resident in a minor urban area with a population of 10,000 or less, had about twice the rate of crash involvement as drinking drivers, and were also less likely to wear a seat belt. This suggests the existence of poorer driving behaviours among the rural population.

With respect to the non selection of the measure of parental support for GDLS, it must be acknowledged that the questions were asked in the context of consideration of the possible inconvenience to the family posed by the requirement for a licensed adult driver to accompany learner drivers. This may have had the effect of diluting any expression of support for GDLS restrictions on safety grounds. An increased risk of traffic offenses among young men has been associated with living in a situation other than with both parents (Shope et al., 1996). In the present study, living in a single parent family at age 15 years did not predict traffic convictions. Separation from parents that occurred after the age of 15 years was not considered however, since the focus of interest was risk status around the minimum age for driver licensure.

Of the component measures abstracted from the SCI, involvement in part time work was identified as the second best predictor in the final regression model, and was also the second most frequently occurring variable identified by the bootstrap procedure. This finding was contrary to the hypothesis that low involvement in conventional society would be predictive of problem behaviour (i.e. the receipt of traffic convictions). It is, however, plausible that early participation in work may indicate an aspiration to independence and adult status consistent with the developmental 'transition proneness' concept of Problem-behaviour Theory (Jessor, 1984, p. 82). It is also consistent with the finding of other studies that economic advantage is associated with an elevated risk of traffic convictions (Crettenden & Drummond, 1994), although socioeconomic status measured at the family level was not a predictor in the present study. Furthermore, involvement in part-time work is indicative of being socially active, which is consistent with the finding that both attachment to school and good social support were predictors. Nevertheless, the latter two findings should be treated with caution, since the bootstrap procedure indicated that these variables were among the least stable predictors. A low score on the measure of

personal strengths, while less important as a predictor in the regression model, was positively associated with traffic convictions in about two thirds of the bootstrap models. This is consistent with a hypothesis that negative self perceptions may predict risky behaviour (Irwin & Millstein, 1986).

None of the measures of symptoms of psychopathology emerged as significant predictors. While this may seem to contradict earlier work (Nada-Raja et al., 1997), it is feasible that in a broader multivariable, non-clinical context, high ADHD symptom scores should lose status as a predictor. The present study also differed by having a longer follow up period and focusing on TON convictions. In this context, it should be noted that the ADHD risk category in the present study was not defined according to strict clinical criteria. This was appropriate, however, given that the research had a public health rather than a clinical focus. The aim was to identify risk factors among the general population of young drivers, rather than identify whether the small group who met clinical criteria was at elevated risk. Clinicians are aware of the possibility that young clients who present with clinical levels of ADHD and conduct disorder symptomatology may be at significantly elevated risk of traffic crash involvement and injuries (Barkley, Guevremont, Anastopoulos, DuPaul & Shelton, 1993).

In conclusion, there was limited support for the view that engagement in a specific problem behaviour (i.e. serious offending against traffic regulations) is part of a broader constellation of behaviours and personal characteristics (Jessor, 1987a; Simpson & Beirness, 1992).

4.4. Limitations and strengths of the study

The study cohort is advantaged in terms of parental socioeconomic characteristics (Silva & McCann, 1996), but since the cohort contained representation from all groups in the socioeconomic spectrum (Reeder et al., 1994), the finding that family socioeconomic status at age 15 years was not a predictor of traffic convictions was unlikely to be the result of socioeconomic bias. Furthermore, since drivers were identified irrespective of their licence status, the present study may better represent the broad range of young drivers than would be the case had other selection procedures been used, such as identifying a socioeconomically representative sample of licensed drivers from official records.

A potential major source of error in longitudinal studies is bias due to attrition. It is not uncommon for respondents to become increasingly unrepresentative of an initial sample, since those with the more adverse characteristics are less likely to be followed up (Cox, Rutter, Yule & Quinton, 1977). In the present study, although 82% of the cohort at age 13 years and 95% at ages 15 and 18 years were followed up, full data for both the outcome and the explanatory variables in the final model were only available for 60% ($n = 504$) of the 840 eligible. Nevertheless, since some data were available for the remainder, it was possible to make comparisons between those with full data, and those with incomplete data who were excluded. As expected, cohort members for whom incomplete data were available were more likely to be among those for whom a higher mean number of traffic convictions were recorded. This group also contained significantly more of those for whom other data were missing. The missing cases analysis identified three variables in the final regression model (school attachment, residence, and work), and a fourth (car driving exposure, 18–21 years) identified in the bootstrap analysis, for which cohort members not included in the final regression model had a significantly higher mean number of traffic convictions

than those included. For this reason, the final model may tend to underestimate the strength of each of those factors.

While self reports can provide reliable data, 'socially desirable' behaviour may tend to be exaggerated and 'socially undesirable' behaviour minimised (Harrell, 1985). Means of improving the validity of self report data include the assurance of confidentiality, establishment of good rapport, and concentration on relatively recent events (Nurco, 1985). In the DMHDS, confidentiality is assured. Interviews were carried out by interviewers trained for the task, which included recognition of the need to establish good rapport. The recall period for most measures was 1 year, which tends to minimise any recall inaccuracy that may occur over longer periods, yet allows sufficient time for a behaviour or event to have occurred. The overall nature of the DMHDS, with its high followup based on lifelong involvement, means that cohort members tend to be cooperative and their responses genuine.

The measures incorporated in the present study were neither designed specifically for a study of traffic convictions nor derived from the theoretical model (Problem-behaviour theory) used, broadly, to guide and structure the research. Given the prohibitive cost of longitudinal studies, it was considered expedient to use an opportunistic design that incorporated data collected for other purposes. While that approach placed limitations on the study, a predictive model was successfully fitted to the data. Had we been able to include other measures it is likely that an even stronger predictive model could have been built. For example, many specific measures of driving-related beliefs and perceptions (Parker et al., 1992) were lacking, as were measures of personality—a dimension associated with health risk behaviour (Caspi et al., 1997). While none of the MHLC scores predicted traffic convictions, it should be noted that general measures of health locus of control are considered to be less appropriate than specific measures that are directly related to the aspect of life being considered (Rotter, 1975). Such measures were not available for the study cohort.

The restriction of the study to consideration of only the most serious traffic offenses was justified, given the serious uncontrolled biases that would have been introduced had less serious offenses been included. Nevertheless, this restriction increased the proportion of alcohol related convictions to one third of all offenses, which should be taken into consideration when making comparisons with studies undertaken in jurisdictions where there may not be similar biases in long term traffic conviction histories.

There were two strong advantages of the present study. First, it was based on broad multivariable analyses that are best able to approximate the complex ecology of the determinants of human behaviour. Studies that restrict themselves to a limited range of factors may provide valuable insights, for example, into the relationships between driving specific intentions, perceptions, and behaviours (Parker et al., 1992;Parker, West, Stradling & Manstead, 1995), but may also result in other potentially important factors in the broader social environment being overlooked. Early involvement in part-time work, marijuana use, rural residence, early motorcycle riding, and the experience of riding as a passenger with an alcohol intoxicated adult were five such factors identified in the present study. Second, the rare opportunity to use a longitudinal design allowed temporal separation of the explanatory variables from the outcome. Apart from the driving exposure variables, the measurement of the explanatory variables preceded the outcome by up to 6 years. Thus, there is the potential to at least infer causality in any predictive relationships identified, whereas, in cross-sectional studies causal inference is problematic (Susser, 1988).

4.5. Some implications for road safety

Overall, the research provided unique insights by using (i) a broad psychosocial model, and (ii) a longitudinal study design. First, the findings supplement those found in research based on other theoretically derived models, in particular, those with a specifically attitudinal focus (Parker et al., 1992). Second, since the predictors were measured up to 6 years prior to the outcome at age 21, it is possible to identify a number of opportunities for early intervention.

It is reassuring that several of the strongest predictors are consistent with current road safety initiatives in New Zealand. The strongest predictor, being male (males had a mean risk of traffic convictions that was nine times that of the females) reinforces the need to continue interventions targeted at young male drivers. Other research has indicated the need to strengthen male perceptions of the negative outcomes of offending (Parker et al., 1992). This is one of the goals of a campaign focusing on what many otherwise hard-to-reach young males fear most, the loss of 'mateship' or 'not being able to be with the boys' (Land Transport Safety Authority, 1997, p. 1) that injury, the death of a friend, or loss of driver licensure may entail. It has also been noted that young drivers may require persuasion that they *can* exert control over the commission of traffic violations (Parker et al., 1992). The best means of communicating this message needs to be further researched among youth.

Another strong predictor, marijuana use, is now an acknowledged road safety concern in New Zealand (New Zealand Press Association, 1998). Although further investigation is required before specific countermeasures may be justified, marijuana use in association with driving is widespread, with as many as 33% of 21-year-old drivers reporting doing this in the past month (Begg & Langley, 1997).

That rural residence was a strong predictor is consistent with the elevated crash risk of the New Zealand rural population (Bailey, 1995) that has led to rural residents being the target of an awareness raising media intervention: 'Country people are dying on country roads' (Land Transport Safety Authority, 1996, p. 1). Improved host responsibility practices (e.g. the provision of transport for those who are tired or have consumed alcohol) may, in particular, be beneficial in rural contexts where driving to social events is the norm because of a lack of alternative transport. The Otago Lifesaver intervention, which rewards responsible behaviour in licensed club premises, provides an example of how positive reinforcement can assist in achieving change in conservative social environments (Reeder et al., 1998). Given that the present study found that differences based on residence exist before the age of leaving school, the targeting of rural schools would be an appropriate countermeasure to complement existing strategies.

Several other predictors were clearly identified in the present study. It is of interest that the young drivers at risk tended to be socially active and showed little evidence of 'pathology', though there was some evidence of poor self-perceptions. This tends to support the view that traffic convictions at this age may be more to do with youthfulness and inexperience rather than 'problem drivers' although repeat alcohol offenses and driving while disqualified were notable. Young, part-time workers were at considerably increased risk, and strategies to target this group are worthy of further investigation. Motorcycle riding has been identified as a national road safety priority target (Officials' Committee on Road Safety, 1991) for which specific training and licensing provisions are currently under review. That poor role models for driving may negatively affect driving behaviour, confirms the need, acknowledged in the GDLS, to establish good role

models and supervision early in the driving career in order that driving attitudes and behaviours that are appropriate for sharing the road environment receive strong reinforcement during the driver training and licensing processes. This should be accompanied by adequate enforcement and penalties for breaching licensing conditions that have a deterrent value. At present, the only penalty for breaking GDLS conditions is an extension by up to 6 months of the offenders current licence. Since some young drivers receive multiple extensions, this sanction is inadequate. Fines, regression to the previous more restrictive licence phase, and licence suspensions are now being considered (Land Transport Safety Authority, 1997).

Finally, when consideration is given to the design and targeting of interventions during the early years of driving, any drivers who acquire a traffic conviction record represent an appropriate remedial target group, given evidence that some individuals ('problem drivers') received multiple traffic convictions during the followup period.

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