Licit and Illicit Drug Use and Driving Among Canadians: Prevalence and Outcomes

by

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ABSTRACT

The author used data from the National Health and Welfare Canadian Survey on Drinking and Driving (1988) to examine the prevalence of driving following drug use and the impact this use has on traffic safety in Canada.

The prevalence of driving following drug use was found to be low except for alcohol. 12.6% of all drivers reported having driven after using alcohol alone or in combination with other substances. Using logistic regression analysis, it was found that age (younger persons) and gender (male) have the most consistent impact on traffic safety. Alcohol use was also found to have an impact on traffic safety when combined with over-the-counter medications (such as antihistamines), although the use of alcohol alone did not have as great an impact as anticipated. The use of illicit substances did not appear to have a major impact on traffic safety in Canada.

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Problem Statement

There is a limited amount of epidemiological information available on the effects of the use of various legal and illegal drugs on traffic safety in the Canadian context. Therefore, Canadian policy-makers and health care professionals have limited epidemiologically based knowledge upon which to develop policy and enhance professional practice when dealing with issues arising out of driving while under the influence of drugs (DWUID). Moreover, individual Canadians lack sufficient information to make informed decisions about driving practices following the use of alcohol and other drugs. While some studies have investigated the effects of certain medications, such as psychotropic drugs, on driving (Chesher, 1985; Ellinwood & Heatherly, 1985; Ferrara, 1987; Hindmarch & Harrison, 1988; Peck, Biasotti, Bolard, Mallory, & Reeve, 1988; Simpson, 1986; Smiley, 1988; Stramer, 1985) and other studies have examined licit and illicit drug use in Canada (Health and Welfare Canada 1989 and 1990), no apparent study has examined the impact of drug use (excluding alcohol) on traffic safety in the Canadian context. The findings of this thesis attempt to add to the knowledge of the impact of DWUID on traffic safety in Canada.

Significance of Study

The Canadian Survey on Drinking and Driving (1988) established a wide base of information on Canadian alcohol consumption patterns and driving habits. This survey asked questions about Canadians' driving behaviour following the use of various substances other than alcohol (see appendix 1 for a list of licit and illicit substances included in the survey). After a preliminary examination of the data, three research questions relating to DWUID were developed.

Studies have shown that the prevalence of DWUID accidents without alcohol involvement has been relatively low in the U.S. (Bud, Muto & Wong, 1988; Clayton, 1989; Poklis, Maginn & Barr, 1986; Simpson, 1988) and Italy (Ferrara, 1987) when compared to the prevalence of accidents which involved the use of alcohol. Studies also indicate an increased risk of motor vehicle accidents when alcohol is used in combination with other substances (Bud et al., 1988; Clayton, 1987; Ferrara, 1987; Simpson, 1987, 1988; Poklis et al., 1986). However, these studies were largely based on American samples and focused predominantly on the use of illegal substances rather than legal substances. Although the impairing effects of many prescription medications on driving abilities have been examined (Ferrara, 1987; Hindmarch & Harrison, 1988), there remains an unsatisfactory level of knowledge relating to the impact of the use of prescription medications, over-the-counter medications and illicit drugs on traffic safety in a Canadian context. The literature and the high number of respondents in the Canadian Survey on Drinking and Driving (1988) who admitted that they drove within two hours after using a licit and/or an illicit substance suggest that there is a need to increase understanding in this area.

Purpose of the Study

The purpose of this study is to examine the impact of driving after medication/drug use on traffic safety in Canada. Traffic safety measures include the number of traffic accidents, serious traffic accidents (defined as causing injury requiring hospitalization and/or causing $1,000 or more in property damage), traffic tickets (excluding parking tickets) and licence suspensions. In this thesis, these four measures are also referred to as "traffic events".

It must be emphasized that the main focus of this thesis is on the impact of drug use, excluding alcohol, on traffic safety. It is not the intention of this thesis to explore prevalence or demographic characteristics associated with DWUID in detail. The information on prevalence and demographic characteristics associated with DWUID is only provided to help give a context to the policy discussions and to help guide the investigation of the impact of DWUID on traffic safety.

Literature Review

In order to develop an understanding of and appreciation for the scope of the current research on traffic safety and substance use, a review of the literature was necessary. Through a review of the literature, the following key factors for DWUID have been identified: the prevalence of driving while under the influence of drugs, the effects of drug use on driving, the relationship between driving following drug use and traffic events, the effects of alcohol and drug combination use, and DWUID risk factors.

There are various approaches that can be used to conduct a research study. The approach of chosen for this study is an epidemiological one. An epidemiological approach appears most suited for analyzing the available data and this approach is consistent with the purpose of this study.

Epidemiological Framework

Epidemiology is primarily the study of diseases or social phenomena. It attempts to discover and explain pathogenic mechanisms of action, including identifying risk factors in diseases and, to the extent possible, etiological agents (Kessler & Levin, 1970). Epidemiological research is also concerned with the distribution of disease in populations (Fletcher, Fletcher & Wagner, 1988). It involves the use of specialized statistical tools and methods that had developed out of the field of epidemiology. Epidemiology has been the basis on which many facets of modern society and health have been examined (Clayton, 1987; Ferrara, 1987; Fletcher et al., 1988; Kessler & Levin, 1970). Within this framework, this thesis attempts to answer three research questions related to DWUID.

Epidemiological Studies of DWUID

There have been numerous studies which explored DWUID using an epidemiological approach. In this section, Clayton (1987) and Ferrara's (1987) works give an overview of current epidemiological findings related to DWUID.

In a review article, Clayton (1987) discussed what was known of epidemiological surveys on drinking, drug use and driving. Clayton (1987) noted a lack of research on the impact of DWUID on motor vehicle accidents. In addition, he made three significant observations. First, there has been an epidemic of illicit drug use in the United States since 1965. Second, there was a relatively predictable pattern of individual drug use over time, evolving from the use of less harmful substances such as alcohol to more harmful substances such as cocaine. As individuals move along the spectrum of drug abuse, they tend to use increasing amounts of the less harmful substances before beginning the use of the "harder" drugs. Third, Clayton (1987) observed that the negative consequences of alcohol and drug use were more likely to occur when two or more substances, such as marijuana and alcohol, were used in combination. These three observations suggest that there is a high potential for drug use to lead to adverse personal and social consequences.

In his 1987 article, Ferrara reviewed existing empirical evidence on the influence of a wide range of psychotropic drugs on driving ability. The substances he examined included alcohol, antidepressants, sedative hypnotics, stimulants, cannabis and anesthetics. His research indicated that psychotropic drugs can impair mental and physical functions, thus having the potential to contribute to road accidents. In his review of empirical evidence, Ferrara (1987) also identified major epidemiological issues and techniques of assessment related to drug use and road safety for further study. These are: 1) the nature and extent of the role played by these substances in road accidents; 2) how motor vehicle crashes involving these substances differ qualitatively from other types of motor vehicle crashes; 3) causes of increased risk in identified populations; and 4) implications of data for prevention programs.

Ferrara (1987) further identified four approaches that have been used in past research to ascertain the role of alcohol in road accidents. The four approaches are those which rely on anecdotal studies, blood testing of crash victims, crash rate comparisons for substance abusers versus non-substance users, and epidemiological studies based on comparative analysis of various drug concentrations in persons who have and who have not been involved in accidents while on the road under similar times and places. This thesis attempts to explore the role of alcohol and other drugs in road accidents using the last approach identified by Ferrara.

Prevalence of DWUID

There have been several studies which investigated the prevalence of DWUID (Alvarez, Prada & Del Rio, 1991; Budd et al., 1988; Clayton, 1989; Ferrara, 1987; Johnston & White, 1989; Poklis et al., 1986). These studies have tended to show that, for the substances tested, the prevalence of DWUID without the presence of alcohol has been low. This set of literature provides a baseline of knowledge against which the results of this thesis can be compared.

Alvarez et al. (1991) examined the use of illegal drugs and driving in Spain. In a review of epidemiological findings, they found that both the prevalence of illegal drug use and hospital emergency room admissions for traffic injuries following drug use were on the rise in Spain. In 1960, the prevalence of traffic casualties related to drug use was 8.1/100,000 inhabitants, while in 1985, the prevalence has increased to 14.4/100,000 inhabitants.

As well as providing information on the prevalence of illegal substance use, Alvarez et al.'s (1991) study also provided some demographic profile information on individuals who drive following illicit drug use. Alvarez et al. surveyed a sample of 675 drivers who were either obtaining their first license or renewing their existing license. Of those subjects who responded to the survey, only 3.4% indicated that they had driven after using an illegal drug. Interestingly, they found that those individuals who were male, young, with relatively higher levels of education, unemployed, and single, were more likely than other categories of subjects to drive after using an illegal substance.

Budd et al. (1989) analyzed drugs found in drivers who were killed in Los Angeles County, California. The blood and urine specimens of 600 fatally injured drivers were analyzed for the presence of alcohol and other substances. The study included the following substances: alcohol, barbiturates, cocaine, marijuana, phencyclidine, opiates, morphine, codeine and various combinations of these substances. The researchers' results indicated that greater than 60% of the study sample tested positive for alcohol and/or drugs. Moreover, alcohol was found to be, by far, the most common form of intoxicating substance, with 41.5% of the fatally injured drivers testing positive for alcohol. Budd et al.'s (1989) study might have underestimated the true involvement of substance abuse in motor vehicle accidents. For example, the fatal deaths of drivers who were not under the influence of chemical substances might have been caused by other drivers who were under the influence of chemical substances. The Budd et al. (1989) study focused on alcohol and illegal substances. No testing for antihistamines or antidepressants was noted despite the fact that other studies have indicated that these substances are commonly used and can adversely affect driving skills (Ferrara, 1987; Hindmarch & Harrison, 1988). In addition, the study focused only on those drivers who were killed in motor vehicle accidents. The impact of chemical substances on the number of accidents involving injured drivers can only be estimated. Regardless of these weaknesses, this study is valuable because it provides an indication of the high number of potentially preventable deaths related to alcohol and/or drug use and driving.

Johnson and White (1989) completed a prospective longitudinal study that assessed the prevalence of driving under the influence of alcohol and marijuana among individuals aged 18 to 21 in New Jersey. The researchers used survey questionnaires to examine the across time relationships between intoxicated driving and drug consumption, risk taking and impulsive orientation, negative intrapersonal state, stress, and the use of alcohol and other drugs to cope with stress.

Like Alvarez et al. (1991), Johnson and White (1989) found that sex (male) and marital status (single) are high risk factors for DWUID. In addition, Johnson and White (1989) also identified that the amount of alcohol consumed, externally focused locus of control, heightened levels of impulsivity, hostility, aggression, depression, paranoid ideation, anxiety and decreased levels of self-esteem are all high risk factors for drunken driving. The findings of the study indicated risk-taking behaviour and substance use for stress reduction as the main factors involved in intoxicated driving among youth. The study also found that 10-50% of these youth have reported driving after using alcohol and marijuana.

Poklis et al. (1987) examined the drug positive cases of DWUID in St. Louis, Missouri over a three year period. The study sample consisted of a total of 137 individuals who were stopped by police for suspicious driving behaviour, but whose behaviour was later found to have no relation to alcohol. The authors found that the number of arrests for DWUID, without alcohol involvement, was less than 0.8% of total arrests for driving while under the influence of a substance. Benzodiazepines accounted for 22% of the 137 cases and barbiturates accounted for 15%. An overwhelmingly large percentage of the sample (81%) was found to be impaired as a result of deliberate self-intoxication with illegal or controlled substances. Given the low prevalence of arrest for DWUID without alcohol involvement and the low number of impaired cases due to therapeutic substance use, the authors concluded that driving under the influence is largely a problem of alcohol and illicit drug use.

One limitation to Poklis et al.'s study is its poor generalizability. The sample size was small, and the study was restricted to one city, in one state, in the United States. The study only focused on those individuals who were arrested and did not necessarily identify the actual number of people who used licit drugs and were impaired drivers. The findings, therefore, likely represent only the low end of the prevalence scale.

In a review article, Simpson (1986) examined epidemiological studies in the U.S. to examine the magnitude of the marijuana problem in traffic accidents, and the risk it poses to traffic safety. Simpson (1986) found that studies assessing the frequency of driving after marijuana use indicated that 1% to 4% of the driving population has driven after using marijuana. Simpson (1986) also found that marijuana was implicated in about 10% of traffic injuries and in 7% to 10% of driver fatalities. Alcohol was likely to be present in 50% to 80% of the cases in which marijuana was present. Simpson stated that studies have found that marijuana use is over-represented among driver injuries and fatalities relative to its use by the driving population. Simpson (1986) also suggested that marijuana is a risk factor for traffic accidents.

In summary, the prevalence of DWUID without alcohol involvement has been found to be very low. However, the effect of alcohol when combined with substances such as marijuana has been shown to be more common and to have deleterious effects. DWUID also tends to involve illicit drug use. Although there is not extensive research in this area, there appears to be few cases of individuals impaired by therapeutic drug use.

Effects of DWUID

The next issue to be reviewed through a discussion of existing literature is the effect of drug use on driving performance. The distinction between the impact of drug use on traffic safety and the effects of drug use on driving performance is that the latter effects can only be measured in a controlled setting within a laboratory or in a road simulation (Chesher, 1989; Ferrara, 1987; Hindmarch & Harrison, 1988; Peck et al., 1988; Smiley, 1988). Research on the effects of drug use on driving establishes the physiological effects of various chemicals upon the psychomotor skills related to motor vehicle operation. This research can also confirm the types of substances that have already been shown to have a potential impact on driving skills (see Appendix 2 for a list of the more prominent substances known to impact driving skills). The interaction of chemicals within an individual is complex, poorly understood and not universal across the population. This complexity has made it difficult to establish legal tolerance levels for substances other than alcohol.

Betts (1988) used a low speed vehicle handling test to determine the effects of psychotropic medications, including antihypertensives, antidepressants, antihistamines and antiemetics on motor vehicle handling. His findings indicated that sedatives tend to slow the physical response of his subjects and make them more careless; however, at the same time, these subjects also took fewer driving risks. Betts' (1988) findings also suggested that individuals who used tranquilizers tend to increase their driving speed, but suffered little judgement impairment.

Chesher (1985) discussed the involvement of two classes of analgesics, antipyretics such as aspirin, and narcotics such as morphine and heroin, on road crashes. Chesher (1985) reviewed available epidemiological data for the behavioral effect of each drug group, and how each group impacted traffic safety. Antipyretic analgesics showed no evidence to suggest any causal involvement in road crashes. The narcotic analgesics were reviewed separately depending on whether they were used legally or illegally, due to differences in the supply and manner of use. Chesher (1985) found that the behavioral pharmacology of IV-administered heroin suggested that any drug-induced deficit in driving performance was not due to psychomotor function effects, but from the effect of the drug on the user's mood states. Accordingly, methadone used in treatment schedules did not demonstrate any significant effect on measures of human-skills performance. Chesher (1985) also found the epidemiological data regarding the role of narcotic analgesics on road crashes contradictory, but it is unlikely narcotic analgesics are a source of significant concern.

Chesher (1989) examined the effects of opioid analgesics on skills performance related to motor vehicle operation. Chesher (1989) pointed out that most of the research on the effects of drug use upon driving related skills also involved the study of alcohol. Alcohol is unique amongst psychoactive substances in its effects on the central nervous system. The effects of alcohol are relatively consistent across individuals and the relationship between the effects of alcohol and blood alcohol concentration level is far more predictable than that for other psychoactive substances. This predictability has allowed the establishment of blood alcohol concentration limits and the development of useful screening methods (Chesher, 1989; Wieczorek, Miller & Nochajski, 1992). As in his earlier study (Chesher, 1985), Chesher (1989) again found that the effects of opioid analgesics on skills performance related to driving are slight, especially when compared to the effects of alcohol, benzodiazepines and barbiturates. Chesher (1989) indicated that opiate analgesics, while they may have some impact on traffic safety, are secondary to alcohol, benzodiazepines and barbiturates.

Ellinwood and Heatherly (1985) examined drug plasma levels as a means of measuring benzodiazepines' effects on driving skills. The authors reviewed existing research on the effects of minor tranquilizers (benzodiazepines) on psychomotor and cognitive performance, and analyzed epidemiological studies that provided evidence for the role of minor tranquilizers in traffic accidents. Studies indicated that drug plasma level is insufficiently correlated with impairment. Ellinwood and Heatherly (1985) found several sources of susceptibility to differential impairment including: acute peak effects, acute tolerance, chronic tolerance, benzodiazepine receptor affinity and individual sensitivity. The authors concluded that behavioral testing itself might become the critical means of assessing drug and/or drug with alcohol induced driving impairment.

Hindmarch and Harrison (1988) examined the effects of paroxetine and other antidepressants in combination with alcohol use on psychomotor activities related to driving. In their study, a double blind, balanced crossover technique in which each subject acted as her own control was used. The subjects were ten healthy female volunteers who received either an antidepressant with or without alcohol, or a placebo with or without alcohol. Following the administration of a study drug, each subject received a psychomotor skills test 1.5 hours and 4 hours post ingestion. The results indicated that paroxetine, unlike other test drugs, showed no sedative effects. Even when combined with alcohol, paroxetine did not appear to cause more sedative effects than when alcohol alone was consumed. This study helps to demonstrate the complex and poorly understood effects of different pharmacological substances. Although all of the drugs tested were antidepressants, they affected the body in a different manner when used alone or when used in combination with other drugs.

Hurst (1987), in a review article, examined the experimental, clinical and epidemiological findings of the relationship between amphetamine use and driving behaviour. He concluded that controlled studies have shown that the effects of amphetamine use in therapeutic doses do not amount to a significant traffic accident hazard and that illicit use of amphetamines is either rare among drivers or is kept separate from driving by users.

Peck et al. (1988) examined the effects of marijuana and alcohol on actual driving performance. The researchers studied 80 male volunteers from California who received one of four experimental treatments: 1) marijuana, 2) alcohol, 3) marijuana and alcohol, or 4) two placebos. The dose for the experimental treatments was controlled for each subject based on body weight. Following consumption, the subjects were given four post-drug runs separated by hourly intervals in a vehicle on a test track. Each subjects driving performance and blood and urine samples were measured. Marijuana and alcohol were found to have a significant effect on driving performance. The impact of marijuana on driving performance was more rapid and less severe than that of alcohol. The combination of use of marijuana and alcohol was found to be particularly detrimental to driving performance.

The authors had hoped to find a useful chemical indicator for marijuana impairment. Although they did find an association between tetrahydrocannabinol blood concentrations and performance variations, the practical implications of the finding were unclear. The authors suggested that the legal allowable blood alcohol concentration level be decreased for those individuals who tested positive for both marijuana and alcohol in their blood. Presently, a handheld breathalyser can detect the presence of alcohol but no equivalent device is available for detecting the presence of marijuana. Until such time that a useful chemical indicator for marijuana impairment and a portable device for marijuana detection are available, there is unlikely to be a cost-effective way of detecting alcohol-marijuana impairment.

Smiley (1988) outlined the differences between on-road studies and simulator studies. On-road studies have higher face validity than simulator studies (Smiley, 1988). However, simulator studies allow the safe study of dangerous situations, such as the use of higher drug dosages, than on-road studies. The primary weakness of simulator studies is the lack of realism. Driving simulator studies tend to lack fidelity in illustrating car dynamics and/or visual scenes.

After reviewing the existing research on the effects of marijuana on driving, Smiley (1988) concluded that marijuana appeared to impair driving performance. Surprisingly, those drivers who were impaired by marijuana were actually aware of their impairment. This awareness seemed to be accompanied by compensatory behaviour on the part of the impaired driver through activities such as slowing down, not overtaking other vehicles and focusing their attention when they expect that a response might be required. However, such compensatory behaviour provided little or no protection when an unexpected event occurred. The effects of marijuana were experienced quickly after drug consumption but the effects did not last for extended periods.

Starmer (1985) reviewed evidence indicating that antihistamine-induced impairment of human psychomotor performance constitutes a traffic hazard. Two distinct classes of histamine antagonists which act at different receptors (H-sub-1 and H-sub-2) were considered. H-sub-1-antagonists are available over-the-counter and are consumed in large quantities. They are a heterogeneous group that antagonizes some of the effects of histamine. Sedating effects which are common with many older H-sub-1 antagonists impair performance in laboratory tasks and interact additively with alcohol and other CNS depressant drugs. Despite this interaction dynamic, the use of H-sub-1-antagonists have been very seldomly suggested as a causal factor in traffic crashes. The use of Histamine H-sub-2-antagonists is more restricted and closely supervised by medically qualified personnel. Among the H-sub-2-antagonists studied, only cimetidine appears to pose a traffic safety threat. With both types of antagonists, it is possible for the prescriber to choose from a number of available drugs for one that has a minimal potential for disrupting driving ability.

Walsh (1985) in a review article on pharmacological sensitivities, further examined the complexities of various drugs. Walsh identified an intricate relationship between the importance of genetics in one's reaction to substances. The pharmacokinetic profiles of individual drugs vary widely which, combined with different subjective responses to drugs, complicate any general assessment of toxicity.

Another complicating factor that Walsh (1985) identified is the effects of aging. As an individual ages, the effects of chemical substances upon the body change. Walsh pointed out that most traffic accidents involving alcohol tended to involve younger drivers. Despite that, older individuals tend to be more sensitive to the effects of chemical substances. With age apparently comes experience which seems to play a role in one's reaction to substances. Experience may affect the way in which an individual reacts to alterations of his/her mood following substance use.

In summary, the literature on the effects of chemical substances upon driving ability indicates that the effects are complex, multifactorial and different for each individual. Even those substances known to impact driving abilities tend to be less impairing and are less commonly used than alcohol. However, many substances are known to interact with alcohol and can increase the level of impairment. The complexity of the impact of chemical substances has made it extremely difficult to develop a reliable plasma indicator for impairment.

Linking DWUID and Accidents

Some authors have pointed out the difficulty of directly attributing traffic accidents to impairment resulting from substance abuse because of the large number of other variables that may contribute to traffic accidents (Bud et al, 1989; Clayton, 1987;

Ferrara, 1987; Klitzner, Vegegas & Gruenewald, 1988; Polkis et al. 1986; Simpson, 1987). Such variables can include a host of demographic characteristics such as driver age, gender, and past experiences including previous driving and drinking habits.

Chan (1987) examined factors which might affect the drinking driver. Although much research has gone into the examination of the effects of alcohol on driving skills, there has been relatively limited research which examines how alcohol impacts traffic safety. Chan noted that the relative risk of becoming involved in a crash with a blood alcohol concentration above 0.15% is greater than 20 to 1. Despite this strong correlation between alcohol use and traffic accidents, the effect of lower blood alcohol concentrations is unclear. Chan (1987) concluded that it is unlikely that any one causal factor could adequately explain the phenomenon of drinking and driving. Similarly, it is unlikely that any single causal factor could adequately predict the effects of drug use on traffic safety.

Honkanen et al. (1980) examined the role of drugs in traffic accidents in Finland. The serum samples from 201 drivers who went to an emergency department following a traffic accident were compared to the serum samples of 325 drivers taken from a random sample of petrol station customers. Along with laboratory tests, a questionnaire regarding psychotropic drug use was administered to all subjects. The results indicated that health status was a more important traffic hazard in Finland than drug use.

Some of the subjects indicated that they had not taken any drugs, while the laboratory tests clearly indicated that these subjects had done so. Therefore, the authors concluded that the questionnaire was not a reliable method of establishing whether a driver had taken a psychotropic drug. However, it is not surprising that people who presented themselves to the emergency department following an accident would deny that they had taken drugs prior to the accident for fear of legal repercussions. In Honkanen et al.'s study (1980), alcohol was found to be the most powerful risk factor for accidents, but diazepam was also implicated. Alcohol and diazepam were found to have potentiating effects on each other.

Oster, et al. (1987) examined the effects of benzodiazepines on accidents and injuries including, but not limited to, traffic accidents. The authors had two purposes in mind: to determine whether patients receiving benzodiazepines were more likely to experience accidents and injuries, and to identify differences in health care utilization between benzodiazepine users and non-users. Subjects included 7,271 benzodiazepine users and 65,439 non-users enrolled in a health insurance plan in the state of Michigan. User status was identified through a review of prescription drug claims within a 4 month period. Claims for accident coverage were used to determine health care utilization. The results indicated that benzodiazepine users were significantly more likely than non-users to experience: 1) at least one accident related episode of care; 2) a greater number of hospital admissions related to accidents; and 3) a greater number of accident-related inpatient days. Users were also found to have sought significantly more non-accident related health care services than non-users. However, the relationship between the use of benzodiazepine and higher accident related health care utilization is unclear. The generalizability of the study would be impacted by the researchers' sample inclusion criteria. In particular, those people with health insurance would obviously require financial resources not indicative of the general American population.

In a later paper, Oster et al., (1990) further explored the relationship between the use of benzodiazepine tranquilizers and accidental injuries. In their previous study (1987), the authors were unable to determine whether differences in health care utilization among people who were prescribed benzodiazepines were related to a higher risk of accident or to an overall higher use of health care services. In their 1990 study, the authors employed a pretest-posttest design to examine three questions: 1) Are persons who are prescribed benzodiazepine tranquilizers more likely to require accident-related medical care than the general population? 2) Is there evidence of a temporal relationship between prescriptions for these people and the likelihood of an accident related medical encounter? and 3) Is there evidence of a relationship between the number of prescriptions and the risk of these encounters?

The authors used pharmacy claims to sample 4,554 people receiving benzodiazepines and a matched control group of 13,662 people who were prescribed other medications. For their pretest, the authors gathered medical diagnoses and prescriptions submitted on claims by individuals who made claims for benzodiazepine prescriptions for three months prior to the individuals' first claim. For their posttest, the authors observed all claims submitted for the six months immediately after the initial benzodiazepine prescription claim. After controlling for age, sex, and prior utilization, the authors reported that there is approximately two times the risk of requiring accident related medical care for benzodiazepine users compared to non-users. However, the authors were only able to infer care requirements as no actual observations were made. Also, people who submitted claims might have been receiving follow-up care for an earlier accident that was unrelated to the use of benzodiazepines. The authors did not distinguish the types of accidents that their subjects were involved in.

Ray, Fought and Decker (1992) examined the effects of commonly used psychoactive drugs on the risk of injurious motor vehicle crashes involving the elderly. Using medical insurance claims, the authors conducted a retrospective cohort study. The subjects were 16,262 Medicaid enrolles, all between 65 and 84 years of age, and holding a valid drivers license in the state of Tennessee. The risk of crash involvement was calculated using Poisson regression models for four groups of psychoactive drugs (benzodiazepines, cyclic antidepressants, oral opioid analgesics, and antihistamines). Demographic characteristics were controlled for and the use of medical care services was used as a health status indicator. Benzodiazepine users were found to have a relative risk for a traffic accident of 1.5, (95% C.I. 1.2-1.9), while cyclic antidepressant users had a relative risk of having a traffic accident of 2.2, (95% C.I. 1.3-3.5). This data analysis suggested that the findings were not confounded by either alcohol use or driving frequency.

Simpson (1987) examined the effect that drugs have on road crashes involving young drivers (ages 16 to 20) in Canada. He noted that there is a lack of research on the effects of various drugs other than alcohol on traffic safety and credited this deficit to the over-emphasis on alcohol studies, the lack of consensus on what other substances should be studied and the increased pharmacokinetic complexity of other chemical substances when compared to alcohol. Unlike alcohol, for which blood alcohol concentration levels can be established, meaningful correlations between fluid/tissue drug levels and behavioral effects cannot be established for many chemical substances.

Simpson (1987) cited another difficulty when trying to establish links between drug use and traffic accidents. He noted that medications used to correct a medical condition might not be the cause of a traffic accident but, rather, the underlying medical condition itself might be the true cause. The above factors make it difficult to establish the role of drug use in traffic accidents.

In his study, Simpson (1987) focused on youth and not the general population because youth appeared to be involved in an inordinate number of traffic accidents. After reviewing available evidence in the literature, Simpson concluded that multiple drug use (excluding alcohol) is not characteristic of young drivers killed or injured in road crashes. Marijuana and cocaine were the two most common substances (other than alcohol) involved in deaths or injuries in road crashes involving young drivers. In the vast majority of cases in which young drivers were killed or injured in road crashes, a drug such as marijuana was used in combination with alcohol.

Skegg, Richards and Doll (1979) completed a retrospective study in Great Britain that examined the relationship between the use of minor tranquilizers and the incidence of road accidents. The authors had previously completed a drug-monitoring study and found that 19% of people in Great Britain, aged 15 and over, received prescribed psychotropic drugs during one year. Given this high prevalence, the authors decided to examine the effects that these drugs might have on road accidents in a two year prospective study. Their study included 43,117 people who had received prescriptions from general practitioners. Medical records for these subjects were then compared with records of hospital admissions and deaths. 57 of the subjects were found to have been either injured or killed while driving a car, a motorcycle or a bicycle. All medication prescriptions that these victims had received for the three months preceding their accidents were compared with those medications dispensed for 1,425 matched control subjects. The authors found a relative risk estimate of 4.9 (95% confidence limits 1.8 and 13.0) between the use of minor tranquilizers and the risk of serious road accidents. It should be noted that the actual number of victims who had received minor tranquilizer prescriptions before their accidents was only five. This study indicated a potential increased risk for motor vehicle accidents following the use of minor tranquilizers (defined as receiving a tranquillizer prescription within three months preceding the accident). Also, there appeared to be an association between the use of antihistamines and motorcycle accidents. The authors admitted that their study could not distinguish whether the accidents were caused by the medications used or by the underlying conditions being treated. The number of accidents in the study was too small to determine the effects of different minor tranquilizers, major tranquilizers, and the effects of other drug combinations.

In summary, the literature regarding the link between drug use and traffic safety has demonstrated that it is extremely difficult to determine the precise impact of drug use on traffic safety, due to the high number of potential variables that could be involved. However, some studies have been able to establish links between drug use and traffic safety.

Ethanol and Drug Combinations

A high prevalence of drinking and driving has been identified in the literature (Budd et al. 1989, Health and Welfare Canada, 1990; Simpson, 1987). The prevalence of DWUID without alcohol involvement has tended to be relatively low (Bud et al., 1989; Clayton, 1989; Ferrara, 1987; Poklis et al., 1986), although there is some evidence that the use of alcohol and other drug combinations are more common (Clayton, 1987; Gjerde et. al, 1988; Johnson & White, 1989; Simpson, 1987, 1988). It has also been suggested that alcohol and drug combinations may play a greater role in the prevalence of traffic accidents and arrests than is generally thought (Clayton, 1987; Gjerde et. al, 1988; Simpson, 1987, 1988). Given the prevalence of alcohol and drug combinations, it is important to understand the combined effects of alcohol and other drug use.

Clayton (1987), in a review of existing research, found that the marijuana/alcohol combination was implicated in traffic accidents involving young drivers. Clayton (1987) found that the likelihood of a traffic accident increases with the use of multiple drugs.

Peck et al. (1988) examined the joint effects of marijuana and alcohol on actual driving performance (see page 22 for study details) and found that marijuana's effects on driving performance were more rapid and less severe than that of alcohol. Given the negative impact that marijuana and alcohol used in combination has on driving skills, Peck et al. suggested that a lower legal blood alcohol level be established for those individuals who test positive for marijuana.

Simpson (1987) in a review of the literature on alcohol, drug use and driving, also found support for an interaction between marijuana and alcohol. Although Simpson (1987) focused predominantly upon young drivers, the synergistic effects of alcohol and marijuana are likely to occur in any age group. However, younger drivers have been shown to be at greater risk for traffic accidents in general, and following the use of alcohol and other substances (Simpson, 1987). Simpson also stated that drug involvement in traffic accidents rarely involved only one substance and that alcohol was by far the dominant substance involved.

Stramer (1985) found an interaction between histamines and alcohol such that their effects potentiated, while Honkanen et al. (1980) found that diazepam and alcohol interacted to increase CNS depression (see pages 24 and page 27, for study details).

In summary, most studies have indicated that alcohol and various substances, legal and illegal, can often have potentiating effects. This cumulative effect can lead to more serious traffic safety consequences when alcohol and other substances are used in combination prior to driving.

DWUID Risk Factors

Research has identified numerous risk factors for DWUID: age, sex, education level, employment status, driving experience, personality traits, and alcohol consumption patterns. The literature reviewed thus far helps to guide the selection of variables to be considered as confounders in this thesis.

Few studies have commented on gender differences in DWUID. Among those studies that have reviewed gender differences, some studies have indicated that being male increases the risk of DWUID (Alvarez et al, 1991; Gjerde et al, 1988; Johnson & White, 1989), while one study found no sex differences relating to DWUID (Newcomb, Maddahian & Bentley, 1986). Those studies that have implicated increased male involvement were based on DWUID arrests, while Newcomb et al.'s study was based on a self-report survey. Moreover, Alvarez et al. (1991) found that more males were killed in traffic accidents involving DWUID than females. Despite the paucity of literature on gender differences and DWUID, there appears to be some differences between men and women. Therefore, this thesis has included gender as a variable when assessing traffic safety effects of DWUID.

Personality traits have been implicated in drug use and DWUID (Bry, McKeon & Pandira, 1982; Johnson & White, 1989; Newcomb et al., 1986; Walsh, 1985). Low self-esteem, sensation seeking tendencies, depression, perceived deviance of drug use and peer drug use are all personality characteristics which have been found to correlate with drug use and DWUID. It appears from the literature that the risk of DWUID is based upon multiple risk factors. If an individual possesses multiple personality traits that have been linked with DWUID and drug use, then that individual is more likely to drive while under the influence of drugs.

Age is another factor which has been implicated in DWUID. Younger drivers appear to be at an increased risk for DWUID, and traffic accidents related to DWUID (Alvarez et al, 1991; Johnson and White, 1989; Simpson, 1987; Walsh, 1985). This observation could be related to less driving experience, less drug use experience or differences in personality traits. Regardless of the cause of youth involvement in DWUID, some consideration of age as a factor need to be incorporated in any study of DWUID.

Other demographic characteristics have also been implicated in the literature. Employment status, marital status and education level have all been found to play a role in DWUID (Alveraze et al., 1991). As well, past alcohol consumption patterns have been implicated (Johnson and White, 1989) in DWUID.

Although there is no consensus, the literature has indicated that the following are potential factors which impact DWUID: age, sex, marital status, low self-esteem, sensation seeking, depression, past alcohol consumption patterns, employment status, education level, and past driving experience. Some of these variables, particularly personality characteristics, cannot be examined in this study; data on personality characteristics were not included in the original Canadian Survey on Drinking and Driving (1988). However, many of the identified demographic characteristics are considered.

Research Questions

The following are the three research questions addressed in this thesis.

1. What is the prevalence of driving within two hours after using any of the following drug groups, either in isolation or in combination?

    A) prescription drugs such as tranquilizers? (CNS effects);

    B) Over-the-counter drugs such as codeine and/or antihistamines? (OTC)

    C) marijuana or hashish?

    D) other drugs such as LSD, heroin, mescalin or cocaine?

    E) alcohol?

2. What are the characteristics of people who use illicit and licit drugs before driving?

3. What is the impact on the prevalence of traffic accidents, and traffic tickets, and the prevalence and seriousness of traffic accidents when driving within two hours after using any of the following drug groups, either in isolation or in combination?

   A) prescription drugs such as tranquilizers? (CNS effects);

   B) over-the-counter drugs such as codeine and/or antihistamines? (OTC)

   C) marijuana or hashish?

   D) other drugs such as LSD, heroin, mescalin or cocaine?

   E) alcohol?

Although this thesis focuses on drugs other than alcohol, alcohol will be considered in the research question and subsequent analysis as a control variable.

Methodology

Data

The data for this study comes from the Canadian Survey on Drinking and Driving (1988). The data are currently maintained by Health and Welfare Canada.

The Canadian Survey on Drinking and Driving surveyed people from every province across the country, for a total sample size of 9,943 individuals. The data were collected via a telephone survey using a random digit dialling technique with a response rate of over 80%. Consequently, people without telephones were excluded from the study. U.S. studies have indicated that the number of American households without access to a telephone ranged from 3% (Frey, 1989) to 7% (Thornberry & Massey, 1988), while Statistics Canada (1988) estimated that only 2% of Canadians did not have access to a telephone. Furthermore, those individuals who did not have access to a telephone tended to be among the poorest members of society (Frey, 1989; Lavrakas, 1993). It is assumed that these individuals who were unable to afford access to a telephone would also be unable to afford access to a motor vehicle. Consequently, the absence of the few potential individuals who drove but did not have access to a telephone is unlikely to significantly affect the generalizability of this thesis's findings. Based on the low exclusion rate and the fact that the study sample was randomly selected, the data are believed to be representative of the general Canadian population.

The Canadian Survey on Drinking and Driving (1988) relied on self-report responses. Although Smith, Remington, Williamson and Anada (1990) did not find self-report responses to be an adequate method of predicting alcohol consumption when compared to alcohol sales data, numerous other authors have found self-reporting methods for reporting alcohol use and related problems to be quite reliable (Clark, 1981; Fitzgerald & Mulford, 1978; Health and Welfare Canada, 1990; Hillman & Sawilowsky, 1992; Johnson & Raskin, 1989; Khavari & Farmer, 1978; O'Hare, Bennett & Leduc, 1991; Polich, 1982; Rouse et al., 1985; Sarvela et al, 1990; Single et al., 1975; Smith et al, 1990). In fact, the use of alcohol sales data studies as a measure of alcohol consumption may be questionable as this measure fails to take into account factors such as out-of-province alcohol sales and alcohol stock piling. The conclusion of an overwhelming majority of researchers is that self-report surveys are an effective means of analyzing alcohol and drug use patterns.

Data Limitations

There are limitations involved in using data from the Canadian Survey on Drinking and Driving (1988). First, an equal number of subjects from each province was included in the survey. Therefore, the survey used a non-weighted sample. Thus, Prince Edward Island and Ontario were equally represented in the survey. Smaller provinces which might have different patterns of alcohol and drug use would have a disproportionate effect on the survey results. No weighting scheme was provided with the data set to allow the researcher to properly weight the scores of each Province. Therefore, the sample selection design limits the generalizability of this thesis's findings to the Canadian driving population.

A second potential limitation of the Canadian Survey on Drinking and Driving (1988) data is its age. The survey was completed in 1988. It is possible that drug use and driving patterns across Canada have changed between 1988 and 1995. Nonetheless, the findings derived from the analysis of the data are believed to be still valid. Health and Welfare Canada (1990) indicated that patterns of illicit drug use in Canada have remained stable for the past four years, and there has been no indication in the literature to suggest that the pattern of drug use and driving has changed since 1988. Moreover, secondary research which focuses on the analysis of causal relationships of social phenomena is relatively time resistant (Hakim 1982; Townsend, 1979).

A third potential limitation of the survey results is the fact that the survey was targeted at those drivers between the ages of 16 and 69. Older drivers where excluded from the survey. This limits the generalizability of the results.

With Secondary analysis there are limitations which arise from the manner in which the original data was collected. The emphasis of the Canadian Survey on Drinking and Driving (1988) was on alcohol use and driving; the study of the use of other drugs was less prominent. Thus, the survey only covered a limited range of drugs. There are thousands of psychotropic and other substances that could potentially affect traffic safety, but which were not considered by this survey. Previous research clearly supports such a bias; alcohol is a much greater concern in terms of the prevalence of its use and problems associated with its use (Bud et al., 1988; Clayton, 1989; Ferrara, 1987; Health and Welfare Canada, 1990; Poklis et al., 1986; Simpson, 1988). Consequently, the Canadian Survey on Drinking and Driving (1988) focused only on those drugs that were thought most likely to be linked to traffic safety issues. The questions involving substance use other than alcohol where quite limited (please see Appendix 3). This lack of detail prevents indepth analysis of the impact of substances other than alcohol on traffic safety. As well, the relatively small numbers of users who used certain illicit drugs inhibit comprehensive description of the consequences associated with the use of those illicit drugs.

In conforming to the Statistics Act, all subjects were given assurances of anonymity and confidentiality. Allowing respondents to remain anonymous increases the response rate and improves the likelihood that they will respond truthfully to sensitive questions (Health and Welfare Canada, 1990). As well, the general validity of self-reporting drug use is also supported by a growing body of literature. However, some degree of under-reporting can be expected (Health and Welfare Canada, 1990). For example, in the case of prescription drugs, many respondents may simply not be knowledgeable of the category to which the drug they use belongs. Therefore, the findings of this thesis should be considered a best case scenario; under-reporting by survey respondents is likely to make problems associated with drug use and driving to appear less widespread than it is.

Population

The Canadian Survey on Drinking and Driving (1988) targeted Canadians between the ages of 16 and 69, throughout the ten Canadian provinces. Surveyors used a random-digit dialling technique to contact households. Those Canadians living full-time in institutions and those households without telephones were not included in the survey. Also, people residing in the Yukon and Northwest Territories were not included. The overall response rate for the survey was over 80%. The total sample size was 9,943; an average of almost 1,000 people from each of the ten provinces participated in the survey. Due to the high response rate, the large sample size and the random nature of the sampling technique, resultant findings are expected to have fair generalizability to the whole Canadian population, excluding the Yukon and Northwest Territories, where the demographic make-up of drivers may be different. Furthermore, an individual researcher cannot practically dedicate adequate time, resources and expertise to conduct such a large survey. Therefore, the use of the Canadian Survey on Drinking and Driving (1988) is a practical and reasonable way of obtaining representative and comprehensive information on the characteristics of Canadian drivers.

Research Design

The design of this thesis study is retrospective and descriptive in nature. The study is also comparative in that differences among individuals who drove after using various licit and illicit substances and those who did not use licit and illicit substances and drive, are explored. The research method does not include a matched design. Subjects were not matched on particular characteristics before analysis.

The study involved a secondary analysis of a national data set. The data were gathered by Statistics Canada using a telephone survey. The Canadian Survey on Drinking and Driving (1988) provides a wealth of information on the driving and substance use habits of Canadians. As the studies primary objective is to explore the prevalence and impacts of drug use and driving on traffic safety, it is reasonable that this comprehensive database be used. Data collection relied on access to the original data set and extensive organization of the data for secondary analysis, with the aid of a computer.

The organization of the data was guided by knowledge and theories gained through a thorough literature review. The epidemiological approach used in this thesis is appropriate for answering the study questions, as the data were quantitative in nature and the purpose of the thesis is to describe and compare the effects of the use of various substances on traffic safety in Canada.

To investigate those areas stated in the research questions, a computer program was used to facilitate the data analysis process. The computer program used was the Statistical Package for the Social Sciences (SPSS) for Windows. In particular, one statistical method used is logistic regression resulting in odds ratios which allow easy interpretation of the effects of a variable on a phenomenon.

Survey Research and Secondary Analysis

Stewart and Kamins (1993) viewed secondary analysis as a valid, non-traditional research design. Hakim (1982) defined secondary analysis as "...any further analysis of an existing data set which presents interpretations, conclusions, or knowledge additional to, or different from, those presented in the first report on the inquiry as a whole and its main results.". Hyman (1972) defined secondary analysis as "...the extraction of knowledge on topics other than those which were the focus of the original survey". This re-analysis of data allows the testing of hypotheses and answering of questions that were either not considered with the initial data collection or were more succinct than the original research and report (Hakim, 1982).

The strength of this design is that it allows the researcher to use data already collected to examine new dimensions and different aspects of the data than those originally considered. From this examination, new relationships among data variables may be identified. This strategy fits well with the stated objectives of the current study.

Another reason for using secondary analysis as the overall research method is that the Canadian Survey on Drinking and Driving (1988) surveyed a large sample size yielding a comprehensive data set. Official government surveys tend to have much larger sample sizes than other types of surveys. This size allows for the study of relatively rare social groups or phenomena such as DWUID (Hakim, 1982).

Stewart and Kemins (1993) discussed limitations of secondary data analysis, some of which apply to the current study. They observed that one of the potential problems inherent in the collection, reporting, and interpretation of secondary information is that the data are often initially collected with a specific purpose in mind, a purpose that may produce deliberate or unintentional bias (Stewart & Kemins, 1993). Further, the data collected may be so extensive that the secondary researcher may arrive at different, even conflicting conclusions, all of which may be supported by some subset of the data (Stewart & Kemins, 1993). Category definitions, particular measures, or treatment effects also may not be the most appropriate for the specific purpose at hand. Despite these limitations, secondary analysis appears to be an appropriate choice as a method for studying DWUID.

Ethical Considerations

The current study did not directly involve any human subjects. All of the data were obtained anonymously. Case numbers were given for each individual in the study beginning with 1 and continuing to 9,943. However, these numbers do not allow identification of the participants in the original study. Case records contain information on each participants age, sex, marital status, education level, occupation and other demographic characteristics. The smallest geographical region that the data can be broken down is by province; it is impossible to identify any single individual who participated in the study. In addition, the survey sample was drawn from the entire population of residents between the ages of 16 and 69 (minus about 2%) from each province. Therefore, there is no risk of breach of confidentiality posed to any of the original participants in the study. Since the data are anonymous and no risk exists for the original participants, there are few ethical considerations. Moreover, inquiries were made at the Research Administration Office at the University of Victoria to determine whether a Human Subjects Form needed to be completed. It was confirmed by the Research Administration Office that, in this case, it is unnecessary to complete a Human Subjects Form.

Data Manipulation

The following are the steps taken to answer each of the research questions. The findings are provided and discussed in the "Research Findings and Discussion" section later:

1. What is the prevalence of driving within two hours after using any of the following drug groups, either in isolation or in combination?

A) prescription drugs such as tranquilizers (CNS effects);

B) over-the-counter drugs such as codeine and/or antihistamines (OTC);

C) marijuana or hashish;

D) other illicit drugs such as LSD, heroin, mescalin or cocaine; and

E) alcohol

In order to answer this question, it was necessary to separate the drug groups into drug categories so that one subject would not appear in more than one drug group. Following the separation of the drug groups, simple frequency distributions were calculated. The resulting prevalence is recorded in Table 3.

2. What are the characteristics of people who use licit and illicit drugs and then drive?

In order to answer this question, a demographic profile for the entire driving population in the survey was first developed. This development involved running simple frequency distributions for the following characteristics: age, gender, marital status, education level, household income level, employment status (main activity last year) problem drinker (as measured by the CAGE Questionnaire), distanced travelled in the past 12 months, and years driving, for every survey respondent who indicated that they drive. These independent variables were measured in the following manner:

1) Age is a ratio variable measuring chronological years and ranged from 16 to 69.
2) Gender is a nominal variable with 0 representing female and 1 representing male.
3) Marital status is a nominal variable and respondents were provided six options (single, married, living with partner, separated, divorced, and widowed) from which they could indicate their status. Responses were differentiated using numerical codes one to six.
4) Education level is an ordinal variable. The highest level of education completed ranged from 1, representing "no schooling", to 8, representing "university degree".

5) Household Income Level is an ordinal variable. Responses were numerically coded. The level of household incomes ranged from code 1 representing "less than $5,000" to code 8 representing "60,000 or greater".

6) Employment Status (or main activity last year) is a nominal variable. Respondents were provided six options (working, looking for work, student, retired, keeping house, and other) from which they could indicate their status. Responses were differentiated using numerical codes one to six.

7) 'Problem drinker' as a variable was determined using the answers which participants gave to four survey questions, now collectively referred to as the CAGE Questionnaire (Mayfield, McLeod & Hall, 1974). Subjects were asked to indicate which response, "often, sometimes, seldom or never", most appropriately reflect their agreement with the following statements: "I feel I should cut down on my drinking"; "People annoy me by criticizing my drinking"; "I feel bad or guilty about my drinking"; and, "I have a drink first thing in the morning to steady my nerves or to get rid of a hangover" (Mayfield, McLeod & Hall, 1974). If a participants response was either 'sometimes' or 'often', that subject received one point. If the subject received three or more points, he/she was designated as a 'problem drinker'.

Although one study (Waterson and Murray, 1989) has reported that the CAGE Questionnaire is not a reliable instrument for detecting alcoholism in populations of low alcohol consumption levels, many studies have found strong support for the effectiveness of the CAGE Questionnaire as an alcoholism screening tool for the general population (Bernadt, Daniels, Blizard, & Murry, 1989; Lee & DeFrank, 1988; Mischke & Venneri, 1987; King, 1986; Beresford, 1985; Mayfield, McLeod & Hall, 1974).

8) Distance travelled in the past 12 months is an ordinal variable. Responses were numerically coded. The distance travelled ranged from code 1, representing "1,600 km or less", to code 6, representing "greater than 32,000 km".

9) Years driving is an ordinal variable. Responses were numerically coded. The number of years of driving experience ranged from code 1, representing "less than 1 year", to code 7, representing "greater than 20 years".

After frequency distributions for various characteristics for the entire driving population had been established, the demographic profile for each drug group (sorted in question one) was generated. The frequency distributions of individual drug groups were then compared to those of the entire driving population using Z-scores and chi-squares to determine whether characteristic differences, if any, were significantly different.

3. What is the relationship between the prevalence of traffic accidents, serious accidents, traffic tickets and licence suspensions, and the impact of driving within two hours of using any of the following drug groups, either in isolation or in combination?

A) prescription drugs such as tranquilizers (CNS effects);

B) over-the-counter drugs such as codeine and/or antihistamines (OTC);

C) marijuana or hashish;

D) other illicit drugs such as LSD, heroin, mescalin or cocaine; and

E) alcohol.

Logistic regression analysis was chosen as the statistical method most appropriate to answer question three. Although multiple regression analysis is an effective tool to help describe the relationship between a dependent variable and a set of independent or predictor variables, the dependent variable is assumed to be measured at the interval or ratio level. In this situation, however, there is clearly a dichotomous dependent variable (accident or no accident) involved and, therefore, multiple regression would be an inappropriate tool to use. Moreover, compared to multiple regression, logistic regression is a much more resilient test which has fewer assumptions. Logistic regression analysis assumes that there is a dichotomous dependent variable and one or more independent variables. The binomial, not the normal, distribution describes the distribution of the errors. The plotted curve of the dependent variable assumes an S shape as the dependent variable is free to range between 0 and 1. This distribution is extremely flexible from a mathematical point of view and lends itself to biologically meaningful interpretation (Hosmer & Lemeshow, 1989). Therefore, a logistic regression is the statistical method of choice.

To answer question three, several steps were taken. First, a benchmark comparison group was created. The comparison group is a 'pure' group consisting of those respondents who had stated that they had taken no substance prior to driving. Then, the traffic event variable (dependent variable) and the drug group variable were recoded so that 0 represented case negative and 1 represented case positive. Following recoding, categorical analysis (simple chi-square) and a univariate logistic regression analysis was completed for each drug group and traffic event. The results of the simple chi-square analyses were then used as a rough comparison against the univariate logistic regression model containing drug groups and traffic events. The results of the univariate logistic regression analysis were used to determine whether drug groups had a significant impact on traffic events. Multivariate logistic regressions were then computed to determine whether the drug group variables continued to have a significant impact on the traffic event variables when other factors were taken into account.

In this study, there are eight independent variables which may act as confounders. These variables were chosen based on the support they have received from existing literature as being key variables in DWUID. The eight potential confounders are: age, sex, previous alcohol patterns, marital status, employment status, education, income, and distance driven per year. No additional variables nor interaction terms were included in the model to avoid increasing the complexity of the model. Literature has suggested that the greater the number of variables, the greater the difficulty with which results can be interpreted (Kleinbaum, 1994; Hosmer and Lemeshow, 1989).

A simple correlation coefficient table (Table 1) generated prior to the running of the logistic regression and correlation tables generated during the regression indicated that some of the potential confounders were correlated. Correlation amongst variables makes interpretation of results difficult (Kleinbaum, 1994; Hosmer and Lemeshow, 1989). However, as can be seen in table 1, the correlations are too low to cause multicollinearity.

Table 1

Correlation Matrix for the Demographic Variables

	A	B	C	D	E	F
A	1.00	-0.01	-0.14	0.04	-0.07	0.01
B	-0.01	1.00	0.06	0.21	0.03	0.45
C	-0.14	0.06	1.00	0.26	-0.03	-0.05
D	0.04	0.21	0.26	1.00	-0.01	0.12
E	-0.07	0.03	-0.03	-0.01	1.00	0.12
F	0.02	0.45	-0.05	-0.05	0.12	1.00

A = Age B = Distance Driven C = Education

D = Income E = Problem Drinker F = Sex

Note: Main activity and marital status are not included in the matrix because they are treated as categorical indicator variables in the logistic regression.

The variable 'Household income' presents some problems. Income is slightly correlated with education (.26) and contains many missing cases. The literature indicates that, with survey data, it is not unusual for participants to refuse to answer questions about income (Hosmer & Lemeshow, 1989). This refusal to answer causes a problem in that when running a logistic regression, cases with missing information on the independent predictor variables would be dropped from the model. In this situation, list wise deletion would cause the elimination of over 400 cases from the model. Although pairwise deletion would result in fewer cases being dropped from the analysis, list wise deletion is a more conservative approach that is better suited exploratory studies. As well, the distribution of other variables for those individuals who did not answer the income question does not appear to be normal. This finding indicates that those individuals who chose not to answer this question might have done so for reasons other than random omission. Therefore, interpretation of the results would be more difficult if income is included in the model and many cases would be lost. For these reasons, household income was not included in the model.

This selection process leaves seven potential predictors: age, sex, problem drinker (as indicated by CAGE Questionnaire results), marital status, employment status, education level, and drug use. Therefore, a quick count shows that there are now seven potential predictors, made up of demographic variables, and eight drug group variables. A general rule of thumb in the use of logistic regression is that one should either have as many positive cases as possible or limit the number of predictors (Kleinbaum, 1991), regressions were not run for those drug groups which contained less than 20 positive cases.

Backward and forward stepwise logistic regressions were then completed for each of the traffic safety measures. The results of both methods were then compared in terms of the models' goodness of fit, significance, and variables remaining in the equation. The best fitting model that provided the most interpretable results was then chosen. In many cases, the results were the same regardless of the method used and no method resulted in a "best model", in a statistical sense (Kleinbaum, 1991).

The standardized residuals were then graphed for each model to determine the distribution. Outliers were considered for elimination. However, with such a large sample size, the elimination of outliers did not result in significant changes to the fit of the model nor change the variables in the final model.

Research Findings and Discussion

Prevalence of Driving After Drug Use

Table 2 shows the prevalence of driving after drug use for the various drug groups, while Table 3 shows the prevalence of driving after using the various drug combinations.

Table 2

Prevalence of Driving After Drug Use

Drug Group	Prevalence	(Cases)
CNS Prescription Medications	1.0 %	(85)
OTC Medications	11.6%	(995)
Marijuana/Hashish	1.0%	(85)
Alcohol	14.6%	(1,248)
LSD, Heroin	0.3%	(26)

Table 3

Prevalence of Sorted Drug Groups

Drug Group/Drug Combination	Prevalence (Cases)
CNS Prescription Medications	0.6 % (59)
OTC Medications	6.5% (646)
Marijuana/Hashish	0.2% (20)
Alcohol	8.9% (885)
CNS & OTC Medications	0.3% (26)
OTC & Alcohol	3.0% (298)
Marijuana/Hashish & Alcohol	0.4% (40)
OTC & Marijuana & Alcohol	0.3% (25)
Overall Study	8,538

The prevalence of driving following illicit drug use is low. Less than 2% of drivers reported driving after using an illicit substance. The prevalence of driving following the use of licit substances was much higher: 1,248 or 14.6% of drivers reported that they have driven within two hours after using alcohol. As well, the number of respondents who drove following the use of OTC medications was substantial at 995 (11.6%).

The current study found that the prevalence of driving after illicit drug use was lower than that found by Alveraz et al. (1991). In their Italian study, 3.4% of survey respondents reported having driven after the use of an illegal substance. The number of respondents who indicated that they had driven within two hours of using marijuana (1%) is similar to Simpson's findings (1986) that 1% to 4% of the U.S. driving population had driven after using marijuana or marijuana/alcohol. The prevalence of non-illicit drug use and driving is less than drinking and driving but still significant at 12.6% of the driving population.

Demographic Characteristics and DWUID

The demographic characteristics of those individuals who drove within two hours of using drugs are summarized below.

It should be noted that the way in which the data were sorted for research questions two and three altered the number of cases in each drug group. Although non-CNS substances, such as heart and insulin medications, have not been implicated in the literature as having an effect on traffic safety, any potential effect of these substances was controlled for in the current study. Thus, if a respondent had indicated that they used non-CNS medications and marijuana, they were not included in the marijuana group. This separation allowed for demographic comparisons between drug groups and also helped to clarify the impact of substance use upon traffic safety by simplifying the logic structure underlying the logistic regression model. Therefore, the drug group totals for question one are different than those in question two and three, due to the exclusion of those who used non-CNS medications.

In Tables 4 to 11, the prevalence and demographic characteristics of the various drug groups are reported.

Table 4

Mean Age and Gender Distribution of Drivers Who Used Drugs

Drug Group	Age	Male	Female
Overall Study	38.7	45.2%	54.8%
CNS	42.7	47.5%	52.5%
OTC	**36.2**	**54.2%**	**45.8%**
Marijuana	**24.7**	65.0%	35.0%
Alcohol	**34.7**	**74.4%**	**25.6%**
CNS & OTC	39.9	57.7%	42.3%
OTC & Alcohol	**32.8**	**77.5%**	**22.5%**
Marijuana & Alcohol	**24.7**	**85.0%**	**15.0%**
OTC & Marijuana & Alcohol	**27.5**	**96.0%**	**4.0%**

Note: Bold figures indicate .01 significance for comparisons between drug users and the driving population of the survey.

Those respondents who drove after using OTC medications ($\underline{Z} = -44.17$, $\underline{p} < .01$, two-tailed), marijuana ($Z = -4.57$, $\underline{p} < .01$, two-tailed), alcohol ($\underline{Z} = -8.68$, $\underline{p} < .01$, two-tailed) OTC and alcohol ($\underline{Z} = -7.39$, $\underline{p} < .01$, two-tailed), marijuana and alcohol ($\underline{Z} = -6.45$, $\underline{p} < .01$, two-tailed), and OTC and marijuana and alcohol ($\underline{Z} = -4.08$, $\underline{p} < .01$, two-tailed) were significantly younger than drivers in the general population (Table 4). This finding is in keeping with other studies which have found youth to be a factor in DWUID (Alverez et al., 1991; Johnson & White, 1989; Health and Welfare Canada 1990; Simpson, 1987; and Walsh, 1985). From both the literature and this study's results, it appears that younger drivers are more likely to drive following substance use.

Males were also more likely than females to drive following the use of OTC medications Chi (1, $\underline{N}$=6649) = 6.4, $\underline{p} < .01$, alcohol Chi(1, $\underline{N}$=6649) = 262.4, $\underline{p} < .01$, alcohol and OTC Chi(1, $\underline{N}$=6649) = 103.5, $\underline{p} < .01$, alcohol and marijuana Chi(1, $\underline{N}$=6649) = 22.5, $\underline{p} < .01$ and alcohol and OTC and marijuana Chi(1, $\underline{N}$=6649) = 26.8, $\underline{p} < .01$ (Table 4). Several studies support the conclusion that males are more likely to drive following substance use (Alveraz et al., 1991; Gjerde et al., 1988; Health and Welfare Canada, 1990; Johnson and White, 1989). Only one study found no gender differences (Newcomb et al., 1986). The current study found that males were almost three times more likely to drive following alcohol use than females. This finding strongly supports the Health and Welfare Canada study (1990) which found the same gender ratio in the prevalence of drinking and driving.

Table 5

Education Level & Household Income Level of Drivers Who Used Drugs

Drug Group	Education Level	Household Income
Overall Study	4.7	5.5
CNS	4.7	5.4
OTC	**5.2**	**5.9**
Marijuana	5.4	4.7
Alcohol	4.6	5.7
CNS & OTC	4.6	5.4
OTC & Alcohol	**5.1**	**6.2**
Marijuana & Alcohol	4.4	5.6
OTC & Marijuana & Alcohol	4.5	5.9

Note: Bold figures indicate .01 significance for comparisons between drug users and the driving population of the survey.

Those individuals who drove after using OTC medications ($\underline{Z}$=6.15, $\underline{p}$< .01, two-tailed) were more educated than the general driving population as were those who used OTC medications with alcohol ($\underline{Z}$=3.63, $\underline{p}$< .01, two-tailed) (Table 5). Alveraz et al. (1991) indicated that those individuals with higher levels of education were more likely to drive following illicit substance use. The findings of this study do not support those findings. First, OTC medications and alcohol are not considered to be illicit substances. Second, it may be possible that the illicit drug groups offer too small a sample size to allow a significant result to emerge. Based on the results of the current study, it is not clear what role, if any, education level plays in DWUID.

Those who used OTC medications alone ($\underline{Z}$=5.59, $\underline{p}$< .01, two-tailed) and in combination with alcohol ($\underline{Z}$=6.25, $\underline{p}$< .01, two-tailed) were more likely to have a higher level of household income than general drivers in the survey population (Table 5). As evident above, the OTC medications and OTC medication and alcohol groups were also more educated than general drivers in the survey population. As education level and household income are correlated, the results are not surprising. Nevertheless, it is not clear what role household income level plays in DWUID. The literature has not implicated household income level in DWUID.

Table 6

Problem Drinker and Distance Driven in the Past 12 Months By Drivers Who Used Drugs

Drug Group	Problem Drinker	Distance Driven
Overall Study	6.0%	3.4
CNS	6.8%	**2.7**
OTC	**2.6%**	**3.8**
Marijuana	15.0%	3.7
Alcohol	**16.4%**	**3.9**
CNS & OTC	11.5%	4.0
OTC & Alcohol	**14.1%**	**4.1**
Marijuana & Alcohol	17.5%	**3.9**
OTC & Marijuana & Alcohol	**12.0%**	**4.1**

Note: Bold figures indicate .01 significance for comparisons between drug users and the driving population of the survey.

Those who drove after using OTC medications ($Z=-4.35$, $p< .01$, two-tailed)were less likely to be problem drinkers than the general survey population while those who drove after using alcohol ($Z=5.25$, $p< .01$, two-tailed) and alcohol with OTC medications ($Z=4.45$, $p< .01$, two-tailed) were more likely to be problem drinkers (Table 6). Although not statistically significant (perhaps due to the small sample sizes), other alcohol and drug combinations, along with the marijuana group, had a high percentage of respondents who were categorized as problem drinkers (Table 6). Johnston and White (1989) found past drinking history to be a predictor in DWUID. This study's findings tend to support those of Johnston and White's research. Problem drinkers appear to be at risk for DWUID.

Those who drove after using antidepressants ($Z=-3.37$, $p< .01$, two-tailed) drove fewer kilometres per year than the general survey population (Table 6). Those who drove after using OTC medications ($Z=6.1$, $p< .01$, two-tailed), alcohol ($Z=8.74$, $p< .01$, two-tailed), and OTC and Alcohol ($Z=7.96$, $p< .01$, two-tailed), drove more in the last year than the general survey population. These groups were also younger than the general survey population and more likely to be male. It may be that younger people drive more or that men drive more frequently than women.

Table 7

Marital Status of Drivers Who Used Drugs

Marital Status	Overall Study	Drug Group CNS	OTC	Marjuana	EtOH
Single	27%	24%	26%	80%	**33%**
Married	62%	61%	**65%**	15%	**55%**
Partner	1%	-	**2%**	-	1%
Separated	3%	3%	3%	-	**6%**
Divorced	4%	6%	**2%**	5%	4%
Widowed	4%	6%	**2%**	-	**1%**

Note: Bold figures indicate .01 significance for comparisons between drug users and the driving population of the survey.

Table 8

Marital Status of Drivers Who Used a Drug Combination

	Drug Group			
Marital Status	CNS OTC	OTC EtOH	Marj EtOH	OTC Marj EtOH
Single	24%	26%	65%	72%
Married	39%	65%	25%	24%
Partner	3%	1%	-	-
Separated	11%	3%	5%	-
Divorced	16%	4%	5%	4%
Widowed	7%	**1%**	-	-

Note: Bold figures indicate .01 significance for comparisons between drug users and the driving population of the survey.

*Although, some results appear as though they should be significant it must be remembered that some of the drug groups have very few positive cases and significant results are less likely.

Those respondents who drove after using OTC medications Chi(1, N=6631) = 13.7, $p<.01$, alcohol Chi(1, N=6631) = 50.5, $p<.01$, OTC medications and alcohol Chi(1, N=6631) = 9.5, $p<.01$, all differed from the overall population in terms of marital status (Table 7 & Table 8). Those who drove after OTC medications were more likely to be married, while those respondents who drove after using alcohol and alcohol with other substances were more likely to be single. Alveraz et al. (1991) found that single people were more likely to drive after using illicit substances. This study appears to provide tentative support for Alveraz et al.'s findings.

Table 9

Main Activity in the Past 12 months of Drivers Who Used a Drug

Main Activity	Overall Study	Drug Group CNS	OTC	Marj	EtOH
Working	62%	**55%**	**73%**	65%	**81%**
Unemployed	3%	2%	3%	5%	3%
Student	9%	9%	10%	**20%**	8%
Retired	7%	**11%**	**3%**	-	**3%**
Keeping House	18%	15%	**10%**	**10%**	**4%**
Other	1%	**8%**	1%	-	1%

Note: Bold figures indicate .01 significance for comparisons between drug users and the driving population of the survey.

Table 10

Main Activity Past 12 months of Drivers Who Used a Drug Combination

	Drug Group			
Main Activity	CNS OTC	OTC EtOH	Marj EtOH	OTC Marj EtOH
Working	68%	**88%**	**72%**	88%
Unemployed	8%	3%	**10%**	-
Student	8%	7%	**15%**	4%
Retired	8%	-	-	-
Keeping House	**8%**	**2%**	3%	4%
Other	-	-	-	4%

Note: Bold figures indicate .01 significance for comparisons between drug users and the driving population of the survey.

The employment status of substance users varied from that of the overall survey sample (Table 9 & Table 10). There does not appear to be a clear pattern of employment status across drug groups or combination drug groups. Although Alvarez, et al. (1991) found that unemployed persons were most likely to be involved in DWUID, the present study does not support their finding.

Table 11

Driving Experience by Drivers Who Used Drugs

Drug Group	Driving Experience
Overall Study	5.28
CNS	5.59
OTC	5.31
Marijuana	**3.60**
Alcohol	5.20
CNS & OTC	5.90
OTC & Alcohol	5.13
Marijuana & Alcohol	**3.54**
OTC & Marijuana & Alcohol	4.44

Note: Bold figures indicate .01 significance for comparisons between drug users and the driving population of the survey.

The marijuana ($\underline{Z}$=-4.3, $\underline{p}$< .01, two-tailed) and marijuana and alcohol ($\underline{Z}$=-5.0, $\underline{p}$< .01, two-tailed) combination groups were more likely to have fewer years driving experience than the general survey population (Table 11). Again, the young age of those who drove after using marijuana or marijuana combinations may explain the lack of driving experience.

Drug Use and Its Impact on Traffic Safety

The third research question asked, "What is the relationship between the prevalence of traffic accidents, serious accidents, traffic tickets and license suspensions when driving within two hours of using:

a) Prescription drugs such as tranquilizers (CNS effects);

b) Over-the-counter drugs such as codeine and/or antihistamines (OTC);

c) Marijuana or hashish;

d) Other illicit drugs such as LSD, heroin, mescalin or cocaine; and

e) alcohol".

Tables 12 through 23 summarize the results of the logistic regression tests for each of the drug groups with more than 20 positive cases. Odds ratios for significant drug user groups are indicated along with the 95% confidence intervals (C.I.).

Table 12 shows the results of the univariate logistic regressions involving the various drug groups. The impact of the drug group was considered separate from any other variable. Table 13 shows the results of the multivariate logistic regression involving the various drug groups and the demographic variables. The impact of the drug groups are considered at the same time as the impact of the demographic variables. Table 14 shows the odds ratios for those drug groups which where significant in the multivariate logistic regression model.

Table 12

Impact of Drug Use and Driving on Traffic Accidents
Univariate Logistic Regression Analysis

Variable	B.	S.E.	Sig.	R.	Exp(B)
CNS	0.57	0.28	0.05	0.02	1.76
OTC	0.08	0.10	0.44	0.00	1.08
Marijuana	1.19	0.45	0.01	0.03	3.28
Alcohol	0.37	0.08	0.00	0.05	1.45
CNS & OTC	0.75	0.41	0.07	0.01	2.12
OTC & Alcohol	0.58	0.13	0.00	0.05	1.78
Marijuana & Alcohol	1.19	0.34	0.03	0.02	2.13
CNS & OTC & Alcohol	1.15	0.40	0.00	0.03	3.15

Table 13

Impact of Drug Use and Driving on Traffic Accidents
Multivariate Logistic Regression Analysis

Variable	B.	S.E.	Sig.	R.	Exp(B)
Age	-0.01	0.00	0.00	-0.06	0.99
Sex	0.17	0.08	0.03	0.02	1.83
OTC & Alcohol	0.33	0.14	0.02	0.02	1.39
Marijuana & Alcohol	0.76	0.34	0.03	0.02	2.13

Table 14

Traffic Accidents-Drug Group Odds Ratios

Drug Group	Odds Ratio	95% C.I.	Significant
OTC & Alcohol	1.39	1.05 - 1.84	Yes
Marijuana & Alcohol	2.13	1.09 - 4.15	Yes

In the multivariate logistic regression analysis, the use of OTC medications with alcohol and marijuana with alcohol had a significant impact on traffic accidents. Traffic accidents were also predicted by age and sex with younger, male drivers being at a higher risk for accidents (Table 13). Age and sex have been implicated in DWUID research (Alveraz et al. 1991; Gjerde et al. 1988; Health and Welfare Canada, 1990; Johnson and White, 1989; Simpson, 1987; Walsh, 1985) and the current study tends to support the findings of these earlier works. It is surprising that alcohol alone did not appear to predict traffic accidents in the multivariate analysis (Table 13) when other research has clearly linked alcohol to traffic accidents (Budd et al., 1989; Chan, 1987; Honkenanen et al., 1980; Poklis et al., 1987). As evident in the univariate logistic regression analysis (Table 12), alcohol, alone or in combination with other substances, appears to have an impact upon traffic accidents. It may be that, in the current study, the other variables, such as age, are accounting for the affect of alcohol on traffic safety. When the univariate logistic regression for alcohol is computed, the test considers only the alcohol variable. Demographic profiles completed in this study indicate that people who drive after drinking are more likely to be male and younger than the general driving population in the survey. The apparent impact that alcohol has on traffic accidents declines when other factors such as age and sex are controlled. Therefore, it is not necessarily the alcohol variable that causes a significant impact on traffic accidents but rather, other characteristics such as age and sex.

The studies by Budd et al.(1989), Honkenanen et al. (1980) and Poklis et al. (1987) did not attempt to establish the impact of alcohol on traffic accidents in a general driving population survey. Instead, they focused on accident fatalities and police arrests. It is, therefore, not surprising that the different methodologies used between these researchers' studies and this thesis to study the effects of alcohol on traffic accidents, result in different findings.

In addition, alcohol blood concentration levels have clearly been associated with the risk of traffic accident (Chan, 1987). However, the Health and Welfare Canada Survey on Drinking and Driving (1988) only asked whether the subjects had driven after two or more drinks in the last hour. Therefore, subjects answering in the affirmative to this question may only have had two or three drinks in the last hour prior to driving. This consumption may or may not result in a blood alcohol concentration level above the legal limit (0.08% in British Columbia, Canada). However, the reaching of this limit may not play a dramatic role in traffic accidents. Chan (1987) pointed out that although the effect of high blood alcohol concentrations was profound and clear, the effect of lower blood alcohol concentrations is less clear. Therefore, the way in which the survey question is constructed could lead to an underestimation of the impact that alcohol has on traffic accidents.

Some authors have pointed out the difficulty of directly attributing traffic accidents to substance abuse or impairment, due to the large number of other variables that may be involved in traffic accidents (Bud et al, 1989; Clayton, 1987; Ferrara, 1987;

Klitzner et al, 1988; Polkis et al, 1986; Simpson, 1987). The multifactorial nature of traffic accidents could also diffuse the observable role of alcohol.

The alcohol with OTC medications and the alcohol with marijuana combination groups appear to play a role in traffic accidents. This finding is not surprising given the large number of studies which have reported the synergistic effects of alcohol and drug combinations (Clayton, 1987; Gjerde et al. 1988; Hindmarch & Harrison, 1988; Peck et al., 1988; Simpson, 1987, 1988; Smily, 1988).

Table 15 shows the results of the univariate logistic regressions involving the various drug groups. The impact of the drug group was considered separate from any other variable. Table 16 shows the results of the multivariate logistic regression involving the various drug groups and the demographic variables. The impact of the drug groups are considered at the same time as the impact of the demographic variables. Table 17 shows the odds ratios for those drug groups which where significant in the multivariate logistic regression model.

Table 15

Impact of Drug Use and Driving on Serious Traffic Accidents
Univariate Logistic Regression Analysis

Variable	B.	S.E.	Sig.	R.	Exp(B)
CNS	0.78	0.34	0.02	0.03	2.17
OTC	0.06	0.14	0.67	0.00	1.06
Marijuana	0.51	0.63	0.42	0.00	1.66
Alcohol	0.42	0.11	0.00	0.06	1.53
CNS & OTC	0.54	0.55	0.32	0.00	1.71
OTC & Alcohol	0.71	0.16	0.00	0.06	2.03
Marijuana & Alcohol	1.15	0.37	0.00	0.04	3.16
CNS & OTC & Alcohol	1.09	0.47	0.02	0.03	2.98

Table 16

Impact of Drug Use and Driving on Serious Traffic Accidents
Multivariate Logistic Regression Analysis

Variable	B.	S.E.	Sig.	R.	Exp(B)
Age	-0.02	0.00	0.00	-0.07	0.98
Sex	0.40	0.11	0.00	0.06	1.50
OTC & Alcohol	0.36	0.17	0.03	0.03	1.44

Table 17

Serious Traffic Accidents - Odds Ratios

Variable	Odds Ratio	95% C.I.	Significant
OTC & Alcohol	1.44	1.03 - 2.01	Yes

As can be seen in Table 15, the impact of the drug groups is much more pronounced when considered alone. However, these impacts are lessened in the multivariate model. Again, age and sex appear to play a role in the incidents of serious traffic accidents (Table 16). The only drug variable that appears to have an impact on serious accidents is the OTC with alcohol group.

Again, it is surprising that alcohol does not appear to play a greater role in contributing to the occurrence of serious traffic accidents in the multivariate analysis (Table 16). The possible reasons for this finding have already been discussed under the preceding Traffic Accidents section.

Table 18 shows the results of the univariate logistic regressions involving the various drug groups. The impact of the drug group was considered separate from any other variable. Table 19 shows the results of the multivariate logistic regression involving the various drug groups and the demographic variables. The impact of the drug groups are considered at the same time as the impact of the demographic variables. Table 20 shows the odds ratios for those drug groups which where significant in the multivariate logistic regression model.

Table 18

Impact of Drug Use and Driving on Traffic Tickets
Univariate Logistic Regression Analysis

Variable	B.	S.E.	Sig.	R.	Exp(B)
CNS	0.17	0.33	0.61	0.00	0.85
OTC	0.21	0.09	0.02	0.02	1.24
Marijuana	0.98	0.45	0.03	0.02	2.67
Alcohol	1.01	0.08	0.00	0.16	2.76
CNS & OTC	0.37	0.43	0.38	0.00	1.45
OTC & Alcohol	1.05	0.12	0.00	0.10	2.85
Marijuana & Alcohol	1.70	0.33	0.00	0.06	5.49
CNS & OTC & Alcohol	1.27	0.40	0.00	0.03	3.55

Table 19

Impact of Drug Use and Driving on Traffic Tickets
Multivariate Logistic Regression Analysis

Variable	B.	S.E.	Sig.	R.	Exp(B)
Age	-0.04	0.00	0.00	-0.13	0.96
Sex	0.70	0.08	0.00	0.10	2.02
OTC & Alcohol	0.64	0.14	0.00	0.06	1.89
Marijuana & Alcohol	1.16	0.36	0.00	0.04	3.19
Alcohol	0.69	0.09	0.00	0.10	1.99
Education	0.07	0.02	0.00	0.05	1.08

Table 20

Traffic Ticket - Odds Ratios

Variable	Odds Ratio	95% C.I.	Significant
OTC & Alcohol	1.89	1.45 - 2.47	Yes
Marijuana & Alcohol	3.19	1.57 - 6.51	Yes
Alcohol	1.99	1.68 - 2.36	Yes

As can be seen in Table 18, the impact of the drug groups is much more pronounced when considered alone. However, these impacts are lessened in the multivariate model. Age and sex appear to play a role in the prevalence of traffic tickets with males being twice as likely to receive traffic tickets as females (Table 19). As well, education level appears to play a role, with more highly educated individuals more likely to get a ticket. Although Alveraz, et al. (1991), found more highly educated individuals to be at greater risk for DWUID, clear explanations for this finding are not yet available.

The OTC with alcohol, marijuana with alcohol and the alcohol drug groups were more likely to get traffic tickets. This finding could be related to the impairing effects that these substances have on driving performance. It is possible that the individuals were only slightly impaired and their impairment escaped detection, leading to a situation in which only a ticket for a driving offence was given.

Table 21 shows the results of the univariate logistic regressions involving the various drug groups. The impact of the drug group was considered separate from any other variable. Table 22 shows the results of the multivariate logistic regression involving the various drug groups and the demographic variables. The impact of the drug groups are considered at the same time as the impact of the demographic variables. Table 23 shows the odds ratios for those drug groups which where significant in the multivariate logistic regression model.

Table 21

Impact of Drug Use and Driving on Licence Suspensions
Univariate Logistic Regression Analysis

Variable	B.	S.E.	Sig.	R.	Exp(B)
CNS	0.21	0.72	0.77	0.00	1.24
OTC	0.12	0.24	0.63	0.00	1.12
Marijuana	0.60	1.03	0.56	0.00	1.83
Alcohol	1.13	0.16	0.00	0.16	3.08
CNS & OTC	1.07	0.74	0.15	0.01	2.91
OTC & Alcohol	0.72	0.27	0.01	0.06	2.06
Marijuana & Alcohol	1.84	0.45	0.00	0.09	6.28
CNS & OTC & Alcohol	1.56	0.62	0.01	0.05	4.78

Table 22

Impact of Drug Use and Driving on Licence Suspensions Multivariate Logistic Regression Analysis

Variable	B.	S.E.	Sig.	R.	Exp(B)
Age	-0.05	0.01	0.00	-0.13	0.95
Sex	1.79	0.28	0.00	0.17	5.98
OTC	0.72	0.28	0.01	0.06	2.05
Marijuana & Alcohol	1.40	0.50	0.01	0.07	4.05
Alcohol	0.90	0.21	0.00	0.17	2.46
Education	-0.17	0.05	0.00	-0.08	0.84
Problem drinker	.8478	0.23	0.00	0.09	2.33

Tables 23

Licence Suspensions - Odds Ratios

Variable	Odds Ratio	95% C.I.	Significant
OTC	2.05	1.19 - 3.54	Yes
Marijuana & Alcohol	4.05	1.53 - 10.76	Yes
Alcohol	2.46	1.63 - 4.18	Yes

Young drivers and males were more likely to have their licences suspended (Table 22). Males were particularly vulnerable, being nearly six times more likely than females to have their licences suspended. In contrast to what was observed in relation to traffic tickets, less educated individuals were more likely to have their licences suspended. Perhaps more educated individuals had better communication skills or access to legal counsel which allowed them to avoid a licence suspension. Problem drinkers were also at an increased risk for licence suspension. This finding could possibly indicate that suspensions were due to drinking and driving.

OTC medications, marijuana with alcohol, and the alcohol drug groups all appear to have an impact on licence suspensions.

Summary of Findings of Drug Use on Traffic Safety

Younger persons and males are most likely to have experienced a traffic event. Alcohol use alone was not as significant a predictor as might have been expected but alcohol use in combination with other substances was implicated in all traffic safety measures. The ability of the model to account for traffic events was weakest for traffic accidents and serious traffic accidents, but was markedly better for traffic tickets and licence suspensions. OTC in combination with alcohol has a surprisingly high level of implication.

The impact of other drugs such as illicit substances, cannot be clearly examined as their prevalence is so low that results tend to be non-significant. The univariate logistic regressions would tend to support the theory that illicit substance use plays a role in traffic safety, but more detailed studies targeted at drug users would be needed to clarify the effect of illicit substance use on traffic safety. Future studies could follow illicit substance users and compare their traffic records over time with a control group of non-illicit substance users. In terms of the overall Canadian driving population, driving after illicit substance use does not appear to be a major concern.

Policy Implications

Policy implications can be examined in terms of governmental regulations, and the role of health systems in DWUID, and the role of legal enforcement in DWUID. In this section, public health policy is considered, followed by a discussion of legal enforcement considerations.

At the present time, any substances that are to be offered to the public in the form of over-the-counter medications or prescription medications are required by the *Food and Drug Act* to undergo analysis. The Health Protection Branch of Health Canada performs an assessment of any substances to be offered to the public and considers the products mechanism of action, known effects, potential dosage and other criteria as specified in regulation. Depending on the results of the analysis, substances may be required to carry warning labels. These labels warn potential users of the adverse effects of the substance on activities such as driving and operating machinery, and the effects of combining the use of that substance with alcohol. As the OTC medications with alcohol group appears to have an impact on traffic safety, these results may indicate that the label warnings of some OTC substances are either ignored by the consumer or there is inadequate clarity. Further research to explore the effects of OTC medications alone and in combination with alcohol on traffic safety is needed to more clearly examine the role of OTC medications in traffic safety.

Based on the findings of this study, there appears to be a link between traffic safety and OTC medications. This conclusion suggests that policy discussions should focus on methods to improve labelling, and public education initiatives should be considered and their potential benefits assessed. In addition, health service professionals may need to increase their awareness of the potential impacts of the use of certain OTC medications on traffic safety. One Canadian study (Barnes and Chappell, 1981) found that pharmacists lacked knowledge of alcohol and drug interactions. Pittman, Staudenmeier and Kaplan (1991) believe that medical institutions assign a low priority to drinking and other drug use problems, preferring to pursue further legal means of social control rather than assessing the role that the health system has, and can play in the reduction of the incidents of driving and drug use. Present health teaching practices may not be rigorous enough, and future studies could examine health practices related to DWUID. Future research could also focus on the improvement of health professionals' awareness of the potential impacts of medication on driving.

In dealing with DWUID, society has chosen to rely predominantly upon legal sanctions. Presently, police officers are required to use their judgement when determining whether an individual is under the influence of a chemical substance. There are no standard psychomotor tests to determine impairment and police officers are required to rely on visible signs and their own past experience. If a police officer has "reasonable and probable grounds", the alleged offender may be apprehended and brought to a hospital for further testing. "Reasonable and probable grounds" is not a clearly defined term and each situation must, therefore, be assessed on an individual case basis, relying on the subjective judgement of each police officer.

Nichols and Ross (1990) examined the effectiveness of legal sanctions in dealing with drinking drivers in the United States. They reviewed the literature to explore the effectiveness of different types of legal sanctions as deterrence based policies. From their literature review, Nichols and Ross (1990) found that those policies based on increasing the certainty and swiftness of punishment were most likely to have a deterrent effect. Policies based on increasing the severity of being charged with drinking and driving were found to be less effective as deterrents and, in fact, appeared to be more costly to implement. The authors also found that license suspensions, when coupled with increasing the swiftness and certainty of punishment were more effective than other forms of punishment. Nichols and Ross (1990) concluded that deterrence-based drunk driving counter-measures should focus on increasing the likelihood of being caught and the swiftness with which punishment is delivered.

The authors further recommended that the emphasis among the types of sanctions that can be applied be on actions relating to licensing. Nichols and Ross's research (1990) may also be applicable to other substance abuse situations. If the deterrence of drinking and driving can be increased by swift and frequent enforcement, those same efforts may also be effective in curbing driving after medication/drug use.

However, Snortum (1988) found that causal assessments of the effects of legal sanctions on alcohol impaired driving generally only promote a temporary suppression of alcohol impaired driving. There appears to be some evidence of stable compliance in Scandinavia and long-term decline in drinking and driving casualties in the United States.

Snortum believed that simple deterrence policies might not be the only, or even the most effective, method of deterrence.

Prevention strategies and prevention policies also need to be considered. Klitzner, Vegega and Gruenewald (1988) empirically examined assumptions underlying youth drinking and driving prevention programs. Predictions on drinking and driving practices were reliable only for those who perceived drinking and driving as a deviant behaviour. This finding suggests a need to analyze and gain a better understanding of the assumptions underlying prevention programs in general. Policies aimed at prevention could be directed towards creating the perception that driving after substance use is deviant. However, this could be difficult given the forces in society outlined by Ross (1991) that promote drinking and, by extension, drug use.

As pointed out by Ross (1991), Chan (1987) and Snortum (1988), it is unlikely that there be easy solutions to the problem of driving after substance use. Given the difficulties that Walsh (1985) and Peck, et al (1988) experienced in trying to determine the drug concentrations (other than for alcohol) at which impairment occurs, it may be necessary for police officers to continue to rely on current policies of subjective assessment. Although police officers currently receive training in the visible detection of chemical intoxication, an individual police officer who is required to make a decision whether to arrest an alleged offender, will still be required to base their decisions largely on past experience.

Conclusion

This study found that age and gender were the most consistent predictors of traffic events. Younger persons and males are most likely to experience a traffic event. Alcohol used in combination with other substances was implicated in all traffic safety measures. Alcohol alone was not found to be a significant predictor of traffic accidents or serious traffic accidents. This could have been related to the number of terms in the regression model or the wording of the questions in the original survey. The ability of the model to account for traffic events was weakest for traffic accidents and serious traffic accidents but was markedly better for traffic tickets and licence suspensions. The literature has indicated the complex multifactorial nature of traffic accidents and this may explain the weak predictions for traffic accidents and serious traffic accidents.

The OTC medication with alcohol drug group had a surprisingly consistent impact on traffic safety measures. The seriousness of OTC medications when used with alcohol needs to be considered in future research. The data would tend to support the contention by some authors that alcohol is the substance of greatest concern when dealing with traffic safety. Certainly alcohol in combination with other substances has consistent negative impacts on traffic safety. Illicit substance use does not appear to be a major concern. The prevalence of illicit substance use appears to be too low to have a significant impact on the general driving population in Canada. The role of OTC medication needs to be more clearly investigated, and policy and practice options concerning the use of these substances, and their potential effects, need to be explored.

Future studies could be constructed to further focus on the nature of the interaction between medication/drug use and traffic safety, the role of OTC medications, particularly those drug groups thought to affect driving ability and the role of illicit drug use on DWUID. Also, the frequency of use of the OTC drug group and the publics awareness of the risks involved with their use if combined with alcohol needs to be given greater policy attention. If further research confirms the role that OTC medications, alcohol and alcohol combinations play in traffic safety, a reanalysis of existing policy will be necessary.

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APPENDIX 1 - List of Licit and Illicit Substances Included in the Survey

The categories of substances included in the Canadian Survey on Drinking and Driving (1988) are:

A) Prescription drugs such as sleeping pills, diet pills, tranquilizers or antidepressants.

B) Other prescription drugs such as heart medication, insulin or antibiotics.

C) Over-the-counter drugs such as codeine, antihistimines or cold medications.

D) Marijuana or hashish.

E) Other drugs such as LSD, heroin, mescalin or cocaine.

APPENDIX 2 - List of the More Prominent Substances Known to Impact Driving Skills

Barbituates[1]
- Amobarbitol
- Butabarbital
- Butalbital
- Pentobarbital
- Phenobarbital
- Secobarbital

Cocaine[1]
- Benzoylecgonine

Ethanol[1]

Opiates[1]
- Codeine
- Morphine

Phencyclidine[1]

Tetrahydrocannabinol (THC)[1]

Antidepressants[2]
- Amitriptyline
- Amitriptyline-chlordiazepoxide
- Desipramine
- Imipramine
- Mianserin
- Nomifensine
- Nortriptyline
- Viloxazine
- Mianserin-alcohol

Sedative-hypnotics[2]
- Bromazepam
- Clobazam
- Diazepam
- Flurazepam
- Lorazepam
- Lormetazepam
- Midazolam
- Nitrazepam
- Temazepam
- Bromazepam-alcohol
- Diazepam-alcohol
- Lorazepam-alcohol
- Lormetazepam-alcohol
- Midazolam-alcohol
- Amylobarbitone
- Secobarbital

Anaesthetics[2]
- Alphadione
- Methohexitone
- Thiopentone

[1]Budd, Muto, & Wong (1989)
[2]Ferrara (1987)

APPENDIX 3

Questions From the National Survey on Drinking and Driving (1988) related to Drug and Alcohol Use and Which Were Used in The Research of This Thesis

Alcohol related question:

"During the past 12 months, have you driven a motor vehicle after having two or more drinks in the previous hour?". Respondents were given YES and NO as response alternatives.

Drug related questions:

"During the past 12 months, have you used any of the following substances? Prescription drugs such as sleeping pills, diet pills, tranquilizers or antidepressants? Other prescription drugs such as heart medication, insulin or antibiotics? Over-the-counter drugs such as codeine, antihistamines or cold medications? Marijuana or hashish? Other drugs such as LSD, heroin, mescalin or cocaine?". Respondents were given YES and NO as response alternatives.

"The last time this was used, did you drive within 2 hours of using it?" Respondents were given YES, NO and DON'T KNOW as response alternatives.

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Title of Thesis:

Licit and Illicit Drug Use and Driving Among Canadians: Prevalence and Outcomes

Author [redacted]

Sean Dale Darling
December 20, 1995